Cognition & Motivation

Forging an Interdisciplinary Perspective

Edited by
Shulamith Kreitler

CAMBRIDGE

CAMBRIDGE

more information - www.cambridge.org/9780521888677

COGNITION AND MOTIVATION

This collection examines the many internal and external factors affecting cognitive processes. Editor Shulamith Kreitler brings together a wide range of international contributors to produce an outstanding assessment of recent research in the field. The contributions go beyond the standard approach of examining the effects of motivation and emotion to consider the contextual factors that may influence cognition. These broad and varied factors include personality, genetics, mental health, biological evolution, culture, and social context. By contextualizing cognition, this volume draws out the practical applications of theoretical cognitive research and brings separate areas of scholarship into meaningful dialogue.

Shulamith Kreitler is a professor of psychology at Tel Aviv University. Her work focuses on the cognitive foundations of meaning, creativity, and personality as well as psycho-oncology and behavior disorders. In addition to her work at Tel Aviv University, Professor Kreitler teaches regularly at the University of Haifa and is director of the Psycho-oncology Research Center at the Sheba Medical Center.

Cognition and Motivation

Forging an Interdisciplinary Perspective

Edited by

SHULAMITH KREITLER

Tel Aviv University

CAMBRIDGE
UNIVERSITY PRESS

CAMBRIDGE UNIVERSITY PRESS
Cambridge, New York, Melbourne, Madrid, Cape Town,
Singapore, São Paulo, Delhi, Mexico City

Cambridge University Press
32 Avenue of the Americas, New York, NY 10013-2473, USA

www.cambridge.org
Information on this title: www.cambridge.org/9780521888677

© Cambridge University Press 2013

This publication is in copyright. Subject to statutory exception
and to the provisions of relevant collective licensing agreements,
no reproduction of any part may take place without the written
permission of Cambridge University Press.

First published 2013

Printed in the United States of America

A catalog record for this publication is available from the British Library.

Library of Congress Cataloging in Publication data
Cognition and motivation : forging an interdisciplinary
perspective / [edited by] Shulamith Kreitler.
p. ; cm.
Includes bibliographical references and index.
ISBN 978-0-521-88867-7 (hardback)
I. Kreitler, Shulamith.
[DNLM: 1. Cognition. 2. Motivation. BF 311]
616.8–dc23 2012021042

ISBN 978-0-521-88867-7 Hardback

Cambridge University Press has no responsibility for the persistence or accuracy of URLS
for external or third-party Internet Web sites referred to in this publication and does not
guarantee that any content on such Web sites is, or will remain, accurate or appropriate.

This book is dedicated to the memory of Hans Kreitler (1916–1993), my late husband, who accompanied me with love and inspiration for many years along the road of cognitive and motivational explorations in science and life

Contents

Contributors

Phillip L. Ackerman is a professor of Psychology at the Georgia Institute of Technology. He received his doctorate from the University of Illinois at Urbana-Champaign in 1984. Dr. Ackerman is a Fellow of the American Psychological Association, the Association for Psychological Science, the Human Factors and Ergonomics Society, and the American Educational Research Association. He was the 1992 recipient of the American Psychological Association's Distinguished Scientific Award for Early Career Contribution to Psychology.

Evelyn Au is a professor of Psychology at Singapore Management University. She received her doctorate in social and personality psychology from the University of Illinois at Urbana-Champaign. Her research focuses on the interaction of culture, ecological restraints, the evolution of belief systems, and social cognition.

Frida Barak is Director of Oncology at the Oncology Institute, Barzilai Medical Center, Ashkelon, Israel. She received her training in oncology in the former Soviet Union, Israel, and the United States. Dr. Barak is currently a lecturer in the Faculty of Health Sciences at Ben-Gurion University of the Negev, Israel.

Rainer P. Born is a professor at Institut für Philosophie und Wissenschaftstheorie in Linz, Austria. He received his doctorate in mathematics and has taught philosophy of science, knowledge management, model theory, ethics, systems theory, and cognitive science in Austria and Vienna. Dr. Born is the co-founder of the Austrian Society for Philosophy and served as the organization's president from 1998 to 2002.

Jerome Bruner is Research Professor of Psychology and a Senior Research Fellow in Law at New York University. Dr. Bruner, who received his doctorate from Harvard in 1941, has helped to shape the fields of cognitive, developmental, and linguistic psychology.

Chi-yue Chiu is a professor of Management and Marketing at the Nanyang Business School, Nanyang Technological University, in Singapore. Dr. Chiu is also a specially appointed researcher at the Institute of Sociology, Chinese Academy of Social Sciences, and Research Director of the Institute on Asian Consumer Insight. He received his doctorate in social psychology from Columbia University.

Karl Edlinger is a curator in the Department of History of Science at the Vienna Natural History Museum. His doctoral research focused on the structure and function of sensory organs in Cephalaspidea, marine gastropod mollusks. Dr. Edlinger's current research involves systemic studies of issues in mollusks, evolution, and organism theory.

Anastasia Efklides is a professor of Experimental and Cognitive Psychology at Aristotle University of Thessaloniki, Greece. Her research interests include cognition and meta-cognition, particularly in relation to motivation and self-control. Dr. Efklides is the recipient of several major awards, including a commendation for Outstanding Career Contribution to Educational Psychology from the International Association of Applied Psychology and the 2011 Oevre Award from the European Association for Research on Learning and Instruction.

Michael W. Eysenck is Professorial Fellow at Roehampton University at London. Dr. Eysenck was a professor of Psychology at Royal Holloway University from 1987 to 2009 and has published widely in the areas of cognitive psychology and anxiety and cognition.

Evridiki Fioratou is a research Fellow at the Multidisciplinary Assessment of Technology Centre for Healthcare at the University of Nottingham. She received her doctorate in psychology at Lancaster University. Dr. Fioratou is an experimental and applied cognitive psychologist, whose work focuses on problem solving, insight and learning, as well as decision making and diagnostic processes in healthcare contexts.

Dida Fleisig is a lecturer in the College of Management and Academic Studies at Tel Aviv University, Israel. She received her doctorate in cognitive psychology from Tel Aviv University and currently performs research in the areas of judgment, decision making, and overconfidence.

Eva Gatarik is a research associate at the University of Applied Sciences Upper Austria, Steyr. She previously worked as a research assistant at the

Institute for Philosophy and Philosophy of Science at the University of Linz, and she participated in EU-based regional development projects focusing on network economics.

Ken J. Gilhooly is a professor in the School of Psychology at the University of Hertfordshire. Dr. Gilhooly received his doctorate from the University of Stirling and has published widely in the area of thinking and problem solving. His current work focuses on insight problem solving, creative thinking, the effects of incubation, decision making, and the effects of aging on higher mental processes.

Ksenija Jaušovec has been a researcher at the University of Maribor since 1999. Her current neuropsychological research examines the relationship between neuroelectric and hemodynamic brain activity and problem solving.

Norbert Jaušovec has been a researcher at the University of Maribor since 1984. His current neuropsychological research examines the relationship between neuroelectric and hemodynamic brain activity and problem solving. Dr. Jaušovec serves on the editorial boards of *The Curriculum Journal*, *BMC Neuroscience*, and *The Open Neuroimaging Journal*.

Wendy Johnson received her doctorate in behavior genetics and individual differences at the University of Minnesota after a twenty-year career as a consulting actuary. She is a reader in Psychology at the University of Edinburgh.

Shulamith Kreitler is a professor of Psychology at Tel Aviv University. Her work focuses on the cognitive foundations of meaning, creativity, and personality, as well as psycho-oncology and behavior disorders. In addition to her work at Tel Aviv University, Professor Kreitler teaches regularly at the University of Haifa and is Director of the Psycho-oncology Research Center at the Sheba Medical Center.

Arie W. Kruglanski is a distinguished university professor at the University of Maryland, College Park. He has published widely on subjects including human judgment and belief formation, motivated cognition, and the psychology of goals and is the recipient of many honors and awards. Dr. Kruglanski is a Fellow of the American Psychological Association, the American Psychological Society, and the Society for Personality and Social Psychology. He currently serves as an investigator at the National Consortium for the Study of Terrorism and Responses to Terrorism.

David J. McGarva teaches psychology, counseling, and therapy at the College of Social Sciences at the University of Phoenix. Dr. McGarva is a licensed counselor and psychotherapist based in Woodland Hills, California. His research interests include the motivation of creative behavior, particularly creative writing and writer's block.

Thomas Nickel is a senior psychiatrist and head of the outpatient unit at the Max Planck Institute of Psychiatry in Munich. Dr. Nickel received his training in psychology and medicine at Freiburg University. His research interests include antidepressive therapy and the cognitive and neurobiological effects of antidepressants.

Jaak Panksepp holds the Bailey Endowed Chair of Animal Well-Being Science at the Washington State University College of Veterinary Medicine and is Emeritus Distinguished Research Professor of Psychology at Bowling Green State University. Professor Panksepp pioneered the neuroscientific study of primary-process emotions in mammals and coined the term "affective neuroscience" to describe the field that studies the neural mechanisms of emotion. He has received attention in the popular press for his research on laughter in nonhuman animals, which has led to the identification of novel treatments for depression.

Klaus-Uwe Panther is a retired professor of English linguistics at the University of Hamburg and is currently a visiting distinguished professor at Nanjing Normal University, China. Professor Panther is past president of the International Cognitive Linguistics Association and the German Cognitive Linguistics Association and co-editor of the book series Human Cognitive Processing. His research focuses on the role of meaning and pragmatic function as motivational factors of grammar and the lexicon.

K. Ann Renninger is the Eugene M. Lang Research Professor and Chair of the Department of Educational Studies at Swarthmore College. Her research focuses on the conditions that support the development of interest and learning. She is a former Spencer Fellow of the National Academy of Education and a consultant to National Research Council working groups on the topics of interest and STEM, interest development and STEM integration and education, and the assessment of interest in informal science learning.

Kathryn R. Riley is a doctoral student in chemistry at Wake Forest University. A graduate of Swarthmore College, Riley previously worked with K. Ann Renninger on research and evaluation studies of the extracurricular Science-for-Kids workshops held on the Swarthmore campus and funded through a grant from the Howard Hughes Medical Institute.

Mark A. Runco is the E. Paul Torrance Professor of Creativity Studies at the University of Georgia, Athens. He received his doctorate in cognitive psychology from the Claremont Graduate School and has published widely on the subject of creativity. Professor Runco is the founder of the *Creativity Research Journal*, a Fellow of the American Psychological Association, and the President of Creativity Testing Services. He is the recipient of honors including a Spencer Foundation Research Grant and the Early Scholar Award from the National Association for Gifted Children.

Anna Sheveland is a doctoral candidate at the University of Maryland, College Park. Her research interests include motivated cognition, epistemic authority, political ideology, and terrorism.

Dorothy G. Singer is a retired senior research scientist in the Department of Psychology at Yale University. Dr. Singer is co-director of the Yale University Family Television Research and Consultation Center, affiliated with the Zigler Center for Child Development and Public Policy, and a Fellow of the American Psychological Association. Her research and publications focus on early childhood development, television effects on youth, and parent training in imaginative play. She received the 2006 Distinguished Alumni Award from Columbia University Teachers College and the 2009 Award for Distinguished Lifetime Contributions to Media Psychology from the American Psychological Association.

Jerome L. Singer is Professor Emeritus of Psychology at Yale University and a Fellow of the American Psychological Association. His research focuses on the psychology of imagination and daydreaming, and he has published widely on the subjects of thought processes, imagery, personality, psychotherapy, children's play, and the effects of television. Dr. Singer is the recipient of the 2008 Rudolf Arnheim Award for Distinguished Contributions to the Psychology of Aesthetics, Creativity, and the Arts and the 2009 Paul Farnsworth Award for Lifetime Contribution and Service, both from the American Psychological Association.

Jeff Stewart is an independent scholar living in rural Maine. His 2006 doctoral dissertation at Harvard was entitled "The Development of Consciousness from Affective Sources." He is currently finishing a book on consciousness and the self.

Ola Svenson is a researcher at Decision Research, Oregon, and Professor Emeritus at Stockholm University. He received his doctorate from Stockholm University in psychophysics and measurement theory and has conducted research on cognition and decision making, pioneering process perspective, and the think-aloud method in behavioral decision research. His applied research includes studies of traffic safety, risk analysis, risk perception, and nuclear safety. Dr. Svenson founded the European Group for Process Tracing of Decision Making and is the recipient of the U.S. Society for Risk Analysis 1997 European Distinguished Achievement Award.

Nicole Szesny is a clinical psychologist and research assistant at the Max Planck Institute for Psychiatry in Munich. She received her doctorate in psychology at the University of Munich in 2011. Dr. Szesny's research interests include cognition and neurobiological markers in depression.

Wendy Wan is an associate professor of Business Management at Sun Yat Sen University. She received her doctorate in social and personality psychology from the University of Hong Kong. Her current research examines cultural effects on consumer culture and conflict-related behavior.

Kineret Weissler is a doctoral candidate studying olfactory perception at Tel Aviv University and the Weitzman Institute of Research. Her research uses the framework of the cognitive orientation theory of motivation developed by Shulamith and Hans Kreitler. Weissler was employed by the Israeli ministry of health until 2012.

Manfred Wimmer is a lecturer at the Institute for Scientific Theory and Research at the University of Vienna, as well as a docent and free research collaborator at the Konrad Lorenz Institute. His research interests include the biological origins and sociocultural dynamics of emotions, and both inter- and transdisciplinary approaches to cognition research.

Dan Zakay is a professor of Psychology at Tel Aviv University, from which he received his undergraduate and graduate degrees. His research focuses on fundamental issues in cognitive psychology and its applications in fields such as transportation safety and national and community resilience. Professor Zakay founded and directs the graduate program in Organizational Behavior at the Interdisciplinary Center Herzliya and is the 2011 recipient of the EMET Prize in Psychology.

Edward F. Zigler is Sterling Professor of Psychology, Emeritus, at Yale University. He received his doctorate in clinical psychology from the University of Texas, Austin, in 1958, joining the Yale faculty the following year. Professor Zigler founded and is Director Emeritus of Yale's Edward Zigler Center in Child Development and Social Policy, one of the first centers in the United States to combine training in developmental science and social policy construction. He is one of the founders of applied developmental psychology and has played a significant role in education reform, including advocacy for universal preschool education. Professor Zigler has served as a consultant to every U.S. presidential administration since that of Lyndon Johnson, contributing to the development of Head Start and the Family and Medical Leave Act. He is a member of the Institute of Medicine and the American Society of Arts and Sciences.

Josef Zihl is a professor of Neuropsychology at the University of Munich. He received his doctorate in psychology at the University of Innsbruck in 1973. Professor Zihl's research interests include the neuropsychology of depression, cognition and psychopathology, and the plasticity of the visual brain.

Foreword

Jerome Bruner

The interaction of motivation and cognition continues to be one of the central dilemmas in what we now call the human sciences – psychology included. And it has been so from the earliest times; witness Aristotle's searching examination of the dilemma in the *De Anima*. At the outset, cognition is both driven by its own intrinsic motives, like the need for closure or completion, and shaped or influenced by presumably extrinsic motives, like a sexual craving or a desire for dominance. I say "presumably" because closer inspection makes clear that this distinction is misleading.

Alas, as psychology strove to become a "laboratory science," it increasingly divorced itself from the in vivo study of human action, tending to obscure or ignore the critical interdependence of motivation and cognition. Now, at last, we are returning to the in vivo study of the life of mind, and to the ancient and subtle issue of the interaction between desiring and knowing. The present book is a striking example of this new trend. Yet, for all that, it is not altogether a "new" trend: it has always lurked in the background formulation of psychology. How could it not? After all, what impels cognition? What shapes our motives?

Here I must become somewhat autobiographical. When I was a young instructor in psychology at Harvard in the mid-twentieth century, senior colleagues were fond of drawing a distinction between what they called biotropic and sociotropic psychology. The former treated psychological functions as, so to speak, self-contained and rooted in the presumably inherent, if slightly alterable, properties of the nervous system. The biotropic system was (and had to be) describable in the "centimeters-grams-seconds" system (the famous CGS system) of the natural sciences. Sociotropic psychology, on the other hand, looked outward to such matters as culture, social and educational background, and personal desires, among others. The implicit assumption, of course, was that when the sociotropes became scientifically biotropic, they would behave biotropically like their more scientific colleagues.

I was in those days principally interested in the nature of perception – perception in the everyday world, not just in the strictly controlled dark room. It became plain to me early that what we perceived and how we contextualized it was a function not only of what we desired or expected to see but how, necessarily, we went about perceptually structuring what we encountered – necessarily in the sense that there was no such thing as "neutral" perception. Phenomenal experience, in a word, was as much an outcome of our expectancies as it was of a so-called stimulus input. And so, we "regularized" and "conventionalized" stimulus inputs not only in terms of the stimulus impinging on our sense organs, but in accordance with our established expectancies.

Indeed, I shocked some of my more staid senior colleagues at that time by referring to this as the "hypothesis theory of perception." Those were the early days of the so-called New Look in perception. In a word, cognition and motivation were, in vivo, inseparable, even in such seemingly neutral domains as size perception. I recall with amusement now that when one of our studies showed that poor kids overestimated the size of coins more than well-off kids, *The New York Times* ran a story on it, but some of my then-biotrope senior colleagues were definitely not amused: "What are you trying to do, upset the Weber–Fechner law?"

What is striking about the present volume is its rejection of that old separatism. In its opening chapter, for example, Arie W. Kruglanski and Anna Sheveland refer to a "need for cognitive closure." Is it a motive or is it intrinsic in cognition itself? Well, it may be specific or nonspecific. It may be strongly driven or not. If nonspecific and lightly driven, it comes close to what we speak of as "reflection." If the opposite, we speak of it as some sort of "bias." Why then strictly classify the processes involved as either strictly motivational or strictly cognitive? The two are inseparable, and they lead to broader so-called behavioral tendencies as well – like, for example, that those given to a strong need for cognitive closure tend to be more intolerant of the unusual. But let us also bear in mind that the two necessarily work in close and necessary concert. What is to be gained by irreparably separating cognition and motivation? Neither could function without the other.

So let me close these introductory remarks with a "Bravo!" for this book. Cognition and motivation simply cannot operate independently of each other. The task is to delineate more clearly (and more empirically) the nature of their intrinsic reliance on each other, and this book is a real step in that direction.

Introduction

Shulamith Kreitler

I love knowing. My heart loves to know and so my heart tells my brain to do everything necessary in order to know and it happens.

(Jonathan Kreitler, age 5 yrs.)

It is difficult to determine precisely the date on which cognition was "born," that is to say, identified as a discipline in its own right within the broader context of psychology. However, it is quite clear that soon thereafter the issue of its relations with motivation arose.

While such notable theorists as James (1890), Baldwin (1911), and Dewey (1913) each discussed the relation of cognition and motivational engagement, it has only been in the last few years that there has been a revival of interest in motivation and the interrelation of cognition and personality. This has led to publications dealing with the interrelations of cognition with motivation (Sorrentino & Higgins, 1986), social behavior (Baltes & Staudinger, 1996), personality (Kreitler & Kreitler, 1990; Saklofske & Zeidner,1995), interest (Renninger, Hidi, & Krapp, 1992), and emotion (Power & Dalgleish, 2008), to mention only a few. This emerging interest in motivation is linked to an increasing concern for studying the individual in context, examining function as well as structure, analyzing the relation between cognitive and social development, recognizing the importance of cognitive science to the study of learning, and acknowledging the powerful impact of affective functioning on cognition.

The growing awareness of the role of cognition in various fields of psychology has been paralleled by the extension of information about the amazing evolutionary development of the human brain, in particular of those areas that implement cognition. This has led to the deepening conviction that since cognition is so highly developed in human beings and has come to engage such an important part of the human brain – especially in recent phases of evolution – it is highly probable that it fulfills an important role in regard to the major aspects of human functioning and survival – including everyday behavior, social behavior, emotions, physical health, mental health, and well-being.

The increasing impact of cognition in different domains of psychology could be viewed as revealing the unfolding ontogenetic development of cognition. The increasing cerebral space occupied by cognition could be viewed as revealing the phylogenetic development of cognition. The present book is the outcome of the insights generated by the confluence of both the ontogenetic and phylogenetic developments of cognition.

Primary indications of insights of this kind have occurred within particular subfields of psychology. In the present volume, these insights have been offered a much more extended space and salience. Moreover, the range of contexts in which cognition is analyzed has been enlarged. The standard contexts – such as emotions, learning, and personality – have been amplified by the addition of newcomers on the scene – such as physical health, genetics, and biological evolution.

Accordingly, following this extension, motivation has emerged as a concept with a new unfolding connotation. Motivation is commonly conceived as representing those forces that arouse organisms to action toward a desired goal and provide the reason and purpose for behavior. This conception seems to attribute to motivation a specific directionality, awareness of a goal or purpose on the part of the organism, the involvement of consciousness of the acting organism as well as of needs for purposefulness and meaningfulness. Assumptions of this kind may have unduly limited the meanings of motivation, excluding the wealth of connotations that have accrued to the concept of motivation in recent years, including – at least in regard to cognition – the impact of personality, emotions, health, and situational factors, to mention just a few. The more updated conception of motivation considers it as "a modulating and coordinating influence on the direction, vigor and composition of behavior", which "arises from a wide variety of internal, environmental, and social sources" (Shizgal, 1999, p. 566). In that sense, motivation has turned, rather, into a kind of cognition-modulating context whose functioning impacts not only the activation of cognition per se but also determines the manner, extent, and form of its involvement and manifestations.

The reconceptualization of the concepts of motivation and context in relation to cognition has led to a renewed emphasis on interdisciplinary considerations in studying cognition and exploring the range of its manifestations. The implementation of this approach has made it necessary to apply an innovative strategy to interactions between cognition and its contexts. This strategy consists in a double-pronged approach whereby, on the one hand, the impact and effects of various major motivational factors in regard to cognition are explored and, on the other hand, the effects of motivational factors are explored in regard to the functioning of cognition in specific cognitive domains. The two approaches represent two complementary modes of interdisciplinary thinking.

The first approach prompts questions such as 'How do emotions affect cognition'? 'What is the impact of culture on cognition'? 'In what ways does genetics affect cognition'? 'How does personality shape cognition'? It will be noted that in these questions emotions, culture, genetics, and personality are conceived as motivational forces or vectors external to cognition that affect its activation, development, and functioning.

The second approach leads to questions such as 'How does motivation of any sort affect the functioning of cognition in the domain of creativity'? 'How does motivation affect problem solving'? 'What kinds of motivation were found to affect learning'? 'In what ways could a broader and deeper exploration of motivation improve our understanding of the functioning of intelligence'?

The first approach is represented in the different chapters of Part I in the book. They are grouped together under the heading of 'Explanatory Concepts and Contexts'. The second approach is represented in the chapters of Part II of the book. They are grouped together under the heading 'Domains of Cognition in Context'. In the first part, the emphasis is on the explanatory concept that is expected to shed light on cognition as a whole, as a system within the total functioning human being. In the second part, the emphasis is on specific domains of cognition and the manner in which motivation is interwoven within each domain and its actual or potential contribution to shedding light on the functioning of that domain.

Part I includes 12 chapters. Chapter 1 (by Kruglanski & Sheveland) focuses on epistemic motivation, which has been one of the major cornerstones in opening up the vista of the interactions of cognition with motivation. The chapter deals with the role that epistemic motivation plays in the knowledge formation process, in particular reference to the need for cognitive closure construct. Following a general depiction of the epistemic process and the function that the need for closure fulfills in this endeavor, empirical research is presented about the need for closure's consequences at the intrapersonal, interpersonal, and group levels of analysis. Finally, the real-world implications of the need for cognitive closure in domains of political ideology and intergroup relations are described.

Chapter 2 (by S. Kreitler) focuses on the cognitive orientation (CO) theory, which is one of the most comprehensive approaches to cognitive motivation. The chapter presents the CO theory of cognition, which enables predicting cognitive acts as well as changing and improving them. Cognitive acts are described as a function of a motivational disposition, anchored in clusters of four belief types referring to themes representing underlying meanings, and of a cognitive program implementing the motivational disposition. The motivational disposition is shaped by CO clusters for cognition, cognitive functions (e.g., memory, curiosity), types of thinking (e.g., creativity, intuitive thinking), and domains of contents (e.g., mathematics, psychology). Cognitive performance is further affected by the state of the cognitive system as a whole (viz. state of consciousness) and current emotions.

Chapter 3 (by Ackerman) deals with the multiple and constantly emerging effects of personality on cognition. Ackerman reviews a conceptual framework that differentiates between typical behaviors (in the absence of a strong situational press) that are the target of most personality-trait assessments and behaviors of maximal performance (under conditions that elicit the greatest level of effort) that are the target of most cognitive ability and aptitude-trait assessments. Trait complexes, that is, groups of personality and cognitive traits that have significant common variance, are described along with personality traits that have more pervasive associations with cognitive processing. Interactions among these personality and cognitive traits are considered in a broad developmental context, with an emphasis on implications for work and school contexts.

Chapter 4 (by Zihl, Szesny, & Nickel) focuses on cognition, emotion, and motivation from the pathological perspective. Psychopathology is one of the factors whose impact on cognition has been recognized quite early in the history of psychology. Neurobiological, neuropsychological, and psychopathological evidence supports a concept of functional specialization in these functional systems. However, there is intensive interplay between the systems of cognition, emotion, and motivation. The consideration of dissociation and association of impairments in cognition, emotion, and motivation is important not only for a better understanding of the context in which, in particular, cognition and emotion operate, but also for a valid characterization of cognitive and emotional dysfunctions resulting from morphological or pathophysiological alterations of the structures that build the underlying networks.

The following three chapters deal with various aspects of the emotional impacts on cognition. Chapter 5 (by M. Eysenck) is concerned with the negative effects of anxiety on cognitive performance. The main focus is on processing efficiency theory and attentional control theory, which are designed to account for those effects. Both theories assume that there is an important distinction between performance effectiveness and processing efficiency reflecting the relationship between performance effectiveness and use of processing resources. In addition, attentional control theory assumes that anxiety impairs two major executive functions involving inhibitory and shifting processes, respectively. The chapter provides a detailed discussion of the research in recent years concerned with testing aspects of these theories, outlining future research directions.

Chapter 6 (by Stewart & Panksepp) delves into the biological foundations of affective systems that serve as sources for both cognition and motivation. Motivation is derived from core emotional command systems in the mammalian brain. Central to the different emotional command systems is that of SEEKING, a spontaneous generator of neurobiological events that goad the animal toward exploration. The eagerness and expectancy corresponding to this exploratory/investigative foraging drive are massively integrated by brain dopamine activity into a coherent BrainMind state called SEEKING that helps establish the neural conditions for appetitive learning for all kinds of rewards, including the urge to PLAY. SEEKING remains central throughout life, promoting enthusiasm for learning and living, is critical for a life well lived, but can also be led to excesses, in the form of addictions.

Chapter 7 (by Wimmer) deals with the organic origins and evolution of motivation, emotion, and cognition. The major assumptions are that in early periods of phylogenetic development, cognition, emotion, and motivation have been closely bound together, without ever losing their interactive dynamics, and that cognitive functions even on the highest levels are always closely tied to their emotional and motivational substructures. Thus, each analysis of the evolution of cognition has to consider the evolution of emotion/motivation. This transdisciplinary approach is supported by data from classical ethology and developmental psychology as well as by investigations of the symbolic abilities of human beings.

Chapter 8 (by Au, Wan, & Chiu) complements the phylogenic approach by focusing on the social and cultural context of cognition. The authors define culture as a network of procedural and declarative knowledge, shared among a collection of interconnected individuals. If a knowledge item is activated (i.e., when it is cognitively accessible to the individual and applicable to the context), it can affect subsequent judgments and behaviors. Cultural differences in judgments and behaviors reflect cultural differences (a) in the specific knowledge items available in the culture or (b) in the prevalence of situational cues that render a certain subset of knowledge items chronically accessible to members of a culture. Situational and individual difference factors (e.g., need for firm answers, need to belong, cognitive load, or mortality salience) that increase individuals' reliance on culture to provide quick and widely accepted answers tend to enlarge cultural differences in judgment and behavior.

The next three chapters are devoted to more purely physiological aspects. Chapter 9 (by K. Edlinger) addresses the confluence of evolutionary and cultural developments as an epistemologically active vector. Human beings, and in particular perception and cognition, result from a long evolutionary process shared by all species. In Darwinian theories, evolution of organisms and their abilities are considered as outcomes of adaptation. The shortcoming of these approaches is that they lack a consistent theory of organisms, viewed as mosaic-like arrangements of characteristics. In contrast, the theory of organismic constructions, grounded in constructive realism, considers organisms as mechanical constructions constantly engaged in converting energy, functioning in accordance with internal needs. Organisms are not blueprints of their environment. Their prime qualities are dynamics, autonomy, and spontaneity. Cognition is an activity of autonomous entities, actively constructing their own realities in accordance with special internal needs. This view corresponds also to medicine and applies to the functioning of the nervous system, characterizing the organism's relations with the environment, especially perception and cognition.

Chapter 10 (by W. Johnson) explores the issue of what and how genes affect cognition. In particular, the chapter addresses the problem of the paradox between the claims that cognition is heritable but that genes do not control our thoughts. The author reviews the history of the paradox since the development of Mendel's ideas of genetic transmission across generations and Darwin's theory of evolution, and describes the Modern Synthesis that underlies current ideas of genetics and evolutionary biology. The Synthesis has been used to develop the common measures of genetic influences on human cognition. The likely common violations of the assumptions underlying these measures have implications for understanding genetic influences on cognition. Also, issues involved in identifying the specific genes that contribute to cognition are discussed.

Chapter 11 (by N. Jaušovec & K. Jaušovec) addresses the issue of the relationship between brain functioning and cognition. It describes the brain and techniques for studying its function and structure, referring to the theories about the interactions. Following this introduction, it focuses on the relationship between intelligence and brain activation patterns in response to the performance of cognitive tasks employing many different demands. Further, it presents recent neuroscientific research of emotional intelligence, creative thinking, and individual differences in personality traits as well as the evidence on gender-based differences in performance and some possible relations to differences in brain structure and function.

The closing note of Part I is provided by Chapter 12 (by Kreitler, Weissler, & Barak), which leads us into the exciting presently unfolding domain of the impact of physical health on cognition. The review presents empirically found effects on cognitive functioning of physical disorders (i.e., cardiovascular, diabetes, gastrointestinal, hematological, nephrological, respiratory, hormonal, cancer, neurological, chronic pain, and dermatological), of sensory disabilities (e.g., deficiencies in vision or hearing), special bodily states (e.g., sleep loss, pregnancy, menstruation), medical treatments (e.g., surgery, chemotherapy, common drugs), and psychological reactions to physical disorders and treatments (e.g., anxiety, worry, denial). In view of the pervasive impact of physical disorders on cognitive functioning, it is recommended to consider the physical effects in the research and theory of cognition.

Part II includes 10 chapters. They are devoted to highlighting the actual and potential contributions of motivational factors to cognition in its different manifestations, in a variety of domains. Chapter 13 (by Gilhooly & Fioratou) deals with interrelationships between motivation, goals, thinking, and problem solving. It is argued that general motives lead to more specific goals, which in turn guide problem-directed thinking by providing a basis on which to select possible actions or develop possible subgoals. Concerning expert problem solving, it is noted that expertise is developed as a result of extensive deliberate practice carried out typically for at least ten years. Such extended practice depends on high continuing levels of motivation. Intrinsic enjoyment of the domain is important to begin and maintain the process of expertise acquisition. Intrinsic motivation also plays an important role in regard to creativity. In many circumstances, extrinsic motivators are found to impair creative performance, especially if they do not depend on results and are not informative about performance quality.

Chapter 14 (by Zakay & Fleisig) examines the role of motivation in heuristic thinking. Any kind of heuristic, cognitive or motivational (i.e., with or without evident motivational gains), is initiated by a fundamental motivation to act as fast as possible while minimizing the consumption of mental resources in face of uncertainty. Since the activation of motivational heuristics is associated with a need to overcome some motivational threat, it should be a product of a dual-stage process: first, the meaning of the situation is analyzed and the existence of a potential motivational threat is identified; then, the activation of a specific heuristic is executed in line with the identified meaning. Regular metacognitive processes monitor the heuristic thinking process so that a decision is reached whether or not a correction is needed.

Chapter 15 (by Svenson) is devoted to the domain of decision making. The author differentiates in human decision making between process approaches that focus on how decisions are reached and structural approaches that predict choices by the parameters of the problems. The motivation for decision making can be studied in terms of fundamental motivation (resulting from needs for food, social closeness, etc.) or process and representation motivation that focuses on how the individual is motivated to process the information to reach a decision. From the 1950s to the 1990s, process approaches dominated the scene. The situation changed when an interest in emotion, affect, and individual differences brought different fundamental motivations into the field, enriching research on decision making with advanced treatments of fundamental motivation.

Chapter 16 (by Born & Gatarik) extends the exploration of decision making. It focuses on the relation between knowledge and decision making on the basis of the relation between language, information, and reality, which depend on both cognition and motivation. In this context meaning-both as mediator as well as an explanatory way to think about the world – can play a decisive role, determining the limits of any formal decision support system. Both the interplay of knowledge and life and the scheme Language-Information-Reality are essential tools for analyzing the influence of meaning on the acceptance of decisions, and both contribute to an understanding of the relations between decision making and knowledge, cognition and emotion/motivation.

Chapter 17 (by Renninger & Riley) deals with relations of interest and cognition. The theory and research on the relation between interest and cognition suggest that interest affects both the "why" of attending to some content as well as the "what" of cognition. The chapter includes a detailed presentation of the case of L –, an adolescent girl who participated for five years in out-of-school summer science workshops for at-risk youth. Data from her and her peers' engagement in the workshop are contrasted with those from a study of student writers of the same age in order to highlight new aspects of the interplay between interest development and cognition in the learning environment.

Chapter 18 (by Efklides) focuses on learning in the broad sense of the concept. It presents the Metacognitive and Affective model of Self-Regulated Learning, describing the relations between metacognition, cognition, affect, and motivation. The model includes two functioning levels: (a) the Person level that represents traits and what the person brings to the task situation; and (b) the Task x Person level, which involves close interrelations of cognition, affect, metacognition, and regulation of effort (i.e., motivation) when the person works on the task, so that there is consistency and coherence in the person's actions and updating of person characteristics. Metacognition relates cognition and affect and motivates control of cognition and effort/affect as well as attributions about competence in co-regulation and other regulation in collaborative learning.

Chapter 19 (by Panther) shows that motivation is a crucial concept in linguistic theorizing. In particular, a case is made for the relative motivation of grammatical structure by conceptual and pragmatic factors. For purposes of illustration, a case study on English question tags is presented, and it is shown that their form is motivated, although not predictable, by factors such as communicative function, metonymic principles, inferencing within speech–act scenarios, and economy of coding. Tags are found in many other languages than English, but what kinds of tags appear in a specific language cannot be predicted.

Chapter 20 (by Zigler) deals with the role of motivation in regard to cognitive functioning of individuals at the extremes of the IQ curve – the mentally challenged and the gifted. The motivational factors are, in both cases, environmental circumstances, such as educational opportunities, family support, and encouragement in the workplace; personality and behavioral tendencies, such as outerdirectedness or innerdirectedness, responsiveness to tangible or intangible rewards, positive or negative reactions to others; and cognitive-motivational determinants, such as beliefs referring to motivationally orienting themes in regard to cognitive performance. Despite differences in the specific nature of these factors, their joint impact affects the level of cognitive performance in the two groups.

Chapter 21 (by Singer & Singer) deals with reflective self-awareness, daydreaming, anticipatory fantasy, and planning, relating such consciousness to more general cognition, theories of emotionality (e.g., Mandler, Baars, and Tomkins), motivation as reflected in Klinger's current concerns studies, and exploring its origin in the imaginative play of children as well as its implications for theory of mind and heightened self-awareness. Further, research is presented about ongoing consciousness in adults on the basis of signal detection experiments, natural occurring thought, and concepts of a self. Findings based on brain-imaging methods have supported the psychological experimentation by demonstrating a brain-default network that becomes active when external stimuli processing is reduced. The implications of these studies for understanding not only retrospective thought but also planning, imagination, aesthetic, and scientific creativity are indicated.

Chapter 22 (by Runco & McGarva) concludes the book with a focus on creativity. In the last decades, the study of creativity has grown dramatically, reflecting the recognition that it affects not only the arts but all forms of innovation and entrepreneurship in the sciences, technology, and education. Runco approaches the field by considering the who, what, where, when, why, and how of creativity, focusing mainly on the why. The chapter explores what that means, that creativity is motivated or is the result of particular motives – both extrinsic and intrinsic – from various theoretical perspectives (i.e., the Freudian, humanistic, behavioral, psychoeconomic theory, and theory of personal creativity).

Each of the chapters is independent of other chapters, and represents the authors' view with respect to the discussed subject matter as a whole as well as their own special view of the theme, addressing theories, methodologies, and empirical findings. In most cases, no specific studies are presented in detail. The presentation is inclusive, relying on empirical material as examples demonstrating theoretical constructs, conclusions, and implications.

The chapters in each of the parts of the book separately and in the two parts together as a whole complement each other and are designed to constitute the groundwork of an integrative and coherent foundation for forging a reconceptualization of cognition in the context of motivation and beyond.

The explorations of cognition in the multiple motivational contexts may promote the emergence of a new approach to cognition that will highlight its pivotal role in psychology, nurtured by the new unfolding interactions between the motivations and performance, needs and emotions, genetics and learning, thinking and feeling, internal and external environments, and last but not least between physiology and psychology. Only the future can tell whether this growing and enriched ecological environment for cognition will result in a second cognitive revolution in psychology.

This introduction would not be complete without expressing the deep appreciation and gratitude of the editor to the authors of the diverse chapters who have contributed of their expertise, knowledge, and extraordinary abilities and insights to each of the chapters, which constitute real steps forward along the broadening road of exploration and expanding role of cognitive sciences as a whole and cognition in particular. In particular, I would like to mention the special contribution of Ann Renninger, whose insights, cooperation, and support all along in diverse forms have served as a source of inspiration and great help in completing the project of this book.

This book would not have been produced without the continuous support of the editors of Cambridge University Press, whose encouragement, patience, and belief in the goal have been a major *motivational* force in regard to the present *cognitive* project.

References

Baldwin, J. M. (1911). *The individual and society. Or psychology and sociology*. Boston: Richard G. Badger.

Baltes, P. B., & Staudinger, U. M. (Eds.) (1996). *Interactive minds: Life-span perspectives on the social foundation of cognition*. New York: Cambridge University Press.

Dewey, J. (1913). *Interest and effort in education*. Boston: Houghton Mifflin.

James, W. (1890). *The principles of psychology* (Vols. 1 & 2). New York: Holt.

Kreitler, S., & Kreitler, H. (1990). *The cognitive foundations of personality traits*. New York: Plenum.

Power, M., & Dalgleish, T. (2008). *Cognition and emotion: From order to disorder* (2nd ed.). Hove and New York: Psychology Press.

Renninger, K. A., Hidi, S., & Krapp, A. (1992). *The role of interest in learning and development*. Hillsdale, NJ: Erlbaum.

Saklofske, D., & Zeidner, M. (Eds.) (1995). *International handbook of personality and intelligence*. New York: Plenum.

Shizgal, P. (1999). Motivation. In R. A. Wilson & F. C. Keil (Eds.), *The MIT Encyclopedia of the Cognitive Sciences* (pp. 566–568). Cambridge, MA: The MIT Press.

Sorrentino, R. M., & Higgins, E. T. (Eds.) (1986). *The handbook of motivation and cognition: Foundations of social behavior*. New York: Guilford.

PART I

EXPLANATORY CONCEPTS AND CONTEXTS

1

The Role of Epistemic Motivations in Knowledge Formation

Arie W. Kruglanski & Anna Sheveland

The formation of knowledge is among the most ubiquitous human activities, and persons engage in it continuously as individuals and group members. Individual knowledge is indispensable for intelligible action; collective knowledge is indispensable for human progress, as advances in knowledge build on prior views and strive to improve on them. In this chapter, we define human knowledge subjectively (and intersubjectively) as beliefs that people subscribe to and alter under appropriate circumstances.[1] Although at any given time individuals may be completely sure of their knowledge on various subjects, their confidence may still be undermined by new information, or by contrary opinions of trusted sources.

Broadly speaking, the formation of knowledge contains two major elements: the *cognitive* element constituting the "grist" of the epistemic process, and the *motivational* element, metaphorically the "mill" that transforms the grist. The cognitive element represents the fact that new knowledge is constructed from epistemic blocks of prior and current knowledge: new knowledge constitutes *conclusions* based on *evidence*, and such conclusions are derived from the prior knowledge in a deductive fashion. More specifically, new knowledge is mediated by *inference rules* when these are instantiated by *confirmed facts*. The rules constitute prior knowledge to which the individual subscribes; they can be thought of as preexisting *major premises* in a syllogism. The confirmed facts constitute the current information that serves as *minor premises* (see Kruglanski, 1989; Kruglanski et al., 2010; Kruglanski et al., 2007). Both constitute preexisting types of knowledge that individuals may subscribe to, namely the belief that *if X is the case then Y follows*, and that *X is* indeed the case. It is in this sense then that any new knowledge is constructed from the (cognitive) building blocks of prior knowledge.

The number of inference rules from which a given bit of knowledge is constructed may vary. For instance, each such rule may connect the occurrence of a specific behavior to a given personality trait, and the number of such relevant behaviors that a knower may consider might be few or many. Thus, in forming an impression (knowledge) about an individual's friendliness, a given knower might consider instances in which the target person *offered help*, *sought social interaction*, *forgave an insult*, and *made appreciative comments* on a colleague's performance. Another knower might consider only a subset of those behaviors in forming an impression of the target. The implications of each behavior for the trait in question may then be drawn and integrated for an overall impression. All this requires time and effort. It is here that the motivational element becomes relevant. Its function has been extensively discussed under the label of *epistemic motivation* (Kruglanski, 1989, 1996, 2004).

Generally speaking, epistemic motivation affects two aspects of knowledge formation: the *extent* of information processing en route to a judgment, and its *directionality* or *bias* toward specific conclusions. Specifically, a knower may be more or less inclined to (1) retrieve large numbers of inference rules from memory, (2) search for information relevant to those rules, and (3) integrate their implications for an overall impression. Furthermore, a knower may be more or less *pleased* with the rules' implications and give greater weight to pleasing versus displeasing implications. In the remainder of this chapter we describe those motivational properties in greater detail and review a program of empirical research that explored their consequences for phenomena on intra-individual, inter-individual, and group levels of psychological analysis. The central construct in our discussion is the need for cognitive closure defined in what follows.

THE NEED FOR COGNITIVE CLOSURE

The *need for cognitive closure* has been defined as the desire for a definitive answer to a question and the eschewal of continued uncertainty or ambiguity concerning the nature of such an answer (Kruglanski, 1989). Because a definitive answer eliminates the need for further cognitive deliberation, it is said to provide *closure*. An individual's closure motivation is assumed to lie on a continuum ranging from a strong need for closure to a strong need to avoid closure. A second, orthogonal dimension pertains to the *type* of closure (nonspecific versus specific) that the individual may be seeking or avoiding (Kruglanski, 2004).

The desire for closure is *nonspecific* if it is unbiased toward a particular conclusion; given such a need, any conclusion would suffice as long as it was firm, and hence closure-affording. For example, we might expect jury duty to elicit in an impartial jury member a heightened need for nonspecific closure. The juror's need for closure should be (1) elevated because the situation requires that a verdict be reached and (2) nonspecific because an impartial juror would not have preferences for a verdict of guilt or innocence.

In contrast, the need for *specific* closure introduces a bias toward a particular conclusion. For instance, if the juror was prejudiced against a social category of which the defendant was a member (such as her or his gender, religion, age, or ethnic group), she might prefer a verdict that was congruent with those prejudices. This may introduce an unwitting selectivity in information processing and the assignment of disproportionate weight to items supportive of such a conclusion. Also, the juror might have a *conflict* or *commonality* of interests with the defendant; these too might induce needs for specific closure that favor a guilty or innocent verdict, respectively

The magnitude of the need for closure of both the specific and nonspecific kinds is assumed to be determined by the perceived benefits of (this type of) closure relative to the costs of its absence (Kruglanski & Webster, 1996). In other words, when the benefits of closure (e.g., being able to act as a result of the closure formed) outweigh its costs, the need for closure should be heightened. Conversely, the need for closure should be diminished when the costs of closure (e.g., the fear of suffering the consequences of a major error of judgment) outweigh its benefits.

Various needs for specific closure (e.g., esteem protective or enhancing motives, impression management motives, and so forth) received considerable attention in social cognition research. In general, it was found that, when aroused, such needs bias the judgmental process in a need-congruent direction (see Dunning, 1999; Kruglanski, 1996; Kunda & Sinclair, 1999 for reviews). In the domain of knowledge formation, however, the need for *nonspecific closure* commanded incomparably greater amount of research attention. Accordingly, the remainder of this chapter is devoted to the description of a research program focused on the latter type of motivation. In what follows, we consider nonspecific closure effects on intrapersonal, interpersonal, and group levels of analysis.

The Intrapersonal Level

As noted earlier, the magnitude of the need for closure is determined by the perceived benefits of closure and the costs of lacking closure. For instance, the need for nonspecific closure is assumed to be elevated where action is required because the launching of intelligible action requires prior closure. Additionally, the need for closure is assumed to be elevated where the possession of closure would obviate costly or laborious information processing, as may occur under time pressure, in the presence of ambient noise, or when a person is fatigued or intoxicated (see Kruglanski, 2004 for a review). When the need for closure is elevated, the absence of closure is aversive and stressful. In a recent pair of studies, Roets and van Hiel (2008) found that in a decision-making context (i.e., where closure was required), high (but not low) need for closure individuals evinced increased systolic blood pressure and heart rate as well as a rise in self-reported feelings of distress (Study 1). Moreover, as long as no conclusive solution was obtained, high (but not low) need for closure individuals evinced a progressive increase of arousal assessed via a galvanic skin response. In addition to the transient situational determinants of the need for closure, this motivation was also assumed to represent a dimension of individual differences, and a scale was constructed to assess it (Webster & Kruglanski, 1994). By now, this scale has been translated into numerous languages and been shown to converge in its results with situational manipulations of the need for closure[2]; an improved version of the scale was recently published by Roets and van Hiel (2007).

Seizing and freezing phenomena. A heightened need for nonspecific closure induces in individuals the tendency to "seize" on early, closure-affording evidence and "freeze" upon the judgments (beliefs) it suggests. These tendencies were studied in reference to several classic phenomena in social cognition and perception.

For instance, Kruglanski and Freund (1983) presented participants with information about a target person's past behaviors in a work context. Participants were then asked to make a judgment about how successful the target would be at a new job. The target information included both positive and negative information, with the order of this information varied so that some participants saw the negative information first and others saw the positive information first. Need for closure was manipulated via time pressure by giving some participants a three-minute limit to make their judgments (after listening to the information), with a stopwatch in sight reminding them of the time constraint. In the low time-pressure condition, participants were told they would have an unlimited amount of time to complete the judgments.

Orthogonally, we manipulated the accountability variable assumed to lower the need for closure. Half the participants were informed that their responses would be checked by the experimenter (the high-accountability condition), whereas the remaining half were not told this (the low-accountability condition). It was predicted that because of the "seizing and freezing" tendency induced by the need for closure, participants under time pressure (vs. no pressure) would manifest a stronger primacy effect in impression formation, giving greater weight to early (vs. later) appearing items of information, whereas participants in the high versus low accountability condition would manifest a weaker primacy effect. The results lent strong support to these predictions. The primacy effect of the need for closure was subsequently replicated in a number of further studies (Ford & Kruglanski, 1995; Freund, Kruglanski, & Shpitzajzen, 1985; Richter & Kruglanski, 1998; Webster, Richter, & Kruglanski, 1996).

In an intriguing demonstration of need for closure's impact on the use of contextually activated information, Pierro and Kruglanski (2008) conducted a study on the influence of the need for closure on the *transference effect* in social judgment. The Freudian concept of transference refers to the process by which a psychotherapeutic patient superimposes onto the therapist her or his childhood fantasies with regard to a significant childhood figure (typically a parent). Andersen and her colleagues (e.g., Andersen & Cole, 1990; Andersen et al., 1995) showed, however, that the transference effect could be part and parcel of normal socio-cognitive functioning in which a significant other's schema is mistakenly applied to a new target that resembles the significant other in some respects. In a first session of Pierro and Kruglanski's (2008) experiment, participants completed the revised 14-item need for closure scale (Pierro & Kruglanski, 2005) and were asked to visualize and describe a significant other. In a second session, participants were presented with information about a target person with whom they expected to interact. The target person was either described in similar terms as their significant other or was depicted as dissimilar from that person. After having studied this information, participants were presented with a recognition test of their memory for the target. Items about the target person that were not presented in the description were included in the recognition test. The degree of transference was operationally defined as the proportion of statements falsely recognized as having been included in the description of the target person, which were consistent with the representation of the significant other provided in the first session. The results indicated that participants high on the need for closure exhibited a more pronounced transference effect, as indicated by higher false alarm rates, in the similar (vs. dissimilar) condition than did participants low on the need for closure.

Other studies found evidence that the need for closure, whether induced situationally or measured via a scale, augments the effects of prevalent stereotypes on judgments about persons (Dijksterhuis et al., 1996; Jamieson & Zanna, 1989; Kruglanski & Freund, 1983). A stereotype represents a knowledge structure affording quick judgments about members of a stereotyped "category." That the need for closure augments the tendency to utilize stereotype-based evidence in impression formation supports thus the notion that this need induces the seizing and freezing tendencies assumed by the lay epistemic theory.

The Interpersonal Level

Beyond its effects on intrapersonal phenomena in the domain of social judgment, the need for nonspecific closure was shown to exert a variety of interpersonal phenomena in realms of linguistic expression, communication, persuasion, empathy, and negotiation behavior.

Linguistic expression. Several studies looked at need-for-closure effects on linguistic abstractness in interpersonal communications. Abstract language indicates a *permanence* of judgments across situations, and hence a greater stability of closure, consistent with the freezing tendency discussed earlier. For instance, characterizing an individual's behavior in a given situation as aggressiveness (an abstract depiction) implies that he or she may be expected to behave aggressively in other contexts as well. By contrast, depicting the same behavior as a "push" (that is, concretely) carries fewer trans-situational implications. If individuals under high (vs. low) need for closure tend to freeze on their formed knowledge in the interest of epistemic permanence and stability, they should tend to employ abstract terms in their communications. Consistent with this prediction, Boudreau, Baron, and Oliver (1992) found that participants communicating their impressions to a knowledgeable and potentially critical other (assumed to induce a fear of invalidity and lower the need for closure) tended to describe a target in abstract trait terms less often than participants communicating their impressions to a recipient assumed to have little knowledge on the communication topic.

Using Semin and Fiedler's (1991) linguistic category paradigm, Rubini and Kruglanski (1997) additionally found that participants under high (vs. low) need for closure (manipulated via noise *or* measured via the need for closure scale) tended to frame their questions in more abstract terms, inviting reciprocal abstractness from the respondents. That, in turn, contributed to the creation of greater interpersonal distance between the interlocutors, lessening their liking for each other.

Webster, Kruglanski, and Pattison (1997) explored need-for-closure effects on the linguistic intergroup bias (LIB). The LIB reflects the tendency to describe negative in-group behaviors and positive out-group behaviors in concrete terms (suggesting their specificity), and to describe positive in-group behaviors and negative out-group behaviors in abstract terms (suggesting their generality). Consider now how the need for closure may impact these phenomena. On the one hand, the need for closure should induce a general tendency toward abstraction because of the desire of individuals with high need for closure for stable knowledge that transcends the specific situation. However, abstract judgments about positive out-group and negative in-group behaviors should run counter to the tendency for individuals with high need for closure to display in-group favoritism (insofar as the in-group is typically the provider of stable knowledge). This then is one case in which the need for a nonspecific closure is in conflict with the need for a specific closure (implying an in-group bias). The resultant tendencies toward abstractness and concreteness work *in concert* as far as judgment of positive in-group and negative out-group behaviors are concerned, and are *in conflict* (hence possibly canceling each other out) as far as negative in-group and positive out-group behaviors are concerned. Consistent with this prediction, Webster et al. (1997) found that high (vs. low) need-for-closure participants exposed to positive in-group or negative out-group behaviors described such behaviors more abstractly. However, as predicted, high and low need-for-closure participants *did not* differ on the abstractness of their descriptions of negative in-group or positive out-group behaviors.

Persuasion. Research by Kruglanski, Webster, and Klem (1993) explored the conditions under which the need for closure may increase or decrease individuals' susceptibility to persuasion. To do this, participants were presented with information about a legal case, allowed time to process the information, and later engaged in a discussion with a partner (fellow "juror") in order to reach a verdict in the case. When participants were given complete information about the case, including legal analysis suggesting the appropriate verdict, individuals high (vs. low) on the need for closure were less likely to be persuaded by their fellow juror (who argued for the opposite verdict). However, when individuals with high need for closure were given incomplete information lacking the legal analysis, they were more likely to be persuaded by their fellow juror than their counterparts with low need for closure. In short, individuals high (vs. low) on the need for closure tend to resist persuasion attempts when they have formed a crystallized opinion about a topic on which they may freeze, but tend to change their attitudes when presented with persuasive appeals when they lack an opinion about the topic.

Empathy. Webster-Nelson, Klein, and Irvin (2003) found that, because individuals with high need for closure tend to "freeze" on their own perspective, they are less able to empathize with their interaction partners, especially when those are dissimilar from themselves. In the Webster-Nelson et al. (2003) study, the need for closure was manipulated via an induction of mental fatigue. In a similar vein, using a dispositional measure of the need for closure, Shteynberg et al. (2008) found that high (vs. low) scorers were less sensitive to injustice done to their teammate by the experimenter (i.e., perceived the experimenter as less unfair). Finally, using a referential task paradigm, Richter and Kruglanski (1999) found that individuals with high (vs. low) dispositional need for closure tended less to implement an effective "audience design." They tended less to "tune" their messages to their interlocutors' unique attributes; as a consequence, their communications were less effectively decoded by their recipients.

Negotiation behavior. To test the effect of the need for closure in the domain of negotiation behavior, DeDreu, Koole, and Oldersma (1999) measured participants' dispositional need for closure and then (after a 30 min. delay) had them engage in a task in which they operated as sellers and interacted with presumed buyers (actually simulated by computer-programmed responses). The participant's (seller's) task was to negotiate the terms of the sale, including delivery time, price, and form of payment. Each of these was associated with rewards for the participant in the form of chances in a lottery such that greater profit for the seller was associated with higher chances of winning. Participants engaged in six rounds of negotiations, beginning with the buyer. The buyers' responses were pre-programmed to remain at a moderate level, conceding slightly more at each round. To manipulate the focal point to which participants might adjust their negotiations, they were either told that previous participants had received 11,000 points (high focal point), 3,000 points (low focal point), or simply that the range of possible points extended from 0 to 14,000 (no focal point).

Three dependent measures were assessed. First, prior to the start of the negotiations, participants were asked to indicate the minimum amount they would be willing to accept in the negotiation. Second, participants' concessions in the task were determined by the decrease in the amount of points participants demanded from the first to the last rounds of negotiation (with greater numbers indicating a larger concession). After the six trials (in which most participants did not reach an agreement), participants completed a self-report measure of the extent to which they thought systematically during the task.

The results indicated that individuals with high (vs. low) dispositional need for closure tended more to adhere to anchor values. That is, they determined the minimal profits they themselves would accept according to the alleged profits attained by others in the task. When no focal point was provided, participants with high versus low need for closure did not differ in the minimal value they expressed their willingness to accept. In addition, participants with high (vs. low) need for closure made smaller concessions to their negotiation partners and engaged in less systematic information processing.

In another study on the negotiation process, De Dreu and Koole (1997) lowered participants' need for closure via accountability instructions (Tetlock, 1992) or by increasing the costs of invalid judgments (Kruglanski & Freund, 1983). These manipulations lowered participants' tendency to use the '*consensus implies correctness*' heuristic, as well as their tendency to behave competitively and to reach an impasse when a majority suggested a competitive strategy.

Group Phenomena

The foregoing findings exemplify need for closure effects on a variety of intrapersonal and interpersonal phenomena (for an extensive review see Kruglanski, 2004). Extensive research also examined the effects of the closure motivation on groups, including the *group centrism* syndrome described next.

Group Centrism. Some people are more group-oriented than others, and most people are more group-oriented in some situations than in others. Kruglanski et al. (2006) introduced the concept of *group centrism*, defined by the degree to which individuals strive to enhance the "groupness" of their collectivity. Groupness, in turn, has been defined by a firm, consensually supported *shared reality* (Hardin & Higgins, 1996), unperturbed by dissents and disagreements. Although reality sharing has been regarded as the defining essence of groupness (e.g., Bar-Tal, 1990, 2000), its attainment may be facilitated by several aspects of group interaction enhanced by the need for closure. At the initial phases of group formation, this can involve members' attempts to arrive at a speedy consensus by exerting uniformity pressures on each other, as demonstrated in a series of studies by DeGrada et al. (1999).

To further test the influence of need for closure on the group decision-making process, Pierro et al. (2003) engaged participants in a group task after participants' need for closure had been assessed, several months earlier. Participants were divided into groups based on their need-for-closure scores, with some groups containing high need-for-closure individuals and others individuals low on need for closure. Each group was composed of four individuals, role-playing managers in a corporation. The group's goal was to determine which of the company's employees should be given a cash award for their work performance. Each "manager" represented a candidate nominated by this manager's department. The dependent measures included the asymmetry of speaking time (seizing and holding the floor), perceptions of each participant's influence over the group, and each member's style assessed on the laissez fair-autocratic dimension.

Results indicated that groups composed of high need-for-closure members (but not of low) evinced the emergence of an *autocratic group structure* wherein influence emanates from a centralized authority, enhancing the likelihood of commonly shared opinions. Specifically, in groups composed of high need-for-closure persons, some members more than others disproportionately controlled the group discussion by seizing the discussion floor and continuing to talk even when others attempted to interrupt them. Furthermore, in high need-for-closure groups (but not low), members' level of autocratic style (as assessed by independent judges) was positively correlated with their control of the discussion floor. Finally, individuals' floor control was positively correlated with their influence on the group (as indexed by self-report and by assessment of independent observers). This research supports the notion that groups composed of high need-for-closure members are more likely to form autocratic structures in which a single person or a restricted number of individuals serve as the foci of influence that shape the groups' commonly shared realities.

The laboratory findings just described are consistent with Gelfand's (2008) cross-cultural research in 35 countries across the globe in which she finds a significant relationship between the country's degree of autocracy and situational constraint, in turn correlated with inhabitants' need for closure. Although these results may reflect the notion that high need-for-closure individuals tend to construct autocratic societies, they may also mean that life in tight, autocratic societies tends to engender members with a high need for closure. These two tendencies are not necessarily incompatible; their existence and interrelation could be profitably probed in further research.

In addition to influencing group structure, intensified quest for uniformity under heightened need for closure leads to an intolerance of diversity within one's group (Kruglanski et al., 2002; Shah, Kruglanski, & Thompson, 1998). Diversity is a feature that may impede arrival at consensus, thereby reducing the group's ability to reach closure. In this vein, the need for closure heightened via time pressure and ambient noise has been shown to lead to a rejection of opinion deviates in a work group (Kruglanski & Webster, 1991). Elevated need for closure was also found to foster favoritism toward one's in-group, in direct proportion to its degree of homogeneity and opinion uniformity. Finally, the need for closure was found to foster out-group derogation (Kruglanski et al., 2002; Shah et al., 1998), the degree to which was *inversely* related to the out-group's homogeneity and opinion uniformity (Kruglanski et al., 2002). These findings are consistent with the notion that high need-for-closure individuals are attracted to groups (whether in-groups or out-groups) that promise to offer firm shared realities to their members, affording stable cognitive closure.

The quest for stable shared reality on the part of individuals with high need for closure should express itself in conservatism and the upholding of group norms and traditions. Indeed, both political conservatism (Jost et al., 2003) and the tendency to maintain stable group norms across generational cycles (Livi, 2003) were found to be related to a heightened need for closure. In this vein, Chirumbolo (2002), and Van Hiel, Pandelaere, and Duriez (2004) found that the relation between the need for closure and conservatism was mediated by general political attitudes, notably right wing authoritarianism, and social dominance orientation. Roets and Van Hiel (2006) found additionally that these relationships reflected both the freezing and seizing tendencies induced by the need for closure, the latter being specifically assessed via the Decisiveness facet of the need for closure scale.

Additionally, Chirumbolo and Leone (2008) found in two election studies (the 2004 European elections and the 2005 Italian Regional elections) that the need for closure was linearly (and positively) related to voting along the left–right continuum. Finally, Chirumbolo, Areni, and Sensales (2004) found that Italian students high (vs. low) on the need for closure were more nationalistic, religious, exhibited a preference for right-wing political parties, reported anti-immigrant attitudes, scored lower on pluralism and multiculturalism, and preferred autocratic leadership and a centralized form of political power.

Kosic et al. (2004) found evidence that the need for closure augments loyalty to one's in-group and instills a reluctance to abandon it and "defect" to alternative collectivities. Such loyalty persists to the extent that one's in-group is salient in the individuals' social environment. If, however, an alternative group's views became overridingly salient, high need for closure may prompt members to switch groups. In the Kosic et al. study (2004), Croat and Polish immigrants to Italy who were high (vs. low) on the need for closure tended to assimilate less to the Italian culture (i.e., they maintained loyalty to their culture of origin), but only if their social environment at entry consisted of their co-ethnics. However, if it consisted of members of the host culture (i.e., of Italians) high need-for-closure immigrants (vs. low) tended to defect more and assimilate to the Italian culture.

The need for closure may also influence the attitudes of members of existing groups toward potential newcomers. We already reported Chirumbolo et al.'s (2004) finding as to the anti-immigration attitudes of high need-for-closure (vs. low) Italians. More recently, Dechesne et al. (2008) investigated whether individuals high on the need for closure would prefer groups with impermeable (vs. permeable) boundaries. Dutch undergraduate students first completed the need for closure scale, and subsequently read a news article highlighting either the permeability or the impermeability of their college's boundaries. Participants in the impermeable condition read a passage stating, "The choice of one's university is virtually irreversible," whereas participants in the permeable condition read a passage depicting the choice of one's university as reversible. It was found that participants high (vs. low) on the need for closure expressed greater identification with impermeable permeable (vs.) group boundaries that do not allow much traffic in and out of the group. The same pattern of results was found for liking of the group. Dechesne et al. (2008) also found that American students with high (vs. low) need for closure had more negative attitudes toward immigration into the United States.

Conclusions. In summary, a great deal of research attests to the considerable role that the need for nonspecific cognitive closure plays in intrapersonal, interpersonal, and group processes. At the individual level, these processes affect the formation of social judgments, attitudes, and impressions. At the interpersonal level, they enter into communication and persuasion, empathy, and negotiation behavior, and at the group level, into the formation of consensus and the forging of stable social realities for the members. In all these domains and on all these levels of analysis, the need for closure has been shown to constitute a variable with implications for major classes of social psychological phenomena.

EPILOGUE: REAL-WORLD IMPLICATIONS OF THE NEED FOR COGNITIVE CLOSURE

Because much of the empirical work on the need for closure has been conducted in lab settings somewhat removed from the real world, we would feel remiss in concluding this chapter without a discussion of the substantive and far-reaching real-world implications of the construct.

Recall, for one, our previous discussion of the established link between the need for closure and political ideology and behavior, specifically in that a higher dispositional need for closure is positively related to conservatism (Jost et al., 2003) and right-wing voting behavior (Chirumbolo et al., 2004). We have also discussed Kosic et al.'s (2004) findings on the need for closure's role in immigrants' acculturation, which not only provides additional evidence of the need for closure's relevance to important real-world phenomena but also illustrates the complexity and dynamism inherent in the interplay between the need for closure and real-world conditions such as proximity of a community of co-ethnics affording one a sense of shared social reality.

In addition to at times interacting with the need for closure, real-world contexts can also serve to augment individuals' need for closure under some conditions. Situations of conflict and uncertainty, for example, can heighten individuals' need for closure. This is evidenced by Orehek et al.'s (2008) elicitation of a heightened need for closure in American college students who watched a video of the 9/11 terrorist attacks (Study 1) and elderly Dutch citizens who were led to believe that a high percentage of Muslims lived in their neighborhoods (Study 2). In both instances, the elevated need for closure fostered greater in-group favoritism. It appears thus, that real-world situations of uncertainty and conflict induce a heightened need for closure, which in turn engenders a tendency to hew to one's group and its norms and exhibit hostility toward the out-groups.

It is important to emphasize here that the need for closure is a *value-neutral construct*; that is, closure in and of itself is neither inherently good nor bad. What matters is not *that* something is seized and frozen but *what* is seized and frozen, and its social consequences within a given environmental context. If the resulting closure results in behaviors that are valued in some circumstances (e.g., decisiveness, loyalty, patriotism) then the need for closure can be said to have positive consequences. If it results in negatively valued behavior (e.g., discrimination, prejudice, closed-mindedness) the need for closure can be said to have negative consequences. Be that as it may, the need for closure is an indispensable psychological mechanism involved in knowledge formation, and for that reason it underlies a wide variety of psychological phenomena at intrapersonal, interpersonal, group, and intergroup levels of analysis.

Notes

1. This view is consistent with philosophical conceptions of scientific knowledge, arguably the most evolved and substantiated variety of knowledge, as perennially conjectural and potentially subject to refutations (Popper, 1963).
2. In a recent paper, Roets, Van Hiel, Cornelis, and Soetens (2008) argued that in addition to exerting a direct motivational effect similar to that of dispositional need for closure, situational manipulations of need for closure (via time pressure or noise) exert an effect on cognitive capacity as well manifesting itself in deteriorated task performance.

References

Andersen, S. M., & Cole, S. (1990). Do I know you?: The role of significant others in general social perception. *Journal of Personality and Social Psychology*, **59**, 384–399.

Andersen, S. M., Glassman, N. S., Chen, S., & Cole, S. W. (1995). Transference in social perception: The role of chronic accessibility in significant-other representation. *Journal of Personality and Social Psychology*, **69**, 41–57.

Bar-Tal, D. (1990). Causes and consequences of delegitimization: Models of conflict and ethnocentrism. *Journal of Social Issues*, **46**, 65–81.

(2000). From intractable conflict through conflict resolution to reconciliation: Psychological analysis. *Political Psychology*, **21**, 351–365.

Boudreau, L. A., Baron, R. M., & Oliver, P. V. (1992). Effects of expected communication target expertise and timing of set on trait use in person description. *Journal of Personality and Social Psychology*, **18**, 447–451.

Chirumbolo, A. (2002). The relationship between need for cognitive closure and political orientation: The mediating role of authoritarianism. *Personality and Individual Differences*, **32**, 603–610.

Chirumbolo, A., Areni, A., & Sensales, G. (2004). Need for closure and politics: Voting, political attitudes and attributional style. *International Journal of Psychology*, **39**, 245–253.

Chirumbolo, A., & Leone, L. (2008). Individual differences in need for closure and voting behavior. *Personality and Individual Differences*, **44**, 1279–1288.

De Grada, E., Kruglanski, A. W., Mannetti, L., & Pierro, A. (1999). Motivated cognition and group interaction: Need for closure affects the contents and processes of collective negotiations. *Journal of Experimental Social Psychology*, **35**, 346–365.

Dechesne, M., Schultz, J. M., Kruglanski, A. W., Orehek, E., & Fishman, S. (2008). A psychology of borders: Need for closure and the allure of group impermeability. Unpublished Manuscript, University of Maryland.

DeDreu, C. K. W., & Koole, S. L. (1997). Motivated use of heuristics in negotiation. Unpublished raw data.

DeDreu, C. K. W., Koole, S. L., & Oldersma, F. L. (1999). On the seizing and freezing of negotiator inferences: Need for cognitive closure moderates the use of heuristics in negotiation. *Personality and Social Psychology Bulletin*, **25**, 348–362.

Dijksterhuis, A. P., Van Knippenberg, A. D., Kruglanski, A. W., & Schaper, C. (1996). Motivated social cognition: Need for closure effects on memory and judgment. *Journal of Experimental Social Psychology*, **32**, 254–270.

Dunning, D. (1999). A newer look: Motivated social cognition and the schematic representation of social concepts. *Psychological Inquiry*, **10**, 357–375.

Ford, T. E., & Kruglanski, A. W. (1995). Effects of epistemic motivations on the use of accessible constructs in social judgment. *Personality and Social Psychology Bulletin*, **21**, 950–962.

Freund, T., Kruglanski, A. W., & Shpitzajzen, A. (1985). The freezing and unfreezing of impressional primacy: Effects of the need for structure and the fear of invalidity. *Personality and Social Psychology Bulletin*, **11**, 479–487.

Gelfand, M. J. (2008). Culture and social situations: A multilevel analysis of situational constraint across 35 nations. Invited Master Lecture at the Annual Conference of the American Psychological Association.

Hardin, C. D. & Higgins, E. T. (1996). Shared reality: How social verification makes the subjective objective. In R. M. Sorrentino & E. T. Higgins (Eds.) *Handbook of motivation and cognition* (Vol. 3, pp. 28–84). New York: Guilford.

Jamieson, D. W. & Zanna, M. P. (1989). Need for structure in attitude formation and expression. In A. R. Pratkanis, S. J. Breckler, & A. G. Greenwald (Eds.), *Attitude structure and function*. Hillsdale, NJ: Lawrence Erlbaum Associates.

Jost, J. T., Glaser, J., Kruglanski, A. W. & Sullaway, F. J. (2003). Political conservatism as motivated social cognition. *Psychological Bulletin*, **129**, 339–375.

Kosic, A., Kruglanski, A. W., Pierro, A., & Mannetti, L. (2004). Social cognition of immigrants' acculturation: Effects of the need for closure and the reference group at entry. *Journal of Personality and Social Psychology*, **86**, 1–18.

Kruglanski, A. W. (1989). *Lay Epistemics and Human Knowledge: Cognitive and Motivational Bases.* New York: Plenum.

(1996). Motivated social cognition: Principles of the interface. In E. T. Higgins & A. W. Kruglanski (Eds.), *Social psychology: Handbook of basic principles*. New York: Guilford Press.

(2004). *The psychology of closed-mindedness*. New York: Psychology Press.

Kruglanski, A. W., Dechesne, M., Orehek, E., & Pierro, A. (2009) Three decades of lay epistemics: The why, how and who of knowledge formation. *European Review of Psychology*, **20**, 146–191.

Kruglanski, A. W., & Freund, T. (1983). The freezing and un-freezing of lay-inferences: Effects on impressional primacy, ethnic stereotyping and numerical anchoring. *Journal of Experimental Social Psychology*, **19**, 448–468.

Kruglanski, A. W., Orehek, E., Dechesne, M., & Pierro, A. (2010). Lay epistemic theory: Motivational, cognitive, and social aspects of knowledge formation. *Social and Personality Psychology Compass*, **4**, 939–950.

Kruglanski, A. W., Pierro, A., Higgins, E. T., & Capozza, D. (2007). "On the move" or "staying put": Locomotion, need for closure and reactions to organizational change. *Journal of Applied Social Psychology*, **37**, 1305–1340.

Kruglanski, A. W., Pierro, A., Mannetti, L., & De Grada, E. (2006). Groups as epistemic providers: Need for closure and the unfolding of group-centrism. *Psychological Review*, **113**, 84–100.

Kruglanski, A. W., Pierro, A., Mannetti, L., Erb, H. P., & Chun, W. Y. (2007). On the parameters of human judgment. *Advances in Experimental Social Psychology*, **39**, 255–303.

Kruglanski, A. W., Shah, J. Y. Pierro, A., & Mannetti, L. (2002). When similarity breeds content: Need for closure and the allure of homogeneous and self-resembling groups. *Journal of Personality and Social Psychology*, **83**, 648–662.

Kruglanski, A. W., & Webster, D. M. (1991). Group members' reactions to opinion deviates and conformists at varying degrees of proximity to decision deadline and of environmental noise. *Journal of Personality and Social Psychology*, **61**, 212–225.

(1996). Motivated closing of the mind: "Seizing" and "freezing." *Psychological Review*, **103**, 263–283.

Kruglanski, A. W., Webster, D. M., & Klem, A. (1993). Motivated resistance and openness to persuasion in the presence or absence of prior information. *Journal of Personality and Social Psychology*, **65**, 861–876.

Kunda, Z., & Sinclair, L. (1999). Motivated reasoning with stereotypes: Activation, application and inhibition. *Psychological Inquiry*, **10**, 12–22.

Livi, S. (2003). *Il bisogno di chiusura cognitiva e la transmissione delle norme nei piccoli gruppi* [The need for cognitive closure and normtransmission in small groups]. Unpublished doctoral dissertation, Universitá di Roma, La Sapienza.

Orehek, E., Fishman, S., Dechesne, M., Doosje, B., Kruglanski, A., Cole, A. P., & Jackson, T. (2008). Certainty quest and the societal response to terrorism. Unpublished

Pierro, A., & Kruglanski, A. W. (2005). Revised Need for Cognitive Closure scale. Unpublished manuscript, Universitá di Roma, La Sapienza.

(2008). "Seizing and Freezing" on a significant-person schema: Need for closure and the transference effect in social judgment. *Personality and Social Psychology Bulletin*, **34**, 1492–1503.

Pierro, A., Mannetti, L., DeGrada, E., Livi, S., & Kruglanski, A. W. (2003). Autocracy bias in groups under need for closure. *Personality and Social Psychology Bulletin*, **29**, 405–417.

Popper, K. (1963). *Conjectures and refutations: The growth of scientific knowledge*. London: Routledge.

Richter, L., & Kruglanski, A. W. (1999). Motivated search for common ground: Need for closure effects on audience design in interpersonal communication. *Personality and Social Psychology Bulletin*, **25**, 1101–1114.

Roets, A., & van Hiel, A. (2006). Need for closure relations with authoritarianism, conservative beliefs and racism: The impact of urgency and permanence tendencies. *Psychological Belgica*, **46**, 235–252.

(2007). Separating ability from need: Clarifying the Dimensional structure of the Need For Closure Scale. *Personality and Social Psychology Bulletin*, **33**, 266–280.

(2008). Why some hate to dilly-dally and others do not: The arousal-invoking capacity of decision-making for low and high scoring need for closure individuals. *Social Cognition*, **26**, 259–272.

Roets, A., Van Hiel, A., Cornelis, I., & Soetens, B. (2008). Determinants of task performance and invested effort: A need for closure by relative cognitive capacity interaction analysis. *Personality and Social Psychology Bulletin*, **34**, 779–792.

Rubini, M., & Kruglanski, A. W. (1997). Brief encounters ending in estrangement: Motivated language-use and interpersonaI rapport. *Journal of Personality and Social Psychology*, **12**, 1047–1060.

Semin, G. R., & Fiedler, K. (1991). The linguistic category model, its bases, applications and range. In W. Stroebe & M. Hewstone (Eds.), *European Review of Social Psychology* (Vol. 2, pp. 1–30). Chichester: Wiley.

Shah, J. Y., Kruglanski, A.W., & Thompson, E. P. (1998). Membership has its (epistemic) rewards: Need for closure effects on ingroup bias. *Journal of Personality and Social Psychology*, **75**, 383–393.

Shteynberg, G., Gelfand, M., Imai, L., Mayer, D., & Bell, C. (2008). Unpublished data. University of Maryland, College Park.

Tetlock, P. E. (1992). The impact of accountability on judgment and choice: Toward a social contingency model. In L. Berkowitz (Ed.), *Advances in Experimental Social Psychology* (Vol. 25, pp. 331–376). New York: Academic Press.

Van Hiel, A., Pandelaere, M., & Duriez, B. (2004). The impact of need for closure on conservative beliefs and racism: Differential mediation by authoritarian submission and authoritarian dominance. *Personality and Social Psychology bulletin*, **30**, 824–837.

Webster, D. M., & Kruglanski, A. W. (1994). Individual differences in need for cognitive closure. *Journal of Personality and Social Psychology*, **67**, 1049–1062.

(1998). Cognitive and social consequences of the need for cognitive closure. *European Review of Social Psychology*, **8**, 133–173.

Webster, D. M., Kruglanski, A. W., & Pattison, D. A. (1997). Motivated language use in intergroup contexts: Need-for-closure effects on the linguistic intergroup bias. *Journal of Personality and Social Psychology*, **72**, 1122–1131.

Webster, D. M., Richter, L., & Kruglanski, A. W. (1996). On leaping to conclusions when feeling tired: Mental fatigue effects on impressional primacy. *Journal of Experimental Social Psychology*, **32**, 181–195.

Webster-Nelson, D., Klein, C. F., & Irvin, J. E. (2003). Motivational antecedents of empathy: Inhibiting effects of fatigue. *Basic and Applied Social Psychology*, **8**, 133–173.

2

The Structure and Dynamics of Cognitive Orientation

A Motivational Approach to Cognition

Shulamith Kreitler

INTRODUCTION: SOME ASSUMPTIONS ABOUT COGNITION AND MOTIVATION

The theme of cognition has evoked interest and admiration in individuals for many thousands of years, regardless of whether they studied it in philosophy and science or depicted it in art and myths. In different cultures, a special god was appointed for representing it, which at least in some cultures was a woman (e.g., Pallas Athena, Sophia, or the Mahavidyas). Notably, one feature characterizing cognition in these different settings is its aloofness, the special elevated status it enjoys, its sublimity, and the atmosphere of aristocratic reservation surrounding it. This may be due to the fact that cognition is traditionally upstage, representing as it were higher levels of functioning than other psychological systems. It could also be because of its intimate relations with the brain, which is itself a mysterious organ. This aloofness of cognition is still evident, despite the fact that evidence is accumulating about the ties, even interactions, of cognition with other domains – mainly emotions. Nevertheless, the impression is that cognition has not lost its peculiar separateness.

However, there is a set of assumptions that supports very different conclusions about cognition. In contrast to the envisaged restricted relations of cognition with different spheres of action and behavior, the relations of cognition with the brain are not viewed as restricted in any way. Regardless of the espoused model of the brain, it is evident that cognition uses the major parts of the brain; moreover, the development of cognition is related closely to the development of the brain in the course of evolution (Geary, 2005; Roth & Wullimann, 2001). These facts suggest that it is hardly reasonable or likely that a function that uses such large parts of the brain has only limited involvement in the daily occurrences and processes of the organism as a whole. It is more likely that the involvement of cognition in the different domains and functions of the organism is pervasive, and most probably in both directions; that is, it affects the different processes and is also affected by them. This assumption is the first of several that guide this chapter.

The second assumption is that motivation is a major factor affecting the contents and processes of cognition. This statement may seem trivial were it not for the implicit prevalent assumption that cognition simply takes place, similar to digestion and breathing in the physical domain. Because cognition fulfills a basic role concerning the organism and survival in general, it is possible that part of the motivation for cognition is automatic or built-in, as in the case of physical functions. However, as cognition consumes so much of the time and energy resources of the organism, the so-called apparent automatic motivation does not cover the whole of the motivational role for cognition. Hence, it is likely that motivation for cognition is complex in the sense that it includes several components or levels. External or internal triggers may be important constituents of motivation for specific behaviors, but they are implemented in the course of development by further layers of motivation, represented by cognitively shaped beliefs, supported by personality dispositions and emotional tendencies.

The third assumption is that cognition is a major constituent of motivation. This holds regarding behavior in general, emotions, and even physiological processes, at least those involved in physical health or diseases. As will be shown later (see The Cognitive Orientation Model: General Description), the assumption about the cognitive nature of motivation holds regarding behaviors of all kinds – habitual and non-habitual; normal and psychopathological; motoric or emotional. Furthermore, it holds regarding different kinds of individuals – young (at least down to the age of 3–4 years) or old (over 90); normal or psychopathological; and most important of all, regardless of the intellectual level of the person – individuals with normal intelligence as well as those at the lower tail of the IQ curve (see the chapter by Zigler in this book).

The fourth and final assumption is that cognition functions in terms of cognitive acts. This assumption highlights the similarity in motivational effects between cognition and other behavioral domains. A cognitive act denotes an organized sequence of steps including some starting point, the major part of the action, and some concluding point. Examples of cognitive acts are making a plan, recalling something specific, making a decision, solving a certain problem, answering a question, making an act of analysis, drawing a conclusion from a set of data, categorizing an array of inputs, choosing one of two strategies, or deciphering a code. Thus, in case of planning, the starting point of the cognitive act would be a question such as, “How do we go about it,” and the end point would be some kind of plan. In the case of deciphering a code, the starting point would be a question such as, “What does this mean,” and the endpoint of the act would be the transcription of the code or statement of the message in an understandable form or a conclusion, such as, “I am sorry, I failed to decipher the code.” A cognitive act may also be called mental action, and resembles what Piaget called an operation (Piaget & Inhelder, 1973). It is not unlike any other act that an organism performs, the difference being that the components of the act are cognitive in nature – namely, cognitive contents and processes, as distinct from motoric or physiological components. Cognitive contents are items of information, denoted for example by nouns or verbs (e.g., table, to go) and their combinations (e.g., in the form of sentences or images). Cognitive processes are specific changes in cognitive contents resulting in transformations in terms of function, location, combinations, and so forth (e.g., the combination “the table is here” is changed into “the table is broken” or is replaced by “the table is a piece of furniture”). It should further be noted that cognitive acts are not necessarily conscious, nor under voluntary control, although some parts of them may be accessible to awareness. The major point is that cognitive acts are not identical with the underlying cognitive contents and processes of which they consist. The distinction between the cognitive act and its constituents is important in the context of motivation because motivation, as commonly conceived in psychology, refers to cognitive acts but not to the constituent processes. The same holds concerning motor acts, for example. Here too, motivation affects the act of moving from one room to the next, but not the kind of muscles, joints, or blood vessels that are involved in the implementation of the act of movement.

THE COGNITIVE ORIENTATION MODEL: GENERAL DESCRIPTION

There are four major issues or questions comprising motivation in the context of psychology: (1) Why does the organism move/behave at all? (2) Given that it moves/behaves, why does it move in a specific direction or to a specific goal? (3) Given that it moves in a specific direction/toward a specific goal, why does it move in a specific manner or way? (4) Given that it moves in a specific manner/way, why does it stop the movement/behavior? All of the major approaches and theories of motivation in psychology provide answers to one or more of these questions, sometimes emphasizing one at the expense of the others. Thus, drive theories deal mainly with the first and second questions;

incentive and goal theories deal mainly with the second question; instinct theories and habit-formation theories deal mainly with the third question; and feedback theories with the fourth.

In the present context, motivation for cognition will be dealt with from the point of view of the theory of cognitive orientation (CO). The particular advantages of this theory for cognition are that it is a comprehensive theory of motivation regarding cognition; it enables prediction of cognitive acts; and despite being a cognitive-motivational approach, it does not assume rationality, realism, reasonableness, conscious decision making, and voluntary control of the cognitive proceedings. Another important advantage of the CO approach is that it enables a systematic change and improvement of cognitive acts (Kreitler & Kreitler, 1990a; Zakay, Bar El, & Kreitler, 1984).

A major thesis of the CO theory is that any act, cognitive or other, is a function of a motivational disposition and a behavioral program that implements it. The *motivational disposition* consists of a cluster of beliefs, whereas the *behavioral program* consists of cognitive contents and processes structured in sequences, schemes, strategies, or heuristics. For describing the formation of the motivational disposition and behavioral programs, we will apply the system of meaning that provides a presentation of a comprehensive set of cognitive contents and processes – namely, the meaning variables. The meaning variables and their combinations into patterns also provide access for the influence of personality traits and emotions on cognitive performance. Finally, the enactment of the cognitive acts is dependent on the atmosphere of the overall cognitive environment, including mental sets and states of consciousness.

Meaning is a concept that plays a major role in the CO theory. *Meaning* is defined as a pattern of cognitive contents (e.g., a color, an emotion) focused on some input (e.g., a stimulus, an object) that is expressed verbally or nonverbally, and forms together with the input or subject a meaning unit (Kreitler & Kreitler, 1990b). Examples of meaning units are "The sea – is made of water," "Law – a social institution." In a given context, meaning consists of one or more meaning units, each of which may be characterized in terms of the contents (e.g., causes, sensory qualities) assigned to the subject (viz. referent) and relations between it and the subject (e.g., its directness, generality). Meaning variables characterize the contents or the relations between the contents and the subject (e.g., causes or actions characterize the contents; conjunctions or metaphors characterize the relations of the contents to the subject) (see Table 2.1). Thus, meaning variables characterize both the contents and the process of its generation. Meaning assignment proceeds by assigning to a subject one or different kinds of contents. Meaning includes the more interpersonal part as

TABLE 2.1. *Major Variables of the Meaning System: The Meaning Variables*

	Meaning Dimensions		Forms of Relation
Dim. 1	Contextual Allocation	FR 1	Propositional (1a: Positive; 1b: Negative)
Dim. 2	Range of Inclusion (2a: Subclasses; 2b: Parts)	FR 2	Partial (2a: Positive; 2b: Negative)
Dim. 3	Function, Purpose, & Role	FR 3	Universal (3a: Positive; 3b: Negative)
Dim. 4	Actions & Potentialities for Actions (4a: By referent; 4b: To or with referent)	FR 4	Conjunctive (4a: Positive; 4b: Negative)
Dim. 5	Manner of Occurrence & Operation	FR 5	Disjunctive (5a: Positive; 5b: Negative)
Dim. 6	Antecedents & Causes	FR 6	Normative (6a: Positive; 6b: Negative)
Dim. 7	Consequences & Results	FR 7	Questioning (7a: Positive; 7b: Negative)
Dim. 8	Domain of Application (8a: As subject; 8b: As object)	FR 8	Desired, wished (8a: Positive; 8b: Negative)
Dim. 9	Material		
Dim. 10	Structure	SHIFTS IN REFERENT[b]	
Dim. 11	State & Possible Changes in it	SR 1	Identical
Dim. 12	Weight & Mass	SR 2	Opposite
Dim. 13	Size & Dimensionality	SR 3	Partial
Dim. 14	Quantity & Mass	SR 4	Modified by addition
Dim. 15	Locational Qualities	SR 5	Previous meaning value
Dim. 16	Temporal Qualities	SR 6	Association
Dim. 17	Possessions (17a) & Belongingness (17b)	SR 7	Unrelated
Dim. 18	Development	SR 8	Verbal label
Dim. 19	Sensory Qualities[c] (19a: Of referent; 19b: By referent)	SR 9	Grammatical variation
Dim. 20	Feelings & Emotions (20a: Evoked by referent; 20b: Felt by referent)	SR 10	Previous meaning values combined
Dim. 21	Judgments & Evaluations (21a: About referent; 21b: By referent)	SR 11	Superordinate
Dim. 22	Cognitive Qualities and Actions (22a: Evoked by referent; 22b: Of referent)	SR 12	Synonym (12a: In original language; 12b: Translated in another language; 12c: Label in another medium; 12d: A different formulation for the same referent on the same level)
		SR 13	Replacement by implicit meaning value

	Types of Relation[a]		Forms of Expression
TR 1	Attributive (1a: Qualities to substance; 1b: Actions to agent)	FE 1	Verbal (1a: Actual enactment; 1b: Verbally described; 1c: Using available materials)
TR 2	Comparative (2a: Similarity; 2b: Difference; 2c: Complementariness; 2d: Relationality	FE 2	Graphic (2a: Actual enactment; 2b: Verbally described; 2c: Using available materials)
TR 3	Exemplifying-Illustrative (3a: Exemplifying instance; 3b: Exemplifying situation; 3c: Exemplifying scene)	FE 3	Motoric (3a: Actual enactment; 3b: Verbally described; 3c: Using available materials)
TR 4	Metaphoric-Symbolic (4a: Interpretation; 4b: Metaphor; 4c: Symbol)	FE4	Sounds & Tones (4a: Actual enactment; 4b: Verbally described; 4c: Using available materials)
		FE5	Denotative (5a: Actual enactment; 5b: Verbally described; 5c: Using available materials)

[a] Modes of meaning: Lexical mode: TR1+TR2; Personal mode: TR3+TR4.

[b] Close SR: 1+3+9+12 Medium SR: 2+4+5+6+10+11 Distant SR: 7+8+13.

[c] This meaning dimension includes a listing of subcategories of the different senses/sensations: (for special purposes, they may also be grouped into "external sensations" and "internal sensations") for example, color, form, taste, sound, smell, pain, humidity, and various internal sensations.

well as the more personal-subjective part, and may vary in contents, structure, variety, and complexity. The various phases of progression from the input stimulation to the output of behavior consist of different kinds of elaboration of meanings.

THE CO THEORY: HOW DOES IT FUNCTION? MAJOR THEORETICAL STAGES

The CO theory was first formulated in the late sixties in regard to observable behaviors, and underwent several extensions; for example, in regard to emotions, psychopathologies, and the latest in regard to health phenomena (Kreitler, 2004; Kreitler & Kreitler, 1965, 1972, 1976, 1982, 1991a, 1991b). In the present context, the CO model will first be presented briefly in its general standard form, which will serve to introduce the following more detailed description of the model regarding cognitive acts (Figure 2.1).

The CO theory provides detailed descriptions of the processes intervening between input and output. These can be grouped into four stages,

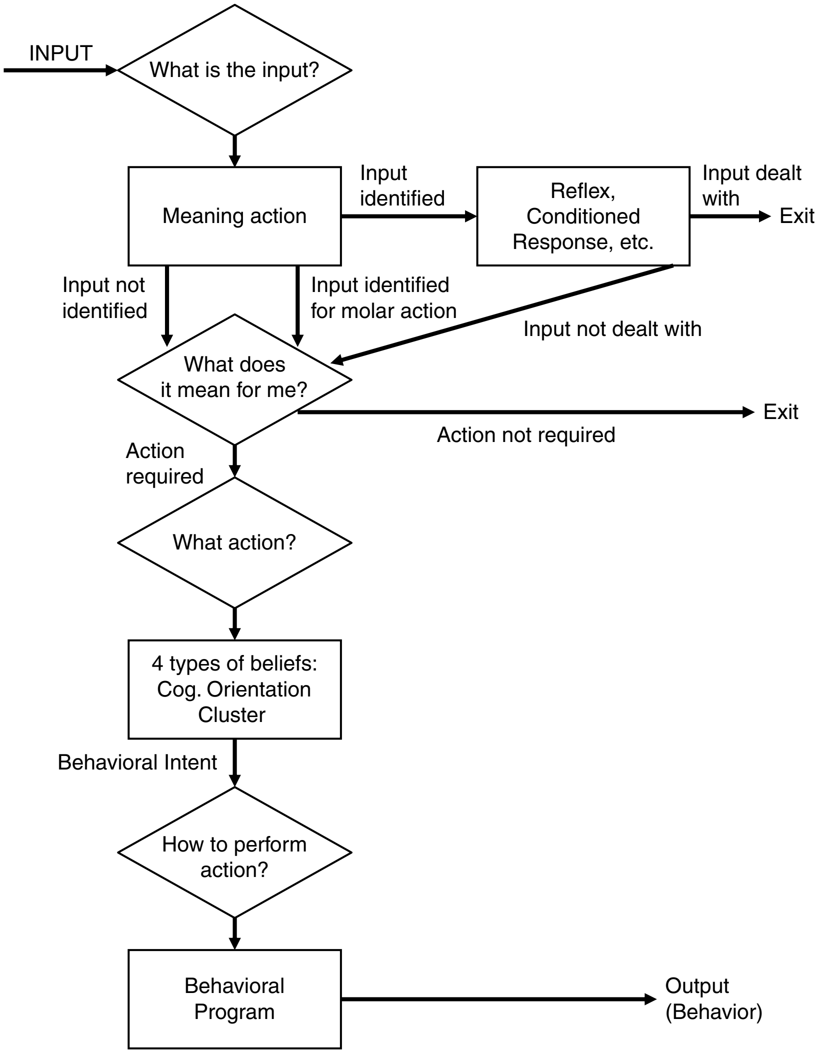

FIGURE 2.1. A schematic flow chart of the CO Model.

each characterized by metaphorical questions and answers. The first three stages describe mainly the formation of the motivational disposition and the fourth focuses on the performance. The *first stage* is initiated by an external or internal input and is focused on the question "What is it?" It consists in identifying the input in terms of a limited and primary "initial meaning" as one of the following: (a) a signal for a defensive, adaptive, or conditioned response, (b) a signal for molar action, (c) as irrelevant in the present situation, or (d) as new or especially significant, and hence as a signal for an orienting response.

The *second stage* is initiated by feedback indicating failure of the conditioned or unconditioned responses to cope with the situation, a meaning signaling the need for molar action, or an input that has failed to be sufficiently identified despite the orienting response. It is focused on the question "What does it mean in general and what does it mean to or for me?" An enriched process of meaning generation sets in based on extended elaboration of both interpersonally shared and personal kinds of meaning, in terms of meaning units in the form of beliefs. By examining the extent to which the person's goals, norms, beliefs about oneself, and reality are involved, meaning generation leads eventually to a specification whether action is required or not. If it is required, a tendency for performing some action emerges.

The tendency for action initiates the *third stage*, which is focused on the question "What will I do?" The answer is sought by means of relevant beliefs of four types: *Beliefs about goals*, which express actions or states desired or undesired by the individual (e.g., "I want to be respected by others"); *beliefs about rules and norms*, which express ethical, aesthetic, social, and other rules and standards (e.g., "One should be assertive"); *beliefs about self*, which express information about oneself, such as one's habits, actions, feelings, or abilities (e.g., "I rarely become excited," "I enjoy thinking about the past"); and *general beliefs*, which express information concerning others and the environment (e.g., "The world is a very dangerous place"). Figure 2.2 presents the formal structure of the four types of beliefs.

The cognitive elaborations in the third stage refer to beliefs that represent deep underlying meanings of the involved inputs rather than their obvious and explicit surface meanings. The meaning elaborations consist in matchings and interactions between beliefs (*belief clustering*) based on clarifying the orientativeness of the beliefs (i.e., the extent to which they support the indicated course of action). If the majority of beliefs of a certain type support the action, that belief type is considered positively oriented concerning that action. Alternately, it may be negatively oriented or lack any orientativeness. If all four belief types support a certain action, or at least three, whereby the fourth is neutral, a cluster of beliefs is formed (*CO cluster*) orienting toward a particular act. It generates a unified tendency orienting toward the performance of an action. This tendency is called *behavioral intent*, and can be considered as a vector representing the motivational disposition toward a given behavior (see Figure 2.3). When there are not enough beliefs in at least two belief types orienting toward the course of action, no CO cluster will be formed. Other resulting possibilities are the formation of two behavioral

BELIEF	SUBJECT	RELATION
Self	I	Factual
Norms	Non - I	Desirable
Goals	I	Desired
General	Non - I	Factual

FIGURE 2.2. Formal characteristics of the four types of beliefs.

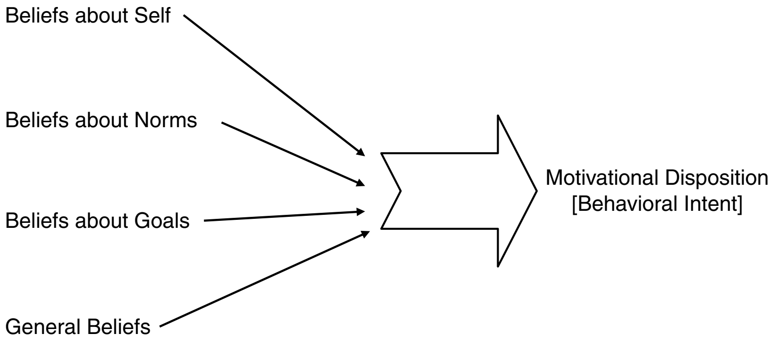

FIGURE 2.3. The vector of the four belief types representing the motivational disposition.

intents when there are two CO clusters (*intent conflict*); the retrieval of an almost complete CO cluster on the basis of past recurrences of similar situations; the formation of incomplete clusters due to the paucity of beliefs of a certain type; or the formation of an inoperable cluster due to the inclusion of as-if beliefs in one or more belief types that may orient toward daydreaming.

The *fourth stage* is initiated by the formation of the behavioral intent, and is focused on the question "How will I do it?" The answer is in the form of a *behavioral program*; namely, a hierarchically structured sequence of instructions governing the performance of the act, including both the more general strategy as well as the more specific tactics. Different programs are involved in executing an overt molar act, a cognitive act, an emotional response, a daydreamed act, conflict resolution, and so forth. There are four major kinds of programs: (1) Innately determined programs (e.g., those controlling reflexes). (2) Programs determined both innately and through learning (e.g., those controlling instincts and language behavior). (3) Programs acquired through learning (e.g., those controlling culturally shaped behaviors such as running elections) or personal habits (e.g., forms of relaxing, arranging one's cupboard). (4) Programs constructed by the individual ad hoc, in line with contextual requirements. Implementing a behavioral intent by a program requires selecting and retrieving a program, and often adapting it to prevailing circumstances. A *program conflict* may occur between two equally adequate programs or between one that is about to be enacted when another is still in operation.

THE CO THEORY OF COGNITIVE ACTS

Applying the CO model to cognitive acts includes four stages, in line with the theoretical model presented above. The first stage starts with some internal or external input (e.g., an image, memory, word). The "What is it?" question results in identifying the input as requiring an action involving resources that exceed those involved in immediate conditioned responses. For example, it could be an input identified as "an image, something I saw." Moreover, it is likely that the initial identification of the input already includes a feature characterizing the general nature of the domain to which the input belongs, namely, cognition (e.g., "an image in a book," "a puzzle"). However, this does not indicate that an action, cognitive or other, will actually be performed. In the second stage, the meaning of the initially identified input is further elaborated in terms of references to both external reality and oneself. Some of the beliefs that may be evoked around the input of "image in a book" could include: "General impressions may be misleading"; "Unclear ideas cannot be controlled" (general beliefs); "I want to have clear thoughts in my mind"; "I want to have a perfect memory" (goal beliefs); "One should try to control what goes on in one's mind"; "Memories should be precise" (norm beliefs); "I feel very uncomfortable if something is not quite clear"; "I like finding out what is in books" (belief about self). Beliefs of this kind indicate that the input initially identified as "an image in a book" is related to personal concerns, reflected in beliefs about norms, goals, and oneself. Hence, a tendency for a cognitive action is evoked. This flows into the third stage, which consists in shaping up a pattern of beliefs of the four types triggered by meanings, some of which appeared already in the second phase – for example, controlling one's thoughts, clarifying thoughts, finding out about books, and precise memory. The beliefs that show up are partly retrieved and partly shaped ad hoc on the basis of available meanings (e.g., a belief about one's impulsivity may not be available for retrieval but may be formed from beliefs about impulsive people – "impulsive people do things without thinking" – and beliefs about oneself – "I never do things without thinking"). The evoked beliefs refer to norms, goals, reality, and oneself. The proportions of each are not necessarily equal, and the order of evocation is probably determined by the involved meanings. Some of the evoked beliefs support or point in the direction of the action – "clarify the image" – others do not support this direction or support others, such as, "let go, forget" or "wait and see if other relevant images come up." However, if a sufficient number of beliefs of the four types support the action of "clarify the image," a motivational disposition (or in term of the CO theory, a behavioral intent) is shaped that brings about the evocation of an adequate cognitive program for clarifying the image.

In other cases, the cognitive act may be more complex, calling for more elaborate cognitive programs that deal with problem solving or classification or critical thinking, and so forth (see Cognitive Performance: Cognitive Programs and Procedures). The initial input may also be more complex, such as a question or a description of a problem, which already include the implication of the need for a molar behavior act. The different phases may be more or less coalesced and run through quickly, depending on how frequently the action has been performed and how homogeneous the support for it is. In the case of often-recurring cognitive acts, it is likely that the CO cluster may stay in an "almost-complete state" and need to be complemented only through a few currently relevant beliefs in order to generate a motivational disposition.

The description of the model for cognitive acts demonstrates that the greater part of the model is devoted to the elaboration and formation of the motivational disposition. Its emergence is a function of the merging of several kinds of CO clusters. The basic one is the CO cluster for cognition, which is amplified by CO clusters for more specific cognitive functions, such as memory, imagination, or problem solving. These CO clusters merely set the scene for the performance of the cognitive act. They are further amplified by CO clusters specifying the kind of thinking that may be applied (e.g., creative, intuitive, logical) and CO clusters specifying the kind of domain in which the cognitive act is about to be performed (e.g., mathematics, design). These CO clusters are followed by the emergence of the CO cluster for the specific cognitive act.

THE CO THEORY: PREDICTING COGNITIVE ACTS

In this section, the procedure for predicting cognitive acts will be described; results will be presented in the next sections. In the framework of the CO theory, predicting cognitive acts is done in conformity with the procedure that has been applied successfully concerning a great number of behaviors in different domains. These include: coming on time; reactions to success and failure; curiosity; achievement; assertiveness; conformity; cheating; overeating; breastfeeding; cessation of smoking; self-disclosure; rigidity; defensive responses; undergoing tests for the early detection of breast cancer; compliance in diabetes patients; paranoia; having colorectal cancer; and so forth. All studies refer to actual observed behavioral or other outputs, in contrast to self-reported ones. The participants were adults, adolescents, children, retarded individuals, schizophrenics, individuals with different physical disorders, and others (Kreitler et al., 1994, 2008; Kreitler & Chemerinski, 1988; Kreitler & Kreitler, 1976, 1982, 1988a, 1991a,1993, 1994a, 1994b, 1997; Lobel, 1982; Kreitler, Schwartz, & Kreitler, 1987; Kreitler, Shahar, & Kreitler, 1976; Nurymberg, Kreitler, & Weissler, 1996; Tipton & Riebsame, 1987; Westhoff & Halbach-Suarez, 1989).

All studies demonstrated that behavior occurs if it is supported by at least three belief types and a behavioral program is available. The success of the predictions is based on applying the special standardized procedure developed in the framework of the CO theory (Kreitler & Kreitler, 1982). The procedure consists in assessing the motivational disposition for the behavior (viz. behavioral intent) by means of a CO questionnaire and examining the availability of a behavioral program for implementing the intent. A CO questionnaire assesses the degree to which the participant agrees to beliefs orienting toward the behavior in question or rejects those that do not orient toward it. The beliefs differ in form and contents. In form, they refer to the four types of beliefs: beliefs about goals, rules and standards (or norms), the self, and others and reality (or general beliefs). In contents, the beliefs refer to themes that represent meanings underlying the behavior in question (called *themes*).

The themes of the CO questionnaire are identified by means of a standard procedure applied to pretest participants that manifest the output (viz. cognitive act) in question or not. The procedure consists in interviewing the participants about the meanings of the key terms and then, in turn, sequentially about their responses (see Figure 2.4 for a schematic representation of the procedure). Repeating the questions about meanings leads to deeper-layer meanings, out of which those that recur in at least 50 percent of the interviewees are selected for the final questionnaire. For example, the themes for planning include avoiding uncertainty and taking charge of situations (Kreitler & Kreitler, 1987a). Examples of themes for different cognitive acts follow (see The Motivational Dispositions for Cognition). It is important to emphasize that the beliefs in the questionnaire do not refer in any way to the behavior or cognitive act in question, but only to the themes that represent

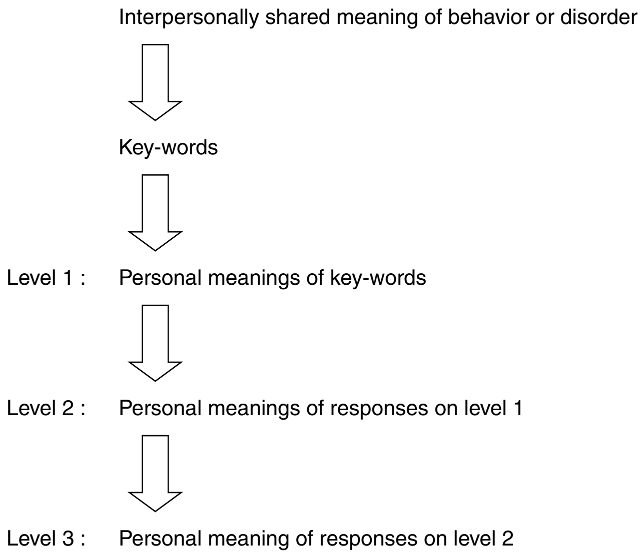

FIGURE 2.4. Schematic description of the process of identifying themes by meaning generation.

the underlying meanings and do not directly evoke associations to the behavior or cognitive act.

Thus, a CO questionnaire mirrors the prediction matrix (see Figure 2.5). It usually consists of four parts presented together in random order, each representing one of the four types of beliefs. Each part contains, in random order, beliefs referring to the different themes. The participant is requested to check on a four-point scale the degree to which each belief seems true (or correct) to him/her. A CO questionnaire is examined for its psychometric properties, including reliability and validity, before it is ready for application.

It is evident that for every kind of behavior it is necessary to construct a particular CO questionnaire. This in itself is the "bad news." However, the "good news" is that a single CO questionnaire may predict a broad range of relevant behaviors, for instance, the CO questionnaire of curiosity yielded significant predictions of 14 different curiosity behaviors (Kreitler & Kreitler, 1994b).

The prediction procedure generated by the CO theory has provided a great number of significant predictions of actual cognitive and other behaviors, of many different kinds and from different domains, in participants of different ages and intelligence levels, even cognitively challenged individuals. Notably, the procedure does not enable the participants to tailor their responses so that they would or would not correspond to their behaviors because it is impossible

Themes	Beliefs about Self	Beliefs about Goals	Beliefs about Norms	General Beliefs
1)				
2)				
3)				
. . .				
n)				

FIGURE 2.5. Schematic representation of the matrix of beliefs predictive of behavior.

to unravel the kind of involved behavior from the statements in the CO questionnaire. Further advantages of the prediction procedure are that applying it does not require any special mind-set, preparation, intention, or even average intelligence on the part of the participants. Additionally, success in predicting does not depend on involving any further criteria or constructs or assumptions or the creation of particular conditions regarding any behavior.

THE MOTIVATIONAL DISPOSITIONS FOR COGNITION

In the present section, sets of themes for different cognitive acts will be presented. Each set of this kind constitutes the basis for one specific CO questionnaire designed to predict the enactment of a specific cognitive act. The themes were identified by the standard procedure of interviewing pretest subjects described above. Each theme was phrased in the form of beliefs of the four types, one item per theme in each type of belief – some in the direction supporting the act, some in the reverse direction. The participants were requested to check one of four presented response alternatives for each item (agree completely, agree, disagree, disagree completely; scored as 4, 3, 2, and 1 points, respectively). The CO questionnaire provides four major scores for belief types for each participant (one for each belief type) and additional scores for each of the themes across belief types, and sometimes for the groupings of the themes based on factor analysis. For predicting a cognitive act, the responses to beliefs of each type are summed across all themes. It is expected that the sums of the four types of beliefs will provide a significant prediction of the cognitive act. We present the themes because they represent the contents of the different motivational dispositions.

CO questionnaires for cognition and cognitive functions. The CO clusters described in this section do not refer to specific cognitive acts but to the activation of cognition as a whole, and major functions or subsystems – such as memory or curiosity – that may subserve many different cognitive acts. First among these is the *CO questionnaire of cognition.* It is designed to enable assessment of the tendency of individuals to deal with cognition, use it, apply it, seek opportunities to engage in thinking activities, develop, and improve it. The major themes identified for this questionnaire focus around understanding oneself and the world; having complete freedom (e.g., in selecting the subject matter and the procedures, in setting up the rules, in shaping the structure); feeling one's strength and testing one's abilities in facing challenges; being in complete control; downplaying emotions; and getting a distance from others. Some of the themes, if endorsed, support dealing with cognition; others (see especially the last two) may orient away from cognition. Specific themes in the CO questionnaire of cognition are related to items or scales in other instruments assessing motivation for cognition, such as need for cognition and tolerance of ambiguity (Kreitler & Margaliot, in press). High scorers on the CO of cognition differed from the low scorers in the following responses: when given the choice, they more often preferred solving problems themselves rather than looking up the solutions; when being presented with problems for solving in their fields of expertise (e.g., construction engineering, electrical engineering), they spent more time working on the problems and changed strategies of solution (according to self-reports) more often, although the solutions they attained were not better or more complete than those of the low scorers (Kreitler & Casakin, 2012; Casakin & Kreitler, in press).

Curiosity represents a major function of the cognitive system. It is focused on gathering or absorbing information, regardless of the source or means. A great part of the functioning of cognition as a whole and of the specific subsystems of cognition as well as the performance of specific cognitive acts depend on the nature and amount of information that has been gathered and is available. Absorbing and getting information is dependent on CO. *The CO of curiosity* is based on themes focused, for example, on the value of knowledge; fear or attraction of the unfamiliar; intrusion of privacy; and changing the order of things. The CO of curiosity predicted in preschoolers and first graders the number of switchings between different presented stimuli, number of inspecting and of exploratory manipulations of unknown objects, and choices of unknown rather than known stimuli (Kreitler & Kreitler, 1986, 1994b) as well as conceptual explorations and setting up hypotheses in a probability learning task (Kreitler & Zigler, 1990). Further, in a study with first graders, an experimental training of five half-hour group sessions was performed for changing beliefs of the four types relevant for curiosity. The training led to the expected increases in the level of curiosity behaviors in the children whose CO of curiosity was raised (Kreitler, Kreitler, & Boas, 1976).

Finally, *the CO of memory* includes themes such as the centrality of inner life, investing in oneself, the importance and value of a mass of information, dealing with the past as a source of stability, conserving ones' possessions, continuity in development, and life as an organized structure rather than a random set of points. High scorers on the CO of memory performed better on various memory tests, verbal and nonverbal, than the low scorers. Notably, this was observed in samples of undergraduates as well as in people over 65 (Kreitler & Kreitler, 1990b).

CO questionnaires for types of thinking. Types of thinking refer to structurally and motivationally defined kinds of thinking that direct the activation of cognition along specific lines. We will deal with creativity, inventiveness, and intuitive thinking.

The CO questionnaire of creativity (Casakin & Kreitler, 2010; Kreitler & Casakin, 2009). This questionnaire refers to 79 themes, which form the following 11 groupings: (1) self-development (investing, promoting, and guarding oneself); (2) emphasis on the inner world (identifying, knowing, developing, and expressing one's thinking, feeling, and imagination); (3) inner-directedness (emphasis on one's desires, will, and decision; self-confidence in one's ability to succeed); (4) contribution to society (concern with contributing something meaningful to the community or society even if it does not involve personal advancement); (5) awareness of one's own uniqueness as an individual (emphasis on oneself as an individual unique in one's talents and way of perceiving, behaving, and being, not necessarily due to nonconformity); (6) freedom in acting (need to act in line with rules and regulations set by oneself rather than by others); (7) restricted openness to the environment (readiness and need to absorb from the environment knowledge and inspiration coupled with resistance to being overwhelmed and harmed by too much openness); (8) acting under conditions of uncertainty (readiness to act under conditions of uncertainty concerning the results, with no control over the circumstances, a tendency which may resemble risk-taking); (9) demanding from oneself (demanding from oneself effort, perseverance, giving up comfort, and readiness for total investment despite difficulties and even failures); (10) self-expression (concern with using one's talents and expressing oneself with authenticity and characteristically); (11) nonfunctionality (readiness to act even if functionality is not clearly evident from the start). The eleven groupings form two factors, confirmed in several different samples. The first factor represents the themes focused on the self – its uniqueness, development, and expression. The second represents the themes focused on maintaining openness to the environment without endangering inner-directness.

The CO of creativity predicted in design students creativity of designs in a particular task assessed by four architectural experts as well as the scores of the four factors of creativity – fluency, flexibility, elaboration, and originality applied to the produced designs (Kreitler & Casakin, 2009); creativity of solutions to engineering problems in engineering students (Kreitler & Casakin, 2012; Casakin & Kreitler, in press); and performance on creativity tests of students in elementary and high schools (Margaliot, 2005; Richter, 2003).

Inventiveness differs from creativity in being focused more on the functional and operational aspects of the output and less on its uniqueness and originality. *The CO of inventiveness* shares several themes with the CO of creativity, such as those that deal with freedom in acting and demanding from oneself, but differs from it in other themes, such as the emphasis on functionality. In general, of the two factors of the CO of creativity, the emphasis on the openness to the environment is more characteristic of the CO of inventiveness, whereas the emphasis on the self is more characteristic of the CO of creativity. In a study with students from different faculties, participants responded to both CO questionnaires and were presented several problems for solution from various domains, such as ecological, engineering, and social. Each participant was characterized as having a higher score on the CO of creativity or inventiveness. The presented solutions were identified by three independent experts as higher in creativity or inventiveness (judgments were unanimous in 69 percent of the solutions). The participants scoring higher in the CO of creativity produced about 75 percent of solutions judged to be creative, whereas those scoring higher in the CO of inventiveness produced about 72 percent of solutions judged to be inventive (Kreitler, 2009b).

Intuitive thinking was defined as the kind of holistic, experiential, and fast thinking, bound to rules of thumb, that puts special premium on heuristics. The major themes in *the CO of intuitive thinking* are opening up to situations, succumbing to the flow, being reactive, promoting one's emotions and relying on them, preferring concreteness, overlooking details, accepting imperfection, being tolerant toward one's mistakes and inconsistencies, readiness to minimize efforts, and avoiding the investment of too many resources. The high scorers on the CO of intuitiveness used heuristics that led them to significantly more intuitive rather than reasoned or analytical solutions of problems – verbal and geometric – than the low scorers (Kreitler, & Margaliot (in press)).

The CO questionnaires for specific domains of contents. Domains of contents represent areas for the deployment of cognition, such as mathematics, design, technology, medicine, or psychology. So far, only two CO questionnaires of this kind are available – for mathematics and clinical versus experimental psychology. *The CO of mathematics* included 17 themes that formed two factors: (1) sticking to rules as the basis for excellence and control; and (2) avoiding risks. The scores of the CO of mathematics significantly predicted the grades in mathematics and students' level of studies in mathematics for matriculation (extended, medium, limited) in students of the 11th and 12th grades (Kreitler & Nussbaum, 1998).

The study about psychology focused on predicting, by means of CO questionnaires, which choice – clinical psychology or experimental psychology – psychology students would make at the end of the first three years of study. The predictions were 95 percent correct as compared to self-reported preferences, which were 61 percent correct. The major themes in the *CO of clinical psychology* were reactiveness, controlling others, focus on intuition, and immediate comprehension, whereas the major themes in the *CO of experimental psychology* were interest in understanding, tendency to manipulate, high ambitions, and delay of gratification (Kreitler, 2008).

The CO questionnaires for specific cognitive acts. Specific cognitive acts represent operations in the cognitive field that have structures that parallel acts of behavior in other domains; that is, they have a starting point, a goal, an end point, and procedures in between. Cognitive acts of this kind are for example planning, organizing/ordering materials, classifying, criticizing, playing chess, explaining, and problem solving of all kinds. *The CO of planning* will serve as one example. The major themes are avoiding uncertainty, taking charge of situations, avoiding surprises, being the winner, preparedness, readiness to be wasteful, and dealing with the future. In one study, the subjects were children in different age groups ranging from 4 years and 9 months to 11 years and 4 months. They were presented 10 planning tasks in different domains, and their plans were evaluated in terms of specific criteria manifesting planning, such as number of alternative plans presented by the planner, number of if-then eventualities considered explicitly in the plans, and degree of chronological orderings in the plans. The high scorers on the CO of planning presented significantly better plans in all domains than the low scorers (Kreitler & Kreitler, 1987a). The same results were obtained in a sample of undergraduates (Kreitler & Kreitler, 1987b).

The CO of chess playing includes a different set of themes, one of which is planning. Other themes are acceptance of rules and restrictions, checking all alternatives, considering difficulties as challenges, and readiness to accept defeat or deal with a rival likely to win. The scores on the CO of chess predicted in children (from the age of 10 onward) and adults the amount of time spent on average in playing chess and learning to play chess as well as the level of expertise in the game itself, as evaluated by expert observers (Kreitler & Margaliot, in press).

The CO questionnaires for cognitive styles. Cognitive styles are preferred or habitual ways of performing various cognitive processes or acts. Some cognitive styles are closer to habits (e.g., scanning, leveling versus sharpening); others appear to be closer to personality traits (e.g., intolerance of ambiguity, field independence). *The CO of rigidity* includes themes such as fear of punishment, limited possibilities for doing things, trying harder or giving up when a task gets difficult, and keeping track of one's responses. Children with IQs lower than 70 scoring high on the CO of rigidity persevered more in their responses and were less likely to change their responses when required than the low scorers (Kreitler & Kreitler, 1988a; see also Chapter 20 in this book).

Intolerance of ambiguity is one of the oldest cognitive styles or cognitive traits. The themes of *the CO of intolerance of ambiguity* include, for example, acceptance of authority, clear demarcation of domains, avoidance multiplicity in favor of homogeneity, internal control, and avoidance of changes. High scorers had a shorter reaction time before identifying ambiguous figures or colors (Kreitler, Maguen, & Kreitler, 1975).

Chaotic thinking is one of the most recent cognitive styles. *The CO of chaotic thinking* includes themes such as acceptance of inconsistency, preference for complexity, preference for ambiguities, avoidance of direct confrontation with difficulties, trying not to miss opportunities, and being aware regarding the environment. In tasks of planning, high scorers in the CO of chaotic thinking as compared with low scorers produced more different plans and considered in each plan a greater variety of aspects, including consideration for personal needs of involved individuals; in tasks of model building, they produced more complex models, considering imaginary eventualities (Kreitler, & Margaliot, in press).

COGNITIVE PERFORMANCE: COGNITIVE PROGRAMS AND PROCEDURES

According to the CO approach, for an output to occur the motivational disposition needs to be implemented by a plan that controls actual performance. There are four basic kinds of programs in the cognitive sphere: (1) innately determined programs, which control the initial response to inputs – the primary reaction to the input and its identification, and if the identification fails, the evocation of the orienting response designed to provide more information for identification; (2) programs determined both innately and through learning (e.g., those controling scanning input arrays or language behavior); (3) programs acquired through learning (e.g., those controlling problem solving, searching for information, strategies of argumentation, and so forth); and (4) programs constructed by the individual ad hoc, in line with contextual requirements.

The programs acquired through learning are the major kinds of programs in the cognitive sphere. They are often denoted by labels, such as schemes, strategies, structures, heuristics, or models. Notably, these programs consist mainly of cognitive components ordered in some structure, which determine the kind of cognitive operations to be undertaken and their order. Cognitive programs use a great variety of cognitive components. Some programs, such as algorithms, consist of a set of well-defined instructions describing the route from an initial state through a well-defined series of successive states, eventually reaching a final ending state. Some programs consist of more general terms that describe phases, such as problem orientation, problem definition, generation of several solutions, choice of solution, and solution implementation. Still other programs refer to skills that are themselves mini programs, such as using a decision tree, applying "hill climbing" (i.e., start with a random solution and improve it by making successively small changes in it), identifying the major factors in the situation, or troubleshooting (for repair of faulty products). Other different programs include steps, such as comparing (e.g., given state with desired state), fine-tuning of declarative or procedural knowledge, finding an analogy, or detecting contradictions (e.g., Altshuller, 1984; Anderson, 1993; Newell & Simon, 1972; Polya, 1957; Sternberg & Frensch, 1991). Many cognitive programs match the description of hierarchically structured cognitive operations.

A careful analysis of the involved steps reveals that they refer to cognitive processes, directly (as in the case of steps, such as compare, detect contradiction, delete negation) or indirectly (as in the case of steps, such as define problem). Hence, it is to be expected that cognitive programs should have correlates in terms of cognitive processes. Several studies have confirmed this expectation. The cognitive processes were assessed by means of the Meaning Test, which provides a comprehensive profile of cognitive processes available to the individuals (Kreitler & Kreitler, 1990b; see Table 2.1). Thus, comparing the profiles of subjects performing well or poorly in a standard set of planning tasks yields a set of cognitive processes differentiating significantly between the two groups. These variables constitute the profile of cognitive processes whose presence or absence underlies the programs of planning, for example, temporal qualities, causality, implications and consequences, manner of occurrence, and operation. The higher the number of relevant cognitive processes the individual has the better his or her performance in the cognitive programs of planning (Kreitler & Kreitler, 1987a, 1987b).

Similarly, regarding curiosity, five major cognitive programs were identified: manipulatory exploration, perceptual exploration, conceptual exploration, exploration of the complex or ambiguous, and adjustive-compliant exploration. Each of these programs corresponds to a set of cognitive processes assessed by means of the Meaning Test. For example, conceptual exploration makes use of conjunctive and disjunctive relations, shifting to a network of related subject matters, consideration of function, manner of operation, and causes and results (Kreitler & Kreitler, 1986, 1994b). Another study showed that even conserving object constancy relies on the use of a cognitive program anchored in meaning variables (Kreitler & Kreitler, 1988b).

The selection of cognitive programs for implementing the motivational disposition for a specific cognitive act is determined by both beliefs and bonds formed through frequent joint evocation of the act and the program. The beliefs guiding the choice are included at least partly in the CO clusters for cognition and cognitive functions, and especially in the CO clusters for particular thinking types and specific domains of contents. These are cognitive programs bound, for example, to intuitive thinking or for mathematics. It may be assumed that cognitive styles, supported by CO clusters, are one of the factors contributing to the selection of one cognitive program over another.

In some cases, the programs for implementing cognitive acts include a part that consists of actual behaviors or are complemented by a part of this kind. For example, manipulatory exploration may involve actual motor handling of objects, responses to a task of rigidity may require physically changing the location of stimuli, and getting information may require questioning people or searching in archives. These examples indicate that the implementation of cognitive acts may be affected by factors that are not purely cognitive, such as tendencies to approach others or handling objects that belong to others. Considerations of this kind suggest that behavioral tendencies that themselves are dependent on CO clusters cannot be overlooked in the context of implementing cognitive acts. Major among these are achievement, reactions to success and failure, perseverance, delay of gratification, and responsiveness to tangible or intangible rewards for one's actions (Kreitler & Kreitler, 1988a; Kreitler et al., 1995).

THE IMPACT OF STATES OF CONSCIOUSNESS

The evocation and formation of motivational dispositions, anchored in CO clusters, and of cognitive programs for their implementation do not occur in a vacuum. They take place in the framework of a cognitive system that itself is characterized by being in a particular state at any given moment in time. The state of a system is commonly defined as a description of a system in terms of parameters relevant for that system – say, positions and momentums in the case of classical mechanics or temperature, pressure, and composition in the case of thermodynamics. Because it was shown that meaning variables constitute the materials with which cognition functions, and that they underlie cognitive acts, it is likely that the state of the system of cognition can be described in terms of meaning variables. The description consists in specifying which meaning variables or sets of meaning variables are salient in the cognitive system at a given time. Salience of meaning variables implies that the contents and processes corresponding to these meaning variables are more easily retrievable and hence are more likely to be involved in the prevailing cognitive activity in the system. Thus, the state of the system represents a constellation of meaning variables.

At any given time, the cognitive system is dominated by a particular constellation of meaning variables. These constellations may change. The factors that may bring about changes of this kind include physical determinants, such as intoxication, fatigue, specific medications, and drugs; certain behaviors, such as dancing or perseverative movements; meditation and various mystical-spiritual practices; emotional states; specific cognitive tasks; and experimental manipulations. It is possible that some changes occur spontaneously due to the internal dynamics of the system. The prevailing sociocultural atmosphere may be a contributing factor in promoting the greater frequency or stability of a certain state of the system.

Studies showed that some meaning variables exert a pervasive impact on the cognitive system, for example, those that constitute the personal-subjective mode of meaning and those that constitute the interpersonally-shared mode of meaning (Kreitler, 1999, 2001, 2002, 2009a). These two modes of meaning differ in the nature of the bonding within the meaning units, between referents and the meaning values assigned to them (see Table 2.1). In the personal-subjective mode, the bonds are exemplifying-illustrative and metaphoric-symbolic, whereas in the interpersonally-shared lexical mode they are attributive and comparative. The personal-subjective mode is used mainly for expressing one's inner world of experiences, which may be subjective and individually shaped. In contrast, the interpersonally-shared mode is used preferentially for expressing one's references to reality and the world shared with others socially and in action. Studies showed that there are differences in cognitive functioning when one or the other mode of meaning is induced experimentally to dominate the scene for a given time (by a brief standard procedure). Dominance of the personal-subjective mode of meaning in the cognitive scene led to the following findings as compared with the dominance of the interpersonally-shared mode: identifying embedded figures is faster and with fewer errors; gestalt completion is faster; there are more associations, especially personal associations; judging emotional expressions on faces is faster and with fewer errors; visual memory is better; understanding of poetry is better; art preferences in the visual arts change in the direction of the expressionistic and symbolists art works; scores on creativity tests are higher; reaction time of response to neutral stimuli is slower; judging validity of syllogisms is poorer; indices of emotional control and reality testing on the Rorschach test are poorer; accuracy of size estimations and size comparisons of lines and circles is poorer. (Kreitler, Kreitler, & Wanounou, 1987–1988).

Because the modes of meaning were correlated with and led to so many different and variegated cognitive effects and in addition to other effects (e.g., self-image, emotions), it seemed justified to consider the changes in the cognitive system as representing states of consciousness.

Further studies showed that other configurations of meaning variables also led to pervasive results in cognitive performance, although of a different kind than those obtained by means of the meaning modes. In these studies, the experimental induction did not focus on the meaning variables but on attitudinal approaches (abstract or concrete approach) or emotional states (anger or joy). Each of these inductions produced specific changes in the meaning variables dominating the cognitive scene. These changes in the dominant meaning variables were responsible for changes in cognitive performance. For example, the induction of the concrete approach led to the salience of the meaning variables relating to the concrete aspects of objects (e.g., sensory qualities, material, weight, size, location) and to weakening of the meaning variables relating to more abstract features (e.g., superordinate categories, subclasses). Accordingly, the judgments of the subjects about severity of situations were more limited in scope and reflected consideration of fewer relevant aspects (Rotstein, 2010).

The conclusion supported by these preliminary studies is that the state of the cognitive system at a given time – which may be called state of consciousness – plays a role in codetermining the cognitive output. However, it is still unclear at present in which ways the state of the cognitive system affects the output. One way may be assumed to be through cognitive programs. This is likely because these programs depend on meaning variables (see Table 2.1) and the state of the cognitive system consists in the differential salience of meaning variables.

Another possibility would be that the state of the cognitive system also affects the salience of different CO clusters. It could be the case that in a certain state of consciousness, specific CO clusters are promoted: the CO of intuitive thinking or the CO of creativity when the personal-subjective mode of meaning is salient; and the CO of analytical thinking or the CO of the cognitive style of ordered thinking are promoted when the interpersonally-shared lexical mode of meaning dominates the cognitive system.

THE INVOLVEMENT OF EMOTIONS AND PERSONALITY TRAITS

Emotions are involved in different ways in cognitive performance. One way was discussed previously (see The Impact of States of Consciousness). Emotions may be assumed to alter the state of the cognitive system and hence to function in a way similar to other transformations identified as producing states of consciousness. We may call this the *setting-producing function* of emotions. Studies showed for example that when a negative emotion dominates the scene, there is a focusing on details and information from external sources; when a positive emotion dominates the scene, there is focusing on generalizations and information from internal sources (e.g., Yiend, 2010). Further, there is evidence that positive affect facilitates careful, thorough thinking and problem solving, promoting both new learning as well as utilization of existing knowledge (Isen, 2004). Studies in which emotions were evoked experimentally showed that each of the emotional states of anxiety, anger, and joy corresponds to a specific constellation of meaning variables that becomes dominant. It is likely that the same holds concerning other emotions. Thus, emotions may contribute to the evocation of CO clusters and cognitive programs for implementing the evoked motivational dispositions. It may be assumed for example that the same or similar motivational disposition would be implemented by different cognitive programs under the impact of different emotional states.

A second way in which emotions are involved in cognitive performance can be called the *adjunctive-evaluative function* of emotions. Emotions accompany cognitive performance. They may provide signals about how the cognitive performance is getting along (e.g., "fine"), whether the chosen track (defined by the evoked CO clusters and the emergent motivational disposition) is adequate, and if the task is at a stage that justifies closure and subsequent completion. Other characteristic emotional evaluations may become manifest as pride over the cognitive achievement; the experience of "flow" (CsíkszentmihályI, 1998) when things move on just right; the aha experience of enlightenment when a creative idea appears; euphoria in response to a good solution to a problem; or the feeling of being stuck when no solution is in sight. A good example of this function of emotions from the analogous domain of behavior is the anxious reaction a driver may have if while driving on a highway he or she suddenly swerves out of the lane. Anxiety did not determine the driving; it merely indicates the role of emotions in continuously checking the operation. Observations of this kind exemplify Damasio's (1994) claim that neurological impairment of emotional reactions (such as the famous nineteenth-century case of Phineas Gage) involves a loss of practical reasoning ability. Several studies, mainly in the field of decision making, suggest that decisions are aided by emotions evoked during the consideration of different options and their consequences (Bechara, 2004; Greenspan, 2004; Naqvi, Shiv, & Bechara, 2006).

The impact of personality traits on cognitive performance is of a different order than that of emotions. Personality traits may be expected to affect cognitive performance because they are currently conceptualized and assessed in psychology as configurations that include attitudes, modes of perceiving, and some kind of behavioral tendencies. This general conception is rendered more specific by the work of Kreitler and Kreitler (1990b), which showed that each personality trait corresponds to a specific pattern of meaning variables. Patterns of this kind make it possible to account for the diverse effects of personality traits. Personality traits are neither attitudes nor modes of information absorption or processing or behavioral habits. However, as sets of meaning variables, they may exert an impact on these and hence on different phases in the evocation and operation of cognitive functioning. These may include mainly the identification of the input as relevant for cognition, elaboration of the meaning of the input as relevant for one or another CO cluster, and the elicitation of specific cognitive styles that may affect the selection of particular cognitive programs. These effects seem at present to be of secondary order because they are not specific and occur only under particular circumstances.

BLUEPRINT FOR A MODEL OF MOTIVATION FOR COGNITIVE PERFORMANCE

The great variety of factors involved in the production of a cognitive act calls for an integration in the form of a blueprint for an inclusive model. In the framework of the CO theory, the motivation for a cognitive act is based on two major factors: the motivational disposition and the cognitive programs. The former are behavioral intents anchored theoretically and operationally in CO clusters; the latter are mainly hierarchically structured cognitive operations, anchored in cognitive processes and meaning assignment variables (Figure 2.6).

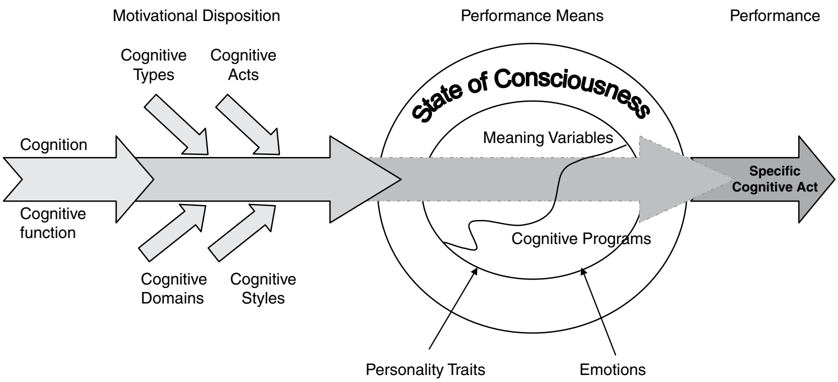

FIGURE 2.6. The general cognitive orientation model of cognitive acts.

The motivational disposition is formed gradually and is shaped by the evocation of different kinds of CO clusters. The major ones are the CO for cognition and the CO clusters for cognitive functions, such as curiosity and memory; the CO clusters for different types of thinking, such as creativity or intuitive thinking; the CO clusters for specific domains of contents, such as technology or mathematics; and finally the CO for the specific cognitive act that is implemented in action. The motivational disposition for the specific cognitive act reflects components from the antecedent CO clusters that were evoked prior to the CO of the cognitive act, namely, for cognition, cognitive functions, types of thinking, and domains of contents. In the case of recurring cognitive acts or inputs, the antecedent CO clusters merge so that the CO cluster for the cognitive act emerges fast without the more detailed elaborations that take place otherwise. In cases of this kind, the CO cluster for the cognitive act may be considered to be in an almost-ready state.

Cognitive programs are mostly in an almost-ready state, so they need only to be retrieved, selected, and adapted to the situation at hand. Cognitive programs may be expected to be mostly available, having been acquired and learned in different contexts – at school or work – and often shaped by CO clusters of cognitive styles. The whole procedure, including the evocation of the relevant CO clusters and the cognitive programs, takes place in a setting characterized by being in a specific state (viz. state of consciousness), affected and monitored by current emotions, and mostly indirectly affected by steady personality traits.

In order to predict a cognitive act, both the motivational disposition and the cognitive program need to be considered. The assessed motivational disposition may be limited to the CO of the cognitive act because in most cases one deals with recurrent acts. For many cognitive acts, there are already CO questionnaires that may be freely used. Concerning the cognitive program, it is mostly only necessary to check its availability by questioning or observation.

In the studies in which both the CO clusters of cognitive acts and the availability of cognitive programs were considered, it turned out that the relative weight of these two factors are approximately equal (Kreitler & Casakin, 2009; Kreitler & Kreitler, 1987a, 1987b).

In addition to predicting cognitive acts, the CO approach provides the theoretical and methodological means for changing cognitive performance by focusing on the relevant CO clusters, cognitive programs, and state of consciousness (Kreitler, 2009a; Kreitler & Kreitler, 1990a). A major role of the CO model of cognitive functioning is to serve as a platform and framework for further studies that will continue to clarify and improve the existing approach and discover new venues and perspectives for the exploration of cognition.

References

Altshuller, G. (1984). *Creativity as an exact science*. New York: Gordon & Breach.

Anderson, J. R. (1993). Problem solving and learning. *American Psychologist*, **48**, 35–44.

Bechara, A. (2004). The role of emotion in decision-making: Evidence from neurological patients with orbitofrontal damage. *Brain and Cognition*, **55**, 30–40.

Casakin, H., & Kreitler, S. (2010). Motivation for creativity in architectural design: Differences between architects and engineers. *International Journal of Technology and Design Education*, **20**, 477–493.

Casakin, H., & Kreitler, S. (in press). Studying design problem solving through the theory of meaning. In S. Helie (Ed.), *The psychology of problem solving: An interdisciplinary approach*. Hauppauge, New York: Nova Publishers.

Csíkszentmihályi, M. (1998). *Creativity: Flow and the psychology of discovery and invention*. New York: Harper Perennial.

Damasio, A. (1994). *Descartes' error*. New York: Putnam's Sons.

Geary, D. C. (2005). *Origin of mind: Evolution of brain, cognition, and general intelligence.* Washington, DC: American Psychological Association.

Greenspan, P. (2004). Practical reasoning and emotion. In A. Mele & P. Rawling (Eds.), *The Oxford handbook of rationality* (pp. 206–221). Oxford, UK: Oxford University Press.

Isen, A. M. (2004). Some perspectives on positive feelings and emotions: Positive affect facilitates thinking and problem solving. In A. S. R. Manstead, N. Frijda, & A. Fischer (Eds.), *Feelings and emotions: The Amsterdam symposium. Studies in emotion and social interaction* (pp. 263–281). New York: Cambridge University Press.

Kreitler, S. (1999). Consciousness and meaning. In J. Singer & P. Salovey (Eds.), *At play in the fields of consciousness: Essays in honor of Jerome L. Singer* (pp. 175–206). Mahwah, NJ: Erlbaum.

(2001). Psychological perspective on virtual reality. In A. Riegel, M. F. Peschl, K. Edlinger, G. Fleck, & W. Feigl (Eds.), *Virtual reality: Cognitive foundations, technological issues and philosophical implications* (pp. 33–44). Frankfurt, Germany: Peter Lang.

(2002). Consciousness and states of consciousness: An evolutionary perspective. *Evolution and Cognition*, **8**, 27–42.

(2004). The cognitive guidance of behavior. In J. T. Jost, M. R. Banaji, & P. A. Prentice (Eds.), *Perspectivism in social psychology: The Yin and Yang of scientific progress* (pp. 113–126).Washington, DC: American Psychological Association.

(2008). The cognitive orientations of clinical and experimental psychology. Lecture presented at the 10th European Congress of Psychology, 3–6 July, Prague.

(2009a). Altered states of consciousness as structural variations of the cognitive system. In E. Franco (Ed., collaborating with D. Eigner), *Yogic perception, meditation and altered states of consciousness* (pp. 407–434). Vienna, Austria: Oestrreichische Akademie der Wissenschaften.

(2009b). Inventive thinking: Who and when? Invited Lecture, The first Israeli TRIZ conference "TRIZ – Theory and Application," Holon Institute of Technology, 23 November, Israel.

(in preparation). The cognitive orientations of intuitive thinking and chaotic style.

Kreitler, S., & Casakin, H. (2009). Motivation for creativity in design students. *Creativity Research Journal*, **21**, 282–293.

Kreitler, S., & Casakin, H. (2012). Motivation for creativity in design: Its nature, assessment and promotion. In J. N. Franco & A. Svensgaard (Eds.), *Handbook on psychology of motivation: New research*. Hauppauge, New York: Nova Publishers.

Kreitler, S., Chaitchik, S., Kreitler, H., & Weissler, K. (1994). Who will attend tests for the early detection of breast cancer? *Psychology and Health*, **9**, 463–483.

Kreitler, S., & Chemerinski, A. (1988). The cognitive orientation of obesity. *International Journal of Obesity*, **12**, 471–483.

Kreitler, H., & Kreitler, S. (1965). *Die Weltanschauliche Orientierung der Schizophrenen* [The cognitive orientation of schizophrenics]. Munich/Basel: Reinhardt.

(1972). The model of cognitive orientation: Towards a theory of human behavior. *British Journal of Psychology*, **63**, 9–30.

(1976). *Cognitive orientation and behavior.* New York: Springer Publishing.

(1982). The theory of cognitive orientation: Widening the scope of behavior prediction. In B. A. Maher, & W. A. Maher (Eds.), *Progress in experimental personality research: Vol. 11. Normal personality processes* (pp. 101–169). New York: Academic Press.

(1986). Types of curiosity behaviors and their cognitive determinants. *Archives of Psychology*, **138**, 233–251.

(1987a). The motivational and cognitive determinants of individual planning. *Genetic, Social, and General Psychology Monographs*, **113**, 81–107.

(1987b). Plans and planning: Their motivational and cognitive antecedents. In S. L. Friedman, E. K. Scholnick, & R. R. Cocking (Eds.), *Blueprints for thinking: The role of planning in cognitive development* (pp. 110–178). New York: Cambridge University Press.

(1988a). The cognitive approach to motivation in retarded individuals. In N. W. Bray (Ed.), *International review of research in mental retardation*, Vol. 15, (pp. 81–123). San Diego, CA: Academic Press.

(1988b). Horizontal decalage: A problem and its resolution. *Cognitive Development*, **4**, 89–119.

(1990a). Cognitive primacy, cognitive behavior guidance and their implications for cognitive therapy. *Journal of Cognitive Psychotherapy*, **4**, 155–173.

(1990b). *The cognitive foundations of personality traits.* New York: Plenum.

(1991a). Cognitive orientation and physical disease or health. *European Journal of Personality*, **5**, 109–129.

(1991b). The psychological profile of the health-oriented individual. *European Journal of Personality*, **5**, 35–60.

(1993). The cognitive determinants of defense mechanisms. In U. Hentschel, G. Smith, W. Ehlers, & J. G. Draguns (Eds.), *The concept of defense mechanisms in contemporary psychology: Theoretical, research and clinical perspectives* (pp. 152–183). New York: Springer-Verlag.

(1994a). Who will breastfeed? The cognitive motivation for breastfeeding. *International Journal of Prenatal and Perinatal Psychology and Medicine*, **6**, 43–65.

(1994b). Motivational and cognitive determinants of exploration. In H. Keller, K. Schneider, & B. Henderson (Eds.), *Curiosity and exploration* (pp. 259–284). New York: Springer-Verlag.

(1997). The paranoid person: Cognitive motivations and personality traits. *European Journal of Personality*, **11**, 101–132.

Kreitler, S., Kreitler, H., & Boas, T. (1976). Predicting and changing the creativity of children. In H. Kreitler, & S. Kreitler, *Cognitive orientation and behavior* (pp. 238–253). New York: Springer Publishing.

Kreitler, S., Kreitler, H., & Wanounou V. (1987–1988). Cognitive modification of test performance in schizophrenics and normals. *Imagination, Cognition, and Personality*, **7**, 227–249.

Kreitler, S., Kreitler, M. M., Len, A., Alkalay, A., & Barak, F. (2008). Psychological risk factors for colorectal cancer? *Psycho-Oncologie*, **2**, 131–145.

Kreitler, S., Maguen, T., & Kreitler, H. (1975). "The three faces of intolerance of ambiguity." *Archives of Psychology*, **127**, 238–250.

Kreitler, S., & Margaliot, A. (in press). Motivation for cognition: The cognitive orientation approach. In A. M. Columbus (Ed.), *Advances in psychology research (Vol. 95).* Hauppage, NY: Nova Publishers.

Kreitler, S., & Nussbaum, S. (1998). Cognitive orientation and interest: The motivational understructure for achievement in mathematics. In L. Hoffmann, A. Krapp, K. Ann Renninger, & J. Baumert (Eds.), *Interest and learning* (pp. 377–386). Kiel, Germany: Institut für die Pedagogik der Naturwissenschaften an der Universität Kiel.

Kreitler, S., Schwartz, R., & Kreitler, H. (1987). The cognitive orientation of expressive communicability in schizophrenics and normals. *Journal of Communication Disorders*, **20**, 73–91.

Kreitler, S., Shahar, A., & Kreitler, H. (1976). Cognitive orientation, type of smoker and behavior therapy of smoking. *British Journal of Medical Psychology*, **49**, 167–175.

Kreitler, S., & Zigler, E. (1990). Motivational determinants of children's probability learning. *Journal of Genetic Psychology*, **151**, 301–316.

Kreitler, S., Zigler, E., Kagan, S., Olson, D., & Weissler, K. (1995). Cognitive and motivational determinants of academic achievements and behavior in third and fourth grade disadvantaged children. *British Journal of Educational Psychology*, **65**, 297–316.

Lobel, T. (1982). The prediction of behavior from different types of beliefs. *Journal of Social Psychology*, **118**, 213–233.

Margaliot, A. (2005). *A model for teaching the cognitive skill of melioration to pre-service science teachers in a college for teachers.* Unpublished doctoral dissertation, Bar-Ilan University, Ramat Gan, Israel.

Naqvi, N., Shiv, B., & Bechara, A. (2006). The role of emotion in decision making: A cognitive neuroscience perspective. *Current Directions in Psychological Science*, **15**, 260–264.

Newell, A., & Simon, H. A. (1972). *Human problem solving*. Englewood Cliffs, NJ: Prentice-Hall.

Nurymberg, K., Kreitler, S., & Weissler, K. (1996). The cognitive orientation of compliance in short and long-term type 2 diabetic patients. *Patient Education and Counseling*, **29**, 25–39.

Piaget, J., & Inhelder, B. (1973). *Memory and intelligence*. New York: Basic Books.

Polya, G. (1957). *How to solve it* (2nd ed.). Princeton, NJ: Princeton University Press.

Richter, R. (2003). *Cognitive aspects of creativity*. Unpublished master's thesis, Tel-Aviv University.

Roth, G., & Wullimann, M. F. (2001). *Brain evolution and cognition*. New York: Wiley.

Rotstein, Y. (2010). *The impact of transformations in state of consciousness on changes in judgments and evaluations*. Unpublished Master's Thesis, Tel-Aviv University.

Sternberg, R. J., & Frensch, P. A. (Eds.), (1991). *Complex problem solving: Principles and mechanisms* (pp. 159–183). Hillsdale, NJ: Lawrence Erlbaum Associates.

Tipton, R. M., & Riebsame, W. E. (1987). Beliefs about smoking and health: their measurement and relationship to smoking behavior. *Addictive Behaviors*, **12**, 217–223.

Westhoff, K., & Halbach-Suarez, C. (1989). Cognitive orientation and the prediction of decisions in a medical examination context. *European Journal of Personality*, **3**, 31–71.

Yiend, J. (2010). The effects of emotion on attention: A review of attentional processing of emotional information. *Cognition and Emotion*, **24**, 3–47.

Zakay, D., Bar-El, Z., & Kreitler, S. (1984). Cognitive orientation and changing the impulsivity of children. *British Journal of Educational Psychology*, **54**, 40–50.

3

Personality and Cognition

Phillip L. Ackerman

THREE FAMILIES OF TRAITS (COGNITION, AFFECT, AND VOLITION)

Philosophers (e.g., Kant, 1790) and psychologists traditionally separate traits (i.e., relatively stable and trans-situational sources of individual differences) into three major categories: affective, cognitive, and conative traits. Affective traits are personality characteristics (such as need for achievement, neuroticism, conscientiousness). *Cognitive traits* include traditional concepts of broad abilities (such as intelligence), narrower ability constructs (e.g., verbal comprehension, math ability), and even more narrow abilities and skills (reaction time to simple stimuli and typing speed). Conative or *volitional traits* include motivation and interests. More generally, conation is characterized as will. For much of the twentieth century, with a few notable exceptions, researchers were typically concerned with only a single category of traits, such as personality or abilities, and there were relatively few studies of the interactions between and interrelations among these different categories of traits. In the last two decades, this kind of isolated research has been augmented by investigations of how these different categories of traits relate to one another. In this chapter, I will briefly review some of these streams of integrative research. First, however, a few general considerations and qualifications are needed.

SITUATIONAL PRESS

One of the barriers to traditional investigation of the relations between personality and cognitive traits is a mismatch between the context for these two domains. As noted by Cronbach (1949), personality traits are considered an individual's needs and orientation in the context of typical behaviors. That is, personality traits are *less* likely to be manifest in behaviors when the individual is subject to strong environmental or situational press. In many environments, such as school or work, there are either strong cultural norms or other situational constraints on the individual, which in turn tend to diminish the individual's range of expressed behaviors. The presence of high levels of environmental press is most easily inferred when an individual is observed to violate the norms (e.g., when a worker speaks rudely to a customer, a student or employee is absent from work or school, someone who is talking loudly in an elevator, a customer not carrying his/her tray to the waste receptacle at a fast-food restaurant, and so on). Another key concept with respect to personality traits is the concept of aggregation (e.g., see Rushton, Brainerd, & Pressley, 1983). Individual differences in personality traits are rarely highly predictive of isolated single behaviors, mainly because any individual action is determined by multiple influences, of which personality traits represent a relatively small contribution. Rather, when behaviors are aggregated across multiple situations, one can infer the individual's tendencies to respond in a particular fashion – which is the essence of a personality trait. So, personality traits are best characterized as behavioral tendencies in the absence of strong environmental or situational press and over multiple opportunities for expression.

In contrast to personality traits, cognitive traits are traditionally considered in a single context, that of maximal performance (Cronbach, 1949; see also Ackerman, 1997). Cognitive or intellectual abilities are assessed when the individual is fully engaged in performing his/her best – that is, when there is a maximum level of motivation and effort devoted to the intellectual task at hand. Abilities ultimately represent the individual's limits of performance – what the individual is capable of doing on a task that has some intellectual, cognitive, or psychomotor requirements. This mismatch between the conditions for cognitive traits and personality traits is the difference between what an individual can do under intensive effort and what the individual will do under weak or nonexistent situational press.

However, most of an individual's interactions, intentions, and feelings occur somewhere between the extreme situational press of an ability-test session (such as when one sits for a university entrance examination) and the extreme lack of situational press, say, associated with a package holiday in a country far from home. Under such circumstances, for the cognitive component, we would need to consider the individual's typical intellectual or cognitive engagement with the environment. For the personality component, we would need to consider the individual's attitudes and desires with respect to things such as affiliation, achievement, tendency toward anxiety, and so on. It is in this gray area that we are most likely to discover how affect and cognition interact, in both the short-term and over the course of development and maturation.

In contrast, one can also consider personality traits in a maximal performance context. For example, an individual's level of introversion/extroversion describes that individual's *preference* for being in social situations, but it does not inherently describe the individual's capability of performing in social situations when there is a strong situational press. Many introverts are quite unhappy when forced to give a presentation to a large audience, but are nonetheless capable of performing well under such circumstances. Very little research has been conducted in this area (Willerman, Turner, & Peterson, 1976), but it is possible that individual differences in personality traits set a zone of tolerable problemiticity for particular kinds of situations. An individual who is highly extroverted may be able to work in isolation for an hour or two, but perhaps no longer without needing a break to interact with others; an individual who is highly introverted may be able to function well at a party for a similar amount of time, but as time increases, remaining at the party may become more and more aversive for the individual. It is also possible that there are individual differences in the flexibility to adapt to situations where the situational press works in ways that are counter to the individual's baseline preferences.

NORMAL PERSONALITY VERSUS PSYCHOPATHOLOGY

The role of personality in cognitive functioning varies from relatively minor ways, in which the normal individual orients toward different stimuli in the environment, to major ways, in which psychopathology seriously impairs or distorts cognitive functioning across many different sources of stimuli. Considerations of the role of psychopathology and personality disorders in cognitive processing, however, are beyond the scope of this chapter. Instead, the treatment will focus entirely on the normal range of personality traits and their relations with cognitive functioning, with specific attention paid to individual differences in personality traits and cognitive functioning, broadly considered.

PERSONALITY AND DEVELOPMENT OF COGNITION

At early stages of development, it is unclear whether personality and cognitive functioning are highly malleable or whether we are unable to reliably and validly measure these constructs prior to the development of language and self-reflective skills. Prior to the age of first school entry, we are generally limited to observational judgments and behavior ratings for personality and for sensory and motor development as indicators of cognitive functioning. In both cases, the reliability and validity of these assessments do not often reach a level that is sufficient to examine the relations between personality traits and cognitive processes. Nonetheless, studies of young children do appear to point to significant associations between some aspects of personality traits (e.g., agreeableness, conscientiousness) and cognitive/intellectual abilities (see Harris, Vernon, & Jang, 2007).

As the child reaches adolescence, it is much easier to arrive at coherent representations of personality traits and cognitive functioning, especially in terms of broad factors of personality traits (e.g., introversion/extroversion, conscientiousness, neuroticism) and cognitive functioning (e.g., verbal, math, and spatial abilities). Although there is not a substantial amount of research in this domain, results from a few large-scale studies, such as that of Demetriou, Kyriakides, and Avraamidou (2003) suggest that at adolescence, the relations between cognitive abilities and personality traits are relatively weak. Rather, the main source of cognitive-affective relations is via the individual's self-attribution of ability – the individual's assessment of his/her own level of intellectual abilities, a construct rooted in the domain of academic self-concept (Shavelson, Hubner, & Stanton, 1976). Several other studies have also suggested that self-attribution, self-concept, or self-estimates of abilities play an important role in mediating the relations between affective traits and cognitive abilities, both at adolescence and in adulthood (e.g., see Ackerman & Wolman, 2007; Chamorro-Premuzic & Furnham, 2008; Chamorro-Premuzic, Furnham, & Moutafi, 2004; Marsh et al., 2005).

Trait Complexes

As individuals reach early adulthood, we tend to see greater coherence in a plethora of affective, cognitive, and conative traits. In a meta-analysis of personality trait, intellectual ability, and vocational interest relations, Ackerman and Heggestad (1997) found at least four broad sets of traits that had significant degrees of overlap, namely: Social, Intellectual/Cultural, Clerical/Conventional, and Science/Math. The Social trait complex is represented by the relatively high correlations between measures of Extroversion and both Enterprising and Social vocational interest themes. The Intellectual/Cultural trait complex is represented by the overlap among crystallized intellectual abilities (e.g., verbal abilities and domain knowledge). The personality trait complex is represented by the overlap of openness to experience and artistic and investigative vocational interest themes. The Clerical/Conventional trait complex is represented by the overlap among personality traits such as Conscientiousness, clerical and perceptual speed abilities, and the Conventional interest theme. The Science/Math trait complex is represented by math and spatial abilities and both Realistic and Investigative vocational interest themes. Most notable about these trait complexes is that there are no personality traits that have unique associations with the Science/Math trait complex, and no ability traits that have unique associations with the Social trait complex. The underlying reason for the lack of personality-cognition overlap for these two trait complexes is not entirely clear. One explanation is that there are insufficient measures for assessing social intellectual abilities, and insufficient measures of personality traits associated with math and scientific orientations. Another possibility is that affective traits are simply not uniquely related to individual differences in orientation toward math/science activities, and there are no common intellectual traits that are uniquely related to individual differences in orientation toward social activities.

The trait-complex approach (Ackerman, 2003; Kanfer & Ackerman, 2000) has an additional component beyond the expression of commonality among affective-cognitive-conative traits. That is, the investment framework proposed by Ackerman (1996) suggests that the trait complexes have facilitative or impeding functions in orientation toward learning and skill acquisition. Individuals faced with learning tasks that are in domains incompatible with their dominant trait complexes are expected to fare more poorly in terms of effort and performance than those who have a better alignment of their dominant trait complexes and the learning tasks. On the one hand, when placed in situations with low environmental press, individuals high in the social trait complex, for example, may avoid opportunities to acquire knowledge and skills in intellectual/cultural and science/math domains (Ackerman & Beier, 2006). On the other hand, individuals high in the intellectual/cultural trait complex may seek out learning opportunities when the environmental press is low. Regardless, when the environmental press is high, the role of the trait complexes is expected to be diminished, as the individuals are faced with maximal performance demands.

COGNITION AND DEVELOPMENT OF PERSONALITY

Genetic, biological, family environment, and other variables undoubtedly account for the largest share of influences on an individual's personality traits. However, an individual's cognitive life also appears to be influential in the development of at least some personality traits. One salient source of such influences is through the individual's development of motivational traits and interests (Holland, 1959). In Holland's developmental theory of vocational choice, vocational interests develop in tandem with an individual's successes and failures during early development, leading to development of individual differences in self-evaluations or self-concept. These patterns of self-concept lead in turn to particular preferences, such as for interpersonal interactions or for orienting toward working with one's hands or with abstract ideas. In this context, development of an interest profile may proceed in concert with development of some aspects of personality-trait profiles, especially for those personality traits that show significant overlap with interest themes in samples of adults and late adolescents, such as: (a) extroversion and social and enterprising vocational interests; (b) conscientiousness and conventional vocational interests; and (c) openness to experience and artistic vocational interests (Ackerman & Heggestad, 1997). Other major personality-trait constructs appear to be less associated with vocational interests, such as neuroticism and agreeableness.

Nonetheless, investment theories of cognitive/intellectual development (Ackerman, 1996; Cattell, 1971; McDougall, 1933) have proposed that as stable patterns of personality, self-concept, and interests develop during childhood and adolescence, individuals begin to differentiate their cognitive effort toward domains of knowledge and skill acquisition that are concordant with their affective and conative traits, ultimately resulting in more or less coherent patterns of abilities, skills, personality, and interests. Within this larger context, the relations among traits associated with typical behaviors (affective and conative traits) – behavioral tendencies under low levels of situational press – tend to be most substantial in magnitude, and the traits that mismatch on high and low situational press (e.g., personality and ability) tend to have less substantial relations. The extant literature on the associations between cognitive, affective, and conative traits tends to bear out this assertion. Correlations between affective and conative traits, such as extroversion and social interests, are often in the neighborhood of $r = .5$; correlations between affective and cognitive traits are more often in the neighborhood of $r = .1–.3$ (Ackerman, 2006; Ackerman & Heggestad, 1997, Sullivan & Hansen, 2004).

Although the correlational data support an array of associations among these families of traits, it is not entirely clear *how* these associations are built, and it is quite possible that the influences are idiosyncratic for particular individuals. An early talent for mathematics or social influence may give rise to both interests in these domains and the pattern of supportive personality traits. Early developments in a propensity toward conscientiousness may result in early success in building basic math skills that in turn yields a heightened interest in mathematics, leading to later attainment of knowledge and skills in math. The most plausible framework for such developmental influences is that the profiles of affective, cognitive, and conative traits develop in a manner where there are multiple feedback loops and cross-influences. Furthermore, on a day-to-day basis, the influences are likely to take place at such a low level that they do not even pervade conscious attention. By the time an individual reaches adolescence, however, these profiles are surely noticeable in terms of how that person interacts with his/her environment, whether at school, home, or with his/her peers.

Neuroticism, Introversion/Extroversion, and Cognition

Up to this point, I have discussed a set of personality traits that have substantial overlap with conative and cognitive traits, but where the influence is differentiated along topic or thematic domains. Other personality traits, such as neuroticism, have a more pervasive effect on cognitive processes; others, such as introversion/extroversion, have more complex relationships with cognitive processes. In the meta-analytic research by Ackerman and Heggestad (1997), it was found that high levels of neuroticism are associated with lower levels of cognitive abilities across a wide range, such as reasoning, math, verbal, and spatial abilities. The correlations are not large in magnitude, but such relations suggest that ceteris paribus (if everything else is equal), individuals who report higher levels of worries, personal concerns, anxiety, and upset tend to do more poorly on tasks that require high levels of cognitive effort.

The relationships between introversion/extroversion and cognitive processes have been investigated to a much higher degree than many of the other personality-cognition relations. Most notable is a body of research reported by Revelle and his colleagues (Humphreys & Revelle, 1984; Revelle et al., 1980). The foundation for this work is the conceptualization that introverts or low impulsives have a higher baseline level of arousal than extroverts or high impulsives, and that under arousal and overarousal have consequences in terms of decreasing cognitive efficiency (consistent with the Yerkes-Dodson law of arousal and performance). The higher baseline arousal for introverts appears to mean that they perform better than extroverts when the level of stimulation is low or tasks are performed in the morning; extroverts tend to perform better than introverts when the level of stimulation is high or tasks are performed later in the day.

Affective States and Cognitive Processes

As discussed earlier, personality is generally considered in terms of stable traits, but affective states also play an important role in cognitive processes.

Positive or negative moods, for example, although generally short-term in duration, clearly influence an individual's ability to focus cognitive attention and further affect how cognitive stimuli are processed, especially when they have personal emotional relevance. These influences are likely to be somewhat asymmetric, in that negative mood states (such as anger or fatigue) tend to result in greater cognitive distractions and impairment than positive moods for increased capabilities for attentional focus. To the degree that such mood states are truly transitory, they may not have lasting effects on development of cognitive skills and knowledge. However, when such mood states are more frequent and lasting, they may indeed have both ramifications for changes to overall personality trait expressions and to cognitive processing. It has been speculated that the trait of test anxiety has characteristics along these lines. That is, an individual's early experiences of failures in testing situations may result in greater apprehension and avoidance behaviors in the face of future situations involving performance evaluation (Sarason, 1959). Over the course of extended exposure to such situations, the individual who is high in test anxiety essentially performs cognitive tests while simultaneously being distracted by worry and dread, which in turn reduces the cognitive attention resources available for test performance, resulting in lower test performance.

Cognitive Processing of Affectively Laden Stimuli

Up to this point, most of the discussion has centered around cognitive/intellectual processing of information that is not emotionally or affectively laden. When it comes to cognitive processing of socially relevant information, there has been substantial controversy about the primacy of affect or cognitive processes, such as in laboratory situations were stimuli are presented for short durations (Murphy & Zajonc, 1993). There is also an earlier literature associated with perceptual defense, where threatening or taboo stimuli are briefly presented to the individual in recognition tasks. A substantial body of research on cognitive processing of affectively laden stimuli has been conducted on clinical populations of individuals with a variety of different affective disorders. However, there is still no current framework that adequately describes cognitive processing of affectively laden stimuli differences among individuals with different personality-trait profiles (within a normal population). The extant data suggest that when there are strong personally relevant affective cues (i.e., those that trigger fear, disgust, sexual interest) or when the stimuli allow for minimal conscious cognitive processing, the role of personality on cognitive processing may be stronger than when the stimuli are less emotionally or affectively laden.

PERSONALITY AND COGNITION IN ADULTHOOD

It can be argued that the situational press in the school environment is not uniformly strong, especially with respect to the *intensity* of cognitive effort demanded. However, as schooling proceeds, the individual is often faced with less situational press in terms of the *direction* of cognitive effort. For example, when the student moves from the common school curriculum present in elementary school to secondary and postsecondary education or vocational training, the individual has more flexibility in terms of the topics or domain selected for further study, whether it be math, science, humanities, technical training, or learning a trade. When students reach this point in their training/education, we expect that aspects of personality that are most associated with cognitive abilities will be most likely to influence the intensity and direction of the individual's efforts. During this period, it is expected that the individual will seek out educational and vocational opportunities that allow for a convergence of the environmental demands and the individual's interest/comfort level. If, for example, the individual is high on the social trait complex, we would expect an increased tendency to orient toward education and training in domains that are most likely to have high demands for social interaction (e.g., teaching, sales, health care worker). If the individual is low on the social trait complex, we would expect an increased tendency to orient toward education and training in domains that provide for a more solitary occupation.

As adulthood is reached and the individual transitions from the school environment to the world of work, matches between personality trait profiles and the cognitive/affective demands of the job become manifest in terms of job satisfaction (Judge, Heller, & Mount, 2002; Tokar & Subich, 1997). Mismatches take various guises, such as when an individual who is introverted takes on a job with high demands for interpersonal interaction or when an individual who is low in conscientiousness is faced with a job that demands great attention to detail. At adulthood, personality traits are much less malleable than they might be in childhood or adolescence. There are, however, strategies that individuals who are otherwise committed to the job or occupation may use to ameliorate or overcome the mismatch between their personality traits and the job demands, such as acquiring cognitive skills that may reduce the effortful aspects of the job requirements (e.g., by obtaining training on improving interpersonal skills or learning how to improve organizational skills).

Because personality traits are most often manifest when environmental press is low, their expression in intellectual activities often takes place most often outside of the structured workplace or school. Individual differences in personality-trait profiles appear to affect the kinds of activities people pursue in terms of avocational interests, such as hobbies or other activities. Individuals who are high in openness to experience may orient toward learning about cultural domains, such as art, music, travel, and reading; individuals who are high in extroversion may orient toward activities that involve high levels of interpersonal interactions. Individuals who are high on conscientiousness or harm avoidance may tend to limit themselves to a relatively narrow set of outside interests. In the long run, these personality differences can be expected to lead to a differentiated set of knowledge structures across domains of science, politics and current events, humanities, business, health and nutrition, and knowledge about other people (e.g., likes and dislikes of friends, birthdays, names, and ages of children). By the time people reach middle age, there is additional congruence between personality traits such as extroversion and openness to experience, on the one hand, and domain knowledge, on the other (Ackerman & Beier, 2006; Beier & Ackerman, 2001). It is important to note that individuals who choose not to acquire domain knowledge in some domains are not necessarily incapable of learning about such domains, especially under high levels of environmental press. Rather, if left to their own preferences, individuals with some patterns of personality traits will gravitate toward or away from experiences that match or mismatch their own interests or comfort level.

Age-Related Changes in Personality and Cognition

In middle age, personality traits and abilities are both relatively stable, although changes have been noted in terms of mean declines in extroversion, neuroticism, and openness to experience (Jones & Meredith, 1996) and some abilities (e.g., reasoning, speeded processing) show declines across the population (Horn, 1989). Self-concept and self-estimates of abilities also show age-related differences as individuals change their perceptions of their own strengths and limitations (Ackerman, Beier, & Bowen, 2002). In addition, changes in values and motives can be expected to result in changes in how individuals view their place in the world and in their own work and family environments (Carstensen, 1998). These changes in orientation and the strength of emotional motives and needs may result in an increase in the influence of personality in focusing cognitive effort. Although the strength of situations may be unchanged, from an external point of view, the degree to which the individual feels bounded by the situations when the extant contingencies are no longer highly valued may be diminished (for a discussion of these issues, see Kanfer & Ackerman, 2004).

CLOSING THOUGHTS

Affect and cognition have traditionally been considered relatively independent areas of inquiry, and as a consequence, implicitly considered to be relatively independent in their operations. In fact, it is quite common to see personality traits referred to in the literature as "non-ability traits." In the context of research from the last two decades, this label should be seen as misleading at best. Cognitive activities involve a complex interplay of intellectual processes and personality processes, such as when one is attempting to memorize new names of people met at a party, trying to think of someone who will make an ideal match for other members of a dinner party, or deciding what to do for a vacation. Our likes and dislikes have an essential affective component that is often mediated by our abilities and cognitive styles associated with our daily problem solving.

Similarly, individual differences in personality traits affect the individual's orientation toward or away from various stimuli for further cognitive processing. People who are high in neuroticism, for example, appear to devote substantial cognitive attention toward parsing situations in search of personally threatening stimuli (Matthews & Deary, 1998). How we code situations or even evaluate the situational press of a particular environment also involves both affective and cognitive processes. Some individuals will interpret a situation as having less environmental press than others, and may behave in a way that is more typical for them than others who interpret the environmental press as allowing little flexibility for behavior. An employee who shows up late for the first day of work might represent someone who either has miscoded the strength of the situation or who has a much lower level of conscientiousness than other employees who arrive on time or early to work. This pattern is reflected in the so-called honeymoon effect described by Helmreich, Sawin, and Carsrud (1986). That is, personality traits may not be highly related to job performance and other job-related behaviors – such as citizenship behaviors – early in job tenure, but with additional time in the job, personality traits become significantly correlated with job performance and other job-related behaviors.

In the final analysis, although there is clearly justification for considering personality and cognition as important domains in their own right, there are various points of interaction and interplay that occur between an individual's preferences, desires, and modes of addressing the world, on the one hand, and their cognitive processes and skills, on the other hand. The correlations between personality traits and cognitive abilities are significant, but not especially large in magnitude. These correlations, however, mask two important aspects of the larger picture. First, there is a mismatch between the conditions of assessment for personality (typical behaviors) and cognitive ability (maximal performance). Second, personality differences are most frequently influential, when there are relatively low levels of environmental press. When these considerations are taken into account, the correlations found between personality traits and cognitive-ability measures suggest that even in the maximal performance situations of cognitive-ability testing personality traits have an influence, whether it is in the testing situation itself or more a result of an accumulated set of the individual's experiences.

References

Ackerman, P. L. (1996). A theory of adult intellectual development: process, personality, interests, and knowledge. *Intelligence*, **22**, 229–259.

(1997). Personality, self-concept, interests, and intelligence: Which construct doesn't fit? *Journal of Personality*, **65**(2), 171–204.

(2003). Aptitude complexes and trait complexes. *Educational Psychologist*, **38**, 85–93.

(2006). Personality, trait complexes, and adult intelligence. In A. Eliasz, S. Hampson, & B. de Raad (Eds.), *Advances in personality, Volume II* (pp. 91–112). New York: Psychology Press.

Ackerman, P. L., & Beier, M. E. (2006). Determinants of domain knowledge and independent study learning in an adult sample. *Journal of Educational Psychology*, **98**, 366–381.

Ackerman, P. L., Beier, M. B., & Bowen, K. R. (2002). What we really know about our abilities and our knowledge. *Personality and Individual Differences*, **34**, 587–605.

Ackerman, P. L., & Heggestad, E. D. (1997). Intelligence, personality, and interests: Evidence for overlapping traits. *Psychological Bulletin*, **121**, 219–245.

Ackerman, P. L., & Wolman, S. D. (2007). Determinants and validity of self-estimates of abilities and self-concept measures. *Journal of Experimental Psychology: Applied*, **13**, 57–78.

Beier, M. E., & Ackerman, P. L. (2001). Current events knowledge in adults: An investigation of age, intelligence and non-ability determinants. *Psychology and Aging*, **16**, 615–628.

Carstensen, L. L. (1998). A life-span approach to social motivation. In J. Heckhausen & C. S. Dweck (Eds.), *Motivation and self-regulation across the life span* (pp. 341–364). New York: Cambridge University Press.

Cattell, R. B. (1971). *Abilities: their structure, growth, and action*. NY: Houghton Mifflin Co.

Chamarro-Premuzic, T., & Furnham, A. (2008). Personality, intelligence and approaches to learning as predictors of academic performance. *Personality and Individual Differences*, **44**, 1596–1603.

Chamorro-Premuzic, T., Furnham, A., & Moutafi, J. (2004). The relationship between estimated and psychometric personality and intelligence scores. *Journal of Research in Personality*, **38**, 505–513.

Cronbach, L. J. (1949). *Essentials of psychological testing* (1st edition). New York: Harper & Brothers.

Demetriou, A., Kyriakides, L., & Avraamidou, C. (2003). The missing link in the relations between intelligence and personality. *Journal of Research in Personality*, **37**, 547–581.

Harris, J. A., Vernon, P. A., & Jang, K. L. (2007). Rated personality and measured intelligence in young twin children. *Personality and Individual Differences*, **42**, 75–86.

Helmreich, R. L., Sawin, L. L., & Carsrud, A. L. (1986). The honeymoon effect in job performance: Temporal increases in the predictive power of achievement motivation. *Journal of Applied Psychology*, **71**, 185–188.

Holland, J. L. (1959). A theory of vocational choice. *Journal of Counseling Psychology*, **6** (1), 35–45.

Horn, J. L. (1989). Cognitive diversity: A framework of learning. In P. L. Ackerman, R. J. Sternberg, & R. Glaser (Eds.), *Learning and individual differences. Advances in theory and research* (pp. 61–116). New York: W. H. Freeman.

Humphreys, M. S., & Revelle, W. (1984). Personality, motivation, and performance: A theory of the relationship between individual differences and information processing. *Psychological Review*, **91**, 153–184.

Jones, C. J., & Meredith, W. (1996). Patterns of personality changes across the life span. *Psychology and Aging*, **11**, 57–65.

Judge, T. A., Heller, D., & Mount, M. K. (2002). Five-factor model of personality and job satisfaction: A meta-analysis. *Journal of Applied Psychology*, **87**, 530–541.

Kanfer, R., & Ackerman, P. L. (2000). Individual differences in work motivation: Further explorations of a trait framework. *Applied Psychology: An International Review*, **49** (3), 469–481.

(2004). Aging, adult development and work motivation. *Academy of Management Review*, **29** (3), 440–458.

Kant, I. (1790). *Critique of judgment.* Translated by Werner S. Pluhar. Indianapolis, IN: Hackett Publishing Co.

Marsh, H. W., Trautwein, U., Ludtke, O., Koller, O., & Baumert, J. (2005). Academic self-concept, interest, grades, and standardized test scores: Reciprocal effect models of causal ordering. *Child Development*, **76**, 397–416.

Matthews, G., & Deary, I. J. (1998). *Personality traits.* NY: Cambridge University Press.

McDougall, W. (1933). *The energies of man: A study of the fundamentals of dynamic psychology.* New York: Charles Scribner's Sons.

Murphy, S. T., & Zajonc, R. B. (1993). Affect, cognition, and awareness: Affective priming with optimal and suboptimal stimulus exposures. *Journal of Personality and Social Psychology*, **64**, 723–739.

Revelle, W., Humphreys, M. S., Simon, L., & Gilliland, K. (1980). The interactive effect of personality, time of day, and caffeine: A test of the arousal model. *Journal of Experimental Psychology: General*, **109**, 1–31.

Rushton, J. P., Brainerd, C. J., & Pressley, M. (1983). Behavioral development and construct validity: The principle of aggregation. *Psychological Bulletin*, **94**, 18–38.

Sarason, S. B. (1959). Test anxiety. *Journal of the National Education Association*, **48** (8), 26–27.

Shavelson, R. J., Hubner, J. J., & Stanton, G. C. (1976). Self-concept: Validation of construct interpretations. *Review of Educational Research*, **46**, 407–441.

Sullivan, B. A., & Hansen, J-I. C. (2004). Mapping associations between interests and personality: Toward a conceptual understanding of individual differences in vocational behavior. *Journal of Counseling Psychology*, **51**, 287–298.

Tokar, D. M., & Subich, L. M. (1997). Relative contributions of congruence and personality dimensions to job satisfaction. *Journal of Vocational Behavior*, **50**, 482–491.

Willerman, L., Turner, R. G., & Peterson, M. (1976). A comparison of the predictive validity of typical and maximal personality measures. *Journal of Research in Personality*, **10**, 482–492.

4

Cognition in the Context of Psychopathology

A Selective Review

Josef Zihl, Nicole Szesny, & Thomas Nickel

INTRODUCTION

The fundamental interrelation between the rational and emotional elements of human nature has been discussed since the old Greek philosophers Plato and Aristotle. Although Plato's theory of mind was essentially dualist, assuming an earthly body that is inhabited by a divine soul, Aristotle proposed a functionalist model of the mind. Plato's idea that affect is a dangerous, invasive force subverting rational thinking has recurred in many theories throughout the ages. In his psychodynamic model, Freud, for example, suggested that the Id has to be dominated by the ego (Lyons, 2008). The view that emotion is also an essential component in cognition and behaviour has emerged through advances in our understanding of emotion and social cognition and their underlying neurobiological substrates (e.g., Adolphs, 2002, 2009; Ochsner & Gross, 2005; Pessoa, 2008; Van Overwalle, 2009). This renewed interest in the relationship between cognition and emotion has led to the development of innovative interdisciplinary research approaches in this field.

The main aim of this review is to identify normal and pathological conditions in which cognition, emotion, and motivation can dissociate and act independently of each other as well as conditions in which they are associated and interact. Neurobiological, neuropsychological, and psychopathological evidence supports a concept of functional segregation for these modalities, albeit there is evidence suggesting in certain contexts that emotion and motivation modulate – that is, enhance or impair, cognition, and emotion may even dominate cognition (e.g., Clore & Palmer, 2009). Rather, it appears that cognition serves as a tool that is used by the emotional and motivational systems. Thus, cognitive processes are always embedded in emotional and motivational contexts. It is, therefore, the interplay between cognition, emotion, and motivation that guarantees successful adaptation to challenges arising, for example, from acquired brain injury or depression.

DEFINITIONS, NEUROBIOLOGICAL FOUNDATION, AND FUNCTIONAL INTERPLAY

Cognition. No uniform and agreed definition exists of what cognition is. According to the APA Dictionary of Psychology (2007), cognition comprises all forms of knowing and awareness, including perceiving, conceiving, remembering, reasoning, judging, imagining, and problem solving. Thus, the cognitive system is composed of the functional subsystems of perception, attention, memory, executive function (planning, problem solving, decision making, self-monitoring), language, and action.

Posner and Raichle (1994) developed an integrative theory of cognitive systems, which is based on the known neurobiological and functional properties of brain organisation. In their theory, elementary cognitive operations are localised in separate brain areas, but performing cognitive tasks involves widely spread networks of neural systems. Within a given network, interactive processes allow a reciprocal information exchange as well as the hierarchical control of functions and processes. Information processing (bottom-up) takes place within several neural systems, which are also activated when processing is guided by attentional networks (top-down). Thus, the different cognitive interacting systems are organised in spatially distributed, parallel, and serial processing modules that possess autonomy but are, at the same time, part of a multistage integration processing system that also supervises the various activities. The cognitive system is a highly complex system with dense local and weaker long-range connections, suggesting a small-world architecture that is, however, controlled by a frontoparietal component for initiating and adjusting control activities; a prefrontal component for integrating emotional, motivational, and cognitive determinants of goal-directed behaviour; and a cingular-opercular component for set maintenance over activity (i.e., task) periods (Dosenbach et al., 2008; Kouneiher, Charron, & Koechlin, 2009).

Emotion is central to the quality and amount of everyday human experience. It is understood as a complex reaction pattern involving behavioural and physiological elements as well as experience by which 'the individual attempts to deal with a personally significant matter or event' (APA, 2007, p. 325). The specific quality of an emotion is determined by the particular significance of the event but also by the attitudes and mood of a person. Emotional adaptation is an individual's ability to maintain a balance in the emotional aspects of life as well as to express emotions appropriate to a given situation. The self-regulation of the influence that one's emotions have on cognition and behaviour is known as *emotional control* (APA, 2007).

Experiences of emotions ('feelings') are labelled affect and range from the simplest to the most complex sensations as well as from the most normal to the most pathological emotional reactions (APA, 2007). *Emotional cognition* means the ability to perceive, recognise, and interpret the emotions of other individuals, particularly in facial expressions and prosody, and to interpret one's own emotions correctly (APA, 2007). The appropriate perception and interpretation of other individuals' emotions is also known as *social cognition* (Adolphs, 2003; Adolphs, Tranel, & Damasio, 2003). Social functions (i.e., social perception, social cognition, sensitivity to the social context, and social action) belong to particular functional systems in the brain. The amygdala is involved in regulating social behaviour and recognising facial emotional expressions; the orbitofrontal cortex is important to reward processing in social conditions; the insula is involved in representing affective states of our own body (e.g., empathy or pain) (Adolphs, 2009). The right amygdala plays a particular role in evaluating sad but not happy faces, suggesting that this brain structure is specifically involved in negative emotions, such as sadness and fear (Adolphs & Tranel, 2004).

Cognition, particularly attention, is involved in the processing of emotional stimuli and in emotion regulation (Koole, 2009). It appears that emotional significance is rapidly and implicitly detected and processed pre-attentively, and is given priority in the competitive access to attentional resources within a subcortical–cortical network subserving the processing of emotional stimuli (Compton, 2003). Furthermore, emotion shapes behaviour via feedback, anticipation, and reflection of actions, and can thereby alter guidelines for future behaviour (Baumeister, Vohs, Dewall, & Zhang, 2007).

Perception and recognition of emotion, particularly from facial expressions and prosody, are essential for both emotional responses and social communication, and rely on linking the perceptual properties of a social stimulus to knowledge-based processes. These processes are based on the individual concepts of emotions, such as happiness, fear, or sadness. The visual cortex, the (right) temporal lobe, the amygdala, and the orbitofrontal cortex are essentially involved in recognition of complex emotions (Adolphs, 2002; Adolphs et al., 2003; Mitchell et al., 2003; Wildgruber et al., 2005). Perception of emotions (so-called social perception) and cognition – for example, attention, episodic memory, and executive functioning (e.g., multi-tasking, intentionality, action monitoring) – may subserve social cognition. However, associated brain activities do not overlap uniquely in the medial prefrontal cortex, indicating a particular role of this structure in social processing (Van Overwalle, 2009). For the integration of cognition, emotion, and motivation, the lateral prefrontal cortex appears crucial, whereas other prefrontal cortical areas (orbitofrontal, ventromedial, anterior cingulate areas) are strongly involved in affective function (Pessoa, 2008).

It is commonly assumed that only the 'objective' information about objects – or in social situations, about persons – determines our attitudes towards and judgments about them. One's evaluations, however, are also based on information from one's own affective states and reactions. Especially in social situations, the feelings that are elicited in us by other people are the crucial factor in the evaluation of other people (Clore & Huntsinger, 2007). Although knowing and feeling are intrinsically intertwined, there are methods to examine cognition and emotion separately through experimental control of one or the other (Clore & Palmer, 2009). Interestingly, experimentally induced mood states demonstrate differential effects of different affective conditions on cognitive processing of stimuli (Westermann et al., 1996). Differences in positive and negative mood have been found in regard to decision making, memory, information processing, and attention (Ashby, Isen, & Turken, 1999; Clore & Huntsinger, 2007).

Interestingly, patterns of emotion function differentially in different periods of development and influence cognition and behaviour associated with different forms of psychopathology (Izard et al., 2002). There are individual differences in the motivation to approach or avoid emotion-inducing situations. This motivation is known as 'need for affect' (Maio & Esses, 2001), and depends on cognitive processes (information processing and attention allocation subserving the need for cognition; inhibition and activation of behavioural responses), emotional processes (e.g., affect intensity, affect sensitivity), and personality traits. In addition, individual differences in the need for affect and social behaviour may be explained by individual differences in emotional development, because feedback between cognition and emotion may generate, maintain, and reconfigure representations of emotional events. This interaction between cognition and emotion also subserves self-organisation of individual developmental paths through periods of stability and change, thus stabilising the whole system and guaranteeing an emotional equilibrium (Lewis, 1995).

Despite empirical evidence that cognition and emotion belong to different brain systems and that many brain areas may be conceptualised as either cognitive or affective, it is important to stress that both cognition and emotion are intimately intertwined and dependent on each other. Pessoa (2008) suggested that complex cognitive-emotional actions have their basis in 'dynamic coalitions' of brain networks that possess a high degree of connectivity.

Furthermore, as Storbeck and Clore (2007) convincingly argued, emotion is neither independent from cognition nor its prerequisite, and affect is also not automatically elicited; however, emotion can regulate cognitive processing.

Motivation can be understood as 'a modulating and coordinating influence on the direction, vigor, and composition of behavior', which 'arises from a wide variety of internal, environmental, and social sources' (Shizgal, 1999, p. 566). Internal sources are usually identified with intrinsic motivation; environmental and social sources are comprised within extrinsic motivation. Jimura, Locke, and Braver (2010) found evidence that the reward value of behavioural goals can enhance cognition performance, whereby reward sensitivity differs individually (see also Silverstein, 2010). Cognitive flexibility is known to be strongly modulated by motivational control (Piech et al., 2009). Motivation to engage in and enjoy effortful cognitive challenges (so-called need for cognition) is a potential predictor of dispositional individual differences in information processing and executive functioning in terms of cognitive resource (i.e., attention) allocation (Enge et al., 2008). In addition, intrinsic motivation level and extrinsic reward predict the rate of improvement in cognitive tasks and psychosocial functioning (Nakagami, Hoe, & Brekke, 2010; Silverstein, 2010). The interplay between attention (relevance of stimuli for a given task), emotion (affective evaluation of stimuli), and motivation (predicted value of stimuli) contribute to the prioritisation and appropriate selection of information for the controlled guidance of actions. However, prior value prediction plays a role in visual selection and conscious perception, indicating that motivation can also act independently (Raymond, 2009).

Reward-related processing of information takes place in the striatum (Delgado, 2007) and the ventral pallidum (Smith et al., 2009). Lateral parietal structures are involved in the priorisation of attention in space by motivation (Gottlieb et al., 2009); prefrontal structures are involved in the integration of cognitive and motivational information (Sakagami & Watanabe, 2007) and in the facilitation of cognitive processes required for goal achievement (Jimura et al., 2010). To summarise, it appears, that the human brain is very sensitive to motivational signals, which can modulate brain activity in structures involved in cognitive processing, in particular attention and memory (Silverstein, 2010). In particular, prefrontal cortical areas facilitate attentiveness to stimuli with motivational relevance, and are highly sensitive to changes in reward values (Ochsner, 2008).

In the following section, empirical evidence is presented for the association, dissociation, and interaction of cognition, emotion, and motivation in the context of pathological conditions, in particular after acquired brain injury and in depression.

THE PATHOLOGICAL CONTEXT

Studies on pathological brain conditions suggest that cognition, emotion, and motivation can be jointly affected, but impairments can also dissociate (i.e., one domain may be affected whereas the others are not). Thus, under normal and pathological conditions, emotion and motivation can modulate cognition, and cognition can regulate emotion and motivation (Taylor & Liberzon, 2007; Silverstein, 2010).

Brain injury. About 30–60 percent of patients with brain injury due to stroke and 30–40 percent of cases with closed head trauma suffer from (chronic) depression (Jorge et al., 2004; Kauhanen et al., 1999). Symptoms of depression include low mood, distorted self-attitude, lack of motivation, anhedonia, subjective cognitive complaints, and hyperactive and disinhibited behaviour (Jorge & Starkstein, 2005). Patients' self-reports of their functional impairments seem less related to their actual cognitive performance than to their depressive symptomatology (Chaytor, Temkin, Machamer, & Dikmen, 2007). Positive emotion can positively influence recovery (Ostir et al., 2008); poststroke depression is associated with higher cognitive impairment (Kauhanen et al., 1999) and lower functional recovery (Parikh et al., 1990) as well as a deterioration of cognitive and social functioning (Jorge et al., 1994). About 40–70 percent of patients do not exhibit depression, although they suffer from similar cognitive dysfunction. It is, however, still unclear whether the association between cognitive and emotional dysfunction is found in every cognitive domain or whether specific domains are particularly affected and others are spared. Interestingly, executive dysfunction, which is often associated with poststroke depression, can affect regulation of cognition and emotion (Jorge et al., 2004; Milders et al., 2008), indicating a strong association between these two domains. Furthermore, apathy following stroke, defined as a reduction in voluntary goal-directed actions, is significantly associated with cognitive impairment or may at least exacerbate cognitive deficits (Brodaty et al., 2005; Jorge, Starkstein, & Robinson, 2010). On the other hand, even pronounced cognitive impairment – for example in severe dementia – is not necessarily associated with apathy (Starkstein et al., 2001).

Frontal lobe injury is known to cause persistent cognitive and psychopathological symptoms (Paradiso et al., 1999). Subjects with lateral prefrontal injury more frequently show cognitive slowness, reduced motivation (apathy), greater severity of depressive symptoms, and social unease, but can experience (negative) emotions. Subjects with medial prefrontal injury, in contrast, show emotional dysregulation and inhibition of experience of mood changes. Emotional (and personality) changes may also occur after small orbitofrontal injury (Namiki et al., 2008) and in cases with traumatic diffuse axonal brain injury (Green, Turner, & Thompson, 2004). Brain-injured subjects suffering from executive dysfunction may benefit less from remediation of emotion recognition deficits (McDonald, Bornhofen, & Hunt, 2009). Interestingly, subjects with retrograde amnesia may nevertheless be able to recollect (pleasant) emotional events from their lives. Medial temporal structures, but not the hippocampus, appear crucial for emotional autobiographical memory, indicating dissociation between the long-term storage of semantic (i.e., cognitive) contents and that of emotional contents (Buchanan, Tranel, & Adolphs, 2005).

Patients with cerebrovascular or traumatic (right-sided) brain injury may show impairments in recognising affective information from the face, voice, bodily movement, and posture (Bornhofen & McDonald, 2008; Charbonneau et al., 2003; Kucharska-Pietura et al., 2003), which may persistently interfere with successful negotiation of social interactions (Ietswaart et al., 2008). In addition, controlling and modulating vocal affect as well as comprehension and expression of affective sentences (prosody) may also be impaired, and may contribute to impaired communication competence and poor social outcome (Marquardt, Rios-Brown, & Richburg, 2001; Watts & Douglas, 2006; Wildgruber et al., 2006; Zupan et al., 2009). Interestingly, face perception, the use of context cues, and semantic knowledge can be affected at the same time the perception of linguistic specifications of prosody is relatively spared, indicating a dissociation between cognition (face processing capacities and semantic knowledge) and recognition of emotion from prosody and facial expression (Croker & McDonald, 2005; Green et al., 2004; Pell, 1998).

Impairments of emotional and social behaviour are typically observed after frontal lobe injury. It can be explained by defective or lost stimulus-reinforcer associations, inaccurate evaluation of stimuli signifying reward or punishment in a social context, and failures to translate emotional and social information into task- and context-appropriate action patterns. These functional impairments arise from impaired perception and interpretation of social and emotional stimuli, inadequate hypotheses about the social environment, and inadequate selection of emotional and social actions. Consequently, patients may show deficient social judgements and decision making; social and perhaps also cognitive inflexibility; lack of self-monitoring, particularly in social situations; and deficient goal-directed behaviour, including apathy, disinhibition, task impersistence, and general disorganisation (Hornak, Rolls, & Wade, 1996; Rankin, 2007; Vecera & Rizzo, 2004).

Depression. According to the Diagnostic and Statistical Manual of Mental Disorders (DSM-IV), depression is a mental disorder that is characterised by low mood, loss of interest, feelings of guilt, low self-worth, disturbed sleep and appetite, listlessness, and cognitive dysfunctions independent of its origin as a result of head injury or as an entity on its own (APA, 1994). In depression, there is evidence for associations as well as dissociations between cognitive and emotional dysfunctions. Patients may exhibit affective and cognitive dysfunctions, but cognitive impairments may also persist even after improvement of depressive symptomatology (Frasch et al., 2009; Landro, Stiles, & Sletvold, 2001; Majer et al., 2004; Reppermund et al., 2007; Reppermund et al., 2009). Yet, there is also evidence in these studies for preserved cognition in the presence of depressive symptomatology. Because these differential patterns can hardly be explained by a lack of motivation, it may be speculated whether these two patterns of dysfunction represent two distinct subgroups. However, irrespective of the presence of cognitive dysfunction, all patients complain of more or less pronounced difficulties with attention, memory, and executive function. This indicates that self-perception of patient's cognitive capacities does not always match with the objectively assessed cognitive status, indicating that at the level of awareness, there seems to be no dissociation between (self-perceived) cognitive performance and emotional dysfunction. Impairments of cognitive functions have been found in a wide range of cognitive domains (e.g., episodic memory, learning, attention, and executive functions) (Austin, Mitchell, & Goodwin, 2001; Bearden et al., 2006; Stordal et al., 2004; Zihl, Groen, & Brunnauer, 1998). Reduced motivation in depression is known to impair cognitive performance, possibly because task-specific self-efficacy and enhancement of task-focused attention fail to increase performance level (Scheurich et al., 2008). The impact of severity and subtype of depression on cognitive dysfunction as well as the influence of age, comorbid disorders, and persistence of these impairments after recovery are still unclear (Austin et al., 2001; Castaneda et al., 2008; Majer et al., 2004; Reppermund et al., 2009). However, cognitive deficits might persist longer than the period of illness, yet this seems to be true for all depressive sub-diagnoses (Neu, Kiesslinger, Schlattmann, & Reischies, 2001).

There is preliminary evidence that particularly executive dysfunction in depression may represent a risk factor for relapse (Dunkin et al., 2000; Majer et al., 2004; Simons et al., 2009), indicating that recovery of emotion regulation and mood may not be sufficient for gaining and stabilising emotional equilibrium. Multiple sources of evidence support the view that depression is associated with frontal lobe dysfunction (Harrison, 2002; Lesser & Chung, 2007). This view would also explain the associative patterns of cognitive and emotional dysfunction as well as the dissociations between the two domains; differing degrees of dysfunction in prefrontal regions can result in more regional frontal lobe syndromes (Duffy & Campbell, 2002). In a more recent paper, Dichter, Felder and Smoski (2009) reported a double dissociation of prefrontal responses in subjects with unipolar depression to the contexts in which the target events were embedded. In a neutral context, they found a hypoactivation of prefrontal structures, which is consistent with findings in normal subjects. In contrast, cognitive control stimuli embedded in a sad context revealed a greater activation of prefrontal structures in the depressed group than in normal subjects. This result could be interpreted as a greater cognitive effort that is required in depression for disengaging from the sad images in order to respond to the target stimuli. Depressed subjects may also show increased processing of negative stimuli and/or diminished processing of positive verbal and visual stimuli, which is paralleled by corresponding brain activation patterns, albeit this finding may only apply to specific subgroups (Canli et al., 2004; Surguladze et al., 2004). These alterations may explain impaired interpersonal functioning in depression, although the mode of presentation of emotional stimuli (e.g., facial expressions) may be crucial; when dynamic facial expressions are used, subjects with depression may perform like normal subjects (Kan et al., 2004). Thus, in a depressive state, additional visual-social information may be required for proper processing and interpretation (i.e., visual cortical areas can enhance emotion processing) (Schultz & Pilz, 2009). Yet, because this enhancement effect also depends on attention allocation to stimuli, the inability to accurately recognise subtle facial emotional signals may be understood as a perceptual bias towards high arousal emotions (Csukly et al., 2009). In bipolar disorders, emotion perception and affect generation deficits have been reported in association with impaired executive function (cognitive control and regulation), suggesting that the variations in mood can be explained partly in terms of specific impairments in the cognitive control of emotion (Green, Cahill, & Malhi, 2007).

A summary of the observations on the pathology of cognition and emotion after acquired brain injury and in depression shows that there is convincing empirical evidence for the association as well as for the dissociation of symptoms. Furthermore, negative emotions can lower functional recovery after brain injury and positive emotions can enhance recovery. In depression, cognitive dysfunction may increase the risk for relapse. Thus, emotion definitely can modulate cognition. Yet, cognition subserves emotion in regaining and maintaining individual self-organisation in periods of change (e.g., after highly challenging life events, brain injury, or in depression) and may thus constitute a protective factor. Cognition may therefore be considered as a tool for planning, executing, and monitoring adaptation to challenging conditions and thus for developing and improving coping strategies

(Ochsner & Gross, 2005). Emotion may elicit, maintain (via motivation), and reinforce such cognitive activities unless successful tools for coping are developed and tested, and also found useful for transfer. Cognition, emotion, and motivation are also engaged in the evaluation of the usefulness of such coping strategies, either concerning their feasibility, accuracy, and speed (cognition) or concerning their positive and negative value for an individual in terms of the specific personal significance of the coping strategy and its effect on one's own behaviour and that of others. The resulting emotional and cognitive adaptation is important for improving and maintaining self-regulated emotional control based on various feedbacks between cognitive and emotional components of the coping strategy. These feedbacks can then generate, maintain, and reconfigure the representation of the adaptation to the challenging task as cognitive *and* emotional events *or* as a cognitive-emotional event. Emotional regulation involves the initiation of new or at least adapted (i.e., adequate) emotional responses and inhibition of inappropriate responses. In conditions of reduced deployment of attentional resources, emotional information is prioritised and receives privileged access to attention and awareness (so-called emotional attention), which enhances processing of emotional signals (Vuilleumier, 2005). For developing and using coping strategies in emotion regulation, personality traits also come into play, as they are known to influence cognitive activities (e.g., Connor-Smith & Flachsbart, 2007). Personality traits can thus enhance (viz. openness), impede, or at least bias (viz. neuroticism) the development and selection of environment- and task-related adaptation strategies. As Bienvenu et al. (2004) have shown, low assertiveness and high openness to feelings are associated with major depressive disorder; neuroticism is related to its acuity. It seems, therefore, that personality traits exert their main influence on cognition via the domain of emotion, which becomes manifest particularly in psychopathological states such as depression.

In conclusion, cognition and emotion seem to represent two separable but intensively and reciprocally interacting functional systems, which can modulate each other positively and negatively. As a rule, they cooperate when developing, testing, and selecting strategies for coping with challenging events and tasks as well as for maintaining emotional stability over time.

TOWARDS AN INTEGRATIVE NEUROPSYCHOLOGICAL VIEW OF COGNITION, EMOTION, AND MOTIVATION

Many neurological disorders and mental illnesses are characterised by pronounced deficits in cognitive and emotional behaviour. The relationship of cognitive and emotional dysfunctions in subjects with brain injury and depression has been discussed above in detail. Yet, other diseases such as schizophrenia (e.g., Herbener et al., 2008; Silverstein, 2010), obsessive compulsive disorder (Green et al., 2007), dementia (Rosen et al., 2006), anxiety disorders (McNaughton, 1997), and post-traumatic stress disorder (Moore, 2009) can also be characterised by pathological alterations and interactions of cognition and emotion. In contrast to the condition of brain injury, where the underlying cause for cognitive and emotional dysfunctions and their interactions is more or less exactly known, the causes of most psychiatric disorders are still largely unknown. Thus, a better understanding of the interdependence of cognition and emotion (Storbeck & Clore, 2007) and the direct and indirect pathways by which cognition regulates emotion and vice versa may improve our knowledge of the neurocircuits underlying the pathomechanisms of psychiatric disorders (Grady & Keightley, 2002; Taylor & Liberzon, 2007). When comparing neuropsychological and psychopathological profiles between subjects with acquired brain injury and those with depression, it appears that cognitive dysfunction can (indirectly) affect emotion and social perception, but emotional and social dysfunction can also affect cognition. This mutual modulation suggests that cognition and emotion build a final common pathway via reciprocally interacting functional systems (Barbas, 2000), which subserves individual self-organisation and in addition stabilises and guarantees emotional equilibrium (Lewis, 1995). Of course, injury to or dysfunction of prefrontal structures and/or their partner structures and interconnections may affect both cognition and emotion (e.g., Duffy & Campbell, 2002; Pessoa, 2008). Interestingly, similar patterns of interaction between cognition and emotion as well as between cognitive dysfunction and psychopathology have been reported after childhood brain injury. Persisting emotional difficulties are often associated with impaired cognitive capacities, in particular executive dysfunction (Powell & Voeller 2004; Tonks et al., 2009), although they can also dissociate (Tonks et al., 2008).

Currently, psychiatric diagnoses are not based on neurobiological findings. Instead, they are based mainly on subjectively defined and reported symptoms and psychopathology. A more detailed neurobiological and neuropsychological characterisation of psychiatric disorders may allow a rearrangement of diagnostic classifications based on more objective, neurobiologically oriented data (see also Dubrovsky, 1995; Levin et al., 2007; Shenal, Harrison & Demaree, 2003). In addition to sleep parameters; genetic, molecular, and endocrine variables; environmental information; neuroimaging technologies; and last but not least cognition and emotion as interacting functional parameters are important variables for a more detailed characterisation of patients that is independent of DSM-IV (APA, 1994) or ICD-10 (WHO, 1993) diagnoses (see also Garety et al., 2007). Examples for such research approaches are the studies of Reppermund et al. (2007) and Majer et al. (2004). Reppermund et al. examined interdependencies between depressive symptoms, cognitive impairment, and dysregulation of the hypothalamic-pituitary-adrenocortical system and found a dissociation of psychopathology and cognition. Despite a significant reduction of depressive symptoms between hospital admission and discharge, a high rate of patients remained cognitively impaired after treatment. Selective attention improved significantly in remitters and non-remitters, and the speed of information processing increased only in remitters (Reppermund et al., 2007). The study of Majer et al. (2004) addresses the relationship between cognition and the course of depression. However, the authors observed cognitive impairment in most cognitive domains along with acute depression; at discharge, the cognitive performance was still below that of normal subjects, albeit impairments were less pronounced. Divided attention, but also verbal memory (Simons et al., 2009) and executive function (Dunkin et al., 2000) might predict response to treatment, remission of symptoms, and risk of relapse.

In addition to the identification and functional characterisation of disease-relevant variants, one major focus of this approach is the identification of subgroups within different psychiatric disorders that display greater etiopathogenetic homogeneity. Especially patients suffering from major depressive disorder seem to represent a rather heterogeneous entity consisting of different phenomenological subgroups. Patterns of association and dissociation between cognitive dysfunction and psychopathology and other aspects of the disease are interesting parameters for the identification of more homogeneous subgroups within the category of depression. Castaneda et al. (2008), for instance, emphasise that it remains unclear why some depressed patients suffer from severe impairments in cognition and others show only mild impairment or perform within the normal range of cognition. This conundrum can be solved only by identifying subsets of disorders and characteristics that are associated with the extent of cognitive impairment. Reppermund et al. (2009) proposed three subtypes of depression regarding the dissociation between cognitive deficits and psychopathological symptoms, which can be described as follows: (i) presence of severe psychopathological symptoms combined with only mild cognitive dysfunction; (ii) cognitive symptoms combined with only mild to moderate psychopathological symptoms; and (iii) a combination of severe depressive symptoms and severe cognitive dysfunction. Reppermund et al. suggested that these three subtypes may correspond to the dysfunction of different neural networks that regulate mood and emotion-associated cognition. The main functional networks affected in depression may overlap with those subserving executive cognitive function (dorsal convexity system), motivation, and emotion (mesial frontal system). These different subtypes might correspond to the apathetic mesial frontal syndrome, the dysexecutive dorsal convexity syndrome, or a combination of both (Duffy & Campbell, 2002).

There is no doubt that cognitive impairment is present during a depressive episode, but many studies have shown that specific cognitive deficits can persist and may therefore represent trait markers (Frasch et al., 2009; Majer et al., 2004; Porter, Bourke, & Gallagher, 2007; Reppermund et al., 2009). Thus, cognitive dysfunction in depression is not merely an epiphenomenon of psychopathological symptoms. Cognitive deficits that are closely associated with depressive symptoms might represent a useful measure, that is, a state marker of treatment response that could be used effectively in clinical trials as well as in clinical practice for determining recovery of core abnormalities and prognosis. In addition, there is evidence that even subclinical depressive symptoms may contribute to cognitive deficits (Clark, Iversen, & Goodwin, 2002). It remains unclear whether such cognitive deficits should be interpreted as a residual depressive syndrome after remission of a depressive episode or as a stable trait marker, indicating the risk of developing a major depressive disorder in general. Yet, it appears important to identify this subgroup of patients for special therapeutic intervention strategies aimed at improvement of cognitive capacities.

In conclusion, converging evidence from the study in normal and abnormal conditions supports the view that cognition, emotion, and motivation represent separate but closely intertwined domains, whereby emotion and motivation play a modulatory role in cognition and cognition subserves the guidance of goal-directed behaviours. The patterns of association and dissociation between cognition, emotion, and motivation are in line with the idea of functional specialisation of the brain. Yet, it appears that cooperations are the rule in this strategic partnership (i.e., cognitive functions always operate in the context of emotion and motivation). The dysfunction of one domain weakens the functional capacity of the other domain, reducing the degrees of freedom in coping with cognitive or emotional demands, and may thus cause serious disability in everyday-life activities (Naismith et al., 2007). Thus, the selection and optimisation of strategies for coping with challenges in normal and pathological life conditions (e.g., after brain injury and in depression) can succeed only when cognitive and emotional resources and (intrinsic and extrinsic) motivation are available at least to a critical minimum. However, as challenges consist not only of physical, cognitive, and emotional demands but also depend on the social environment, perception and expression of social signals represent an important repertoire in human behaviour. This repertoire is also partly based on basic cognitive and emotional functions and their interactions. Studies on the association and dissociation of cognitive and emotional functions might therefore also substantially contribute to the development of advanced treatment algorithms considering cognition, emotion, and motivation.

References

Adolphs, R. (2002). Neural systems for recognizing emotion. *Current Opinion in Neurobiology*, **12**, 169–177.

(2003). Cognitive neuroscience of human social behaviour. *Nature Reviews Neuroscience*, **4**, 165–178.

(2009). The social brain: Neural basis of social knowledge. *Annual Review of Psychology*, **60**, 693–716.

Adolphs, R., & Tranel, D. (2004). Impaired judgments of sadness but not happiness following bilateral amygdala damage. *Journal of Cognitive Neuroscience*, **16**, 453–462.

Adolphs, R., Tranel, D., & Damasio, A. R. (2003). Dissociable neural systems for recognizing emotions. *Brain and Cognition*, **52**, 61–69.

APA (1994). *Diagnostic and statistical manual of mental disorders*, 4th Edition, (DSM-IV). Washington, DC : American Psychiatric Association.

APA Dictionary (2007). Washington, DC: American Psychological Association.

Ashby, F. G., Isen, A. M., & Turken, U. (1999). A neuropsychological theory of positive affect and its influence on cognition. *Psychological Review*, **106**, 529–550.

Austin, M. P., Mitchell, P., & Goodwin, G. M. (2001). Cognitive deficits in depression – Possible implications for functional neuropathology. *British Journal of Psychiatry*, **178**, 200–206.

Barbas, H. (2000). Connections underlying the synthesis of cognition, memory, and emotion in primate prefrontal cortices. *Brain Research Bulletin*, **52**, 319–330.

Baumeister, R. F., Vohs, K. D., Dewall, C. N., & Zhang, L. Q. (2007). How emotion shapes behavior: Feedback, anticipation, and reflection, rather than direct causation. *Personality and Social Psychology Review*, **11**, 167–203.

Bearden, C. E., Glahn, D. C., Monkul, E. S., Barrett, J., Najt, P., Villarreal, V., & Soares, J. C. (2006). Patterns of memory impairment in bipolar disorder and unipolar major depression. *Psychiatry Research*, **142**, 139–150.

Bienvenu, O. J., Samuels, J. F., Costa, P. T., Reti, I. M., Eaton, W. W., & Nestadt, G. (2004). Anxiety and depressive disorders and the five-factor model of personality: A higher- and lower-order personality trait investigation in a community sample. *Depression and Anxiety*, **20**, 92–97.

Bornhofen, C., & McDonald, S. (2008). Emotion perception deficits following traumatic brain injury: A review of the evidence and rationale for intervention. *Journal of the International Neuropsychological Society*, **14**, 511–525.

Brodaty, H., Sachdev, P. S., Withall, A., Altendorf, A., Valenzuela, M. J., & Lorentz, L. (2005). Frequency and clinical, neuropsychological and neuroimaging correlates of apathy following stroke – The Sydney Stroke Study. *Psychological Medicine*, **35**, 1707–1716.

Buchanan, T. W., Tranel, D., & Adolphs, R. (2005). Emotional autobiographical memories in amnesic patients with medial temporal lobe damage. *Journal of Neuroscience*, **25**, 3151–3160.

Canli, T., Sivers, H., Thomason, M. E., Whitfield-Gabrieli, S., Gabrieli, J. D., & Gotlib, I. H. (2004). Brain activation to emotional words in depressed vs. healthy subjects. *Neuroreport*, **15**, 2585–2588.

Castaneda, A. E., Suvisaari, J., Marttunen, M., Perälä, J., Saarni, S. I., Alto-Setälä, T. A. H., Koskinen, S., Lonnquits, J., & Tuulio-Henriksson, A. (2008). Cognitive functioning in a population-based sample of young adults with a history of non-psychotic unipolar depressive disorders without psychiatric comorbidity. *Journal of Affective Disorders*, **110**, 36–45.

Charbonneau, S., Scherzer, B. P., Aspirot, D., & Cohen, H. (2003). Perception and production of facial and prosodic emotions by chronic CVA patients. *Neuropsychologia*, **41**, 605–613.

Chaytor, N., Temkin, N., Machamer, J., & Dikmen, S. (2007). The ecological validity of neuropsychological assessment and the role of depressive symptoms in moderate to severe traumatic brain injury. *Journal of the International Neuropsychological Society*, **13**, 377–385.

Clark, L., Iversen, S. D., & Goodwin, G. M. (2002). Sustained attention deficit in bipolar disorder. *British Journal of Psychiatry*, **180**, 313–319.

Clore, G. L., & Huntsinger, J. R. (2007). How emotions inform judgment and regulate thought. *Trends in Cognitive Sciences*, **11**, 393–399.

Clore, G. L., & Palmer, J. (2009). Affective guidance of intelligent agents: How emotion controls cognition. *Cognitive Systems Research*, **10**, 21–30.

Compton, R. J. (2003). The interface between emotion and attention: a review of evidence from psychology and neuroscience. *Behavioral & Cognitive Neuroscience Reviews* **2**, 115–129.

Connor-Smith, J. K., & Flachsbart, C. (2007). Relations between personality and coping: A meta-analysis. *Journal of Personality and Social Psychology*, **93**, 1080–1107.

Croker, V., & McDonald, S. (2005). Recognition of emotion from facial expression following traumatic brain injury. *Brain Injury*, **19**, 787–799.

Csukly, G., Czobor, P., Szily, E., Takacs, B., & Simon, L. (2009). Facial expression recognition in depressed subjects: the impact of intensity level and arousal dimension. *Journal of Nervous and Mental Disease*, **197**, 98–103.

Delgado, M. R. (2007). Reward-related responses in the human striatum. *Annals of the New York Academy of Sciences*, **1104**, 70–88.

Dichter, G. S., Felder, J. N., & Smoski, M. J. (2009). Affective context interferes with cognitive control in unipolar depression: An fMRI investigation. *Journal of Affective Disorders*, **114**, 131–142.

Dosenbach, N. U., Fair, D. A., Cohen, A. L., Schlaggar, B. L., & Petersen, S. E. (2008). A dual-networks architecture of top-down control. *Trends in Cognitive Sciences*, **12**, 99–105.

Dubrovsky, B. (1995). Fundamental neuroscience and the classification of psychiatric disorders. *Neuroscience and Biobehavioral Reviews*, **19**, 511–518.

Duffy, J. D., & Campbell, J. J. (2002). Regional prefrontal syndromes: a theoretical and clinical overview. In D. T. Stuss & R. T. Knight (Eds.), *Principles of frontal lobe function* (pp. 113–123). Oxford: Oxford University Press.

Dunkin, J. J., Leuchter, A. F., Cook, I. A., Kasl-Godley, J. E., Abrams, M., & Rosenberg-Thompson, S. (2000). Executive dysfunction predicts nonresponse to fluoxetine in major depression. *Journal of Affective Disorders*, **60**, 13–23.

Enge, S., Fleischhauer, M., Brocke, B., & Strobel, A. (2008). Neurophysiological measures of involuntary and voluntary attention allocation and dispositional differences in need for cognition. *Personality and Social Psychology Bulletin*, **34**, 862–874.

Frasch, K., Bullacher, C., Jaeger, M., Kilian, R., Rink, M., Wittek, R., Becker, T., & Neurmann, N. U. (2009). Effects of symptom reduction and psychotropic medication on cognitive impairment in depression. *Psychopathology*, **42**, 59–66.

Garety, P. A., Bebbington, P., Fowler, D., Freeman, D., & Kuipers, E. (2007). Implications for neurobiological research of cognitive models of psychosis: a theoretical paper. *Psychological Medicine*, **37**, 1377–1391.

Gottlieb, J., Balan, P., Oristaglio, J., & Suzuki, M. (2009). Parietal control of attentional guidance: the significance of sensory, motivational and motor factors. *Neurobiology of Learning & Memory*, **91**, 121–128.

Grady, C. L., & Keightley, M. L. (2002). Studies of altered social cognition in neuropsychiatric disorders using functional neuroimaging. *Canadian Journal of Psychiatry*, **47**, 327–336.

Green, M. J., Cahill, C. M., & Malhi, G. S. (2007). The cognitive and neurophysiological basis of emotion dysregulation in bipolar disorder. *Journal of Affective Disorders*, **103**, 29–42.

Green, R. E., Turner, G. R., & Thompson, W. F. (2004). Deficits in facial emotion perception in adults with recent traumatic brain injury. *Neuropsychologia*, **42**, 133–141.

Harrison, P. J. (2002). The neuropathology of primary mood disorders. *Brain*, **125**, 1428–1449.

Herbener, E. S., Song, W., Khine, T. T., & Sweeney, J. A. (2008). What aspects of emotional functioning are impaired in schizophrenia? *Schizophrenia Research*, **98**, 239–246.

Hornak, J., Rolls, E., & Wade, D. (1996). Face and voice expression identification in patients with emotional and behavioural changes following ventral frontal lobe damage. *Neuropsychologia*, **34**, 247–261.

Ietswaart, M., Milders, M., Crawford, J. R., Currie, D., & Scott, C. L. (2008). Longitudinal aspects of emotion recognition in patients with traumatic brain injury. *Neuropsychologia*, **46**, 148–159.

Izard, C. E., Fine, S., Mostow, A., Trentacosta, C., & Campbell, J. (2002). Emotion processes in normal and abnormal development and preventive intervention. *Development and Psychopathology*, **14**, 761–787.

Jimura, K., Locke, H. S., & Braver, T. S. (2010). Prefrontal cortex mediation of cognitive enhancement in rewarding motivational contexts. *Proceedings of the National Academy of Sciences of the United States of America*, **107**, 8871–8876.

Jorge, R. E., Robinson, R. G., Moser, D., Tateno, A., Crespo-Facorro, B., & Arndt, S. (2004). Major depression following traumatic brain injury. *Archives of General Psychiatry*, **61**, 42–50.

Jorge, R. E., Robinson, R. G., Starkstein, S. E., & Arndt, S. V. (1994). Influence of major depression on 1-year outcome in patients with traumatic brain injury. *Journal of Neurosurgery*, **81**, 726–733.

Jorge, R. E., & Starkstein, S. E. (2005). Pathophysiologic aspects of major depression following traumatic brain injury. *Journal of Head Trauma Rehabilitation*, **20**, 475–487.

Jorge, R. E., Starkstein, S. E., & Robinson, R. G. (2010). Apathy following stroke. *Canadian Journal of Psychiatry*, **55**, 350–354.

Kan, Y., Mimura, M., Kamijima, K., & Kawamura, M. (2004). Recognition of emotion from moving facial and prosodic stimuli in depressed patients. *Journal of Neurology, Neurosurgery, and Psychiatry*, **75**, 1667–1671.

Kauhanen, M. L., Korpelainen, J. T., Hiltunen, P., Brusin, E., Mononen, H., Maatta, R., Nieminen, P., Sotaniemi, K. A., & Myllyla, V. V. (1999). Poststroke depression correlates with cognitive impairment and neurological deficits. *Stroke*, **30**, 1875–1880.

Koole, S. (2009). The psychology of emotion regulation: An integrative review. *Cognition & Emotion*, **23**, 4–41.

Kouneiher, F., Charron, S., & Koechlin, E. (2009). Motivation and cognitive control in the human prefrontal cortex. *Nature Neuroscience*, **12**, 939–945.

Kucharska-Pietura, K., Phillips, M. L., Gernand, W., & David, A. S. (2003). Perception of emotions from faces and voices following unilateral brain damage. *Neuropsychologia*, **41**, 1082–1090.

Landro, N. I., Stiles, T. C., & Sletvold, H. (2001). Neuropsychological function in nonpsychotic unipolar major depression. *Neuropsychiatry, Neuropsychology, & Behavioral Neurology*, **14**, 233–240.

Lesser, I. M., & Chung, J. A. (2007). Depression and the frontal lobes. In B. L. Miller & J. L. Cummings (Eds.), *The human frontal lobe: Functions and disorders* (2nd ed.) (pp. 636–648). New York, London: The Guilford Press.

Levin, R. L., Heller, W., Mohanty, A., Herrington, J. D., & Miller, G. A. (2007). Cognitive deficits in depression and functional specificity of regional brain activity. *Cognitive Therapy & Research*, **31**, 211–233.

Lewis, M. D. (1995). Cognition-emotion feedback and the self-organization of developmental paths. *Human Development*, **38**, 71–102.

Lyons, W. (2008). The philosophy of cognition and emotion. In M. Power & T. Dalgleish (Eds.), *Cognition and emotion: From order to disorder* (2 ed.) (pp. 21–59). Hove, UK and New York, NY: Psychological Press.

Maio, G. R., & Esses, V. M. (2001). The need for affect: Individual differences in the motivation to approach or avoid emotions. *Journal of Personality*, **69**, 583–615.

Majer, M., Ising, M., Kunzel, H., Binder, E. B., Holsboer, F., Modell, S., & Zihl, J. (2004). Impaired divided attention predicts delayed response and risk to relapse in subjects with depressive disorders. *Psychological Medicine*, **34**, 1453–1463.

Marquardt, T. P., Rios-Brown, M., & Richburg, T. (2001). Comprehension and expression of affective sentences in traumatic brain injury. *Aphasiology*, **15**, 1091–1101.

McDonald, S., Bornhofen, C., & Hunt, C. (2009). Addressing deficits in emotion recognition after severe traumatic brain injury: The role of focused attention and mimicry. *Neuropsychological Rehabilitation*, **19**, 321–339.

McNaughton, N. (1997). Cognitive dysfunction resulting from hippocampal hyperactivity – a possible cause of anxiety disorder? *Pharmacology, Biochemistry & Behaviour*, **56**, 603–611.

Milders, M., Ietswaart, M., Crawford, J. R., & Currie, D. (2008). Social behavior following traumatic brain injury and its association with emotion recognition, understanding of intentions, and cognitive flexibility. *Journal of the International Neuropsychology Society*, **14**, 318–326.

Mitchell, R. L., Elliott, R., Barry, M., Cruttenden, A., & Woodruff, P. W. (2003). The neural response to emotional prosody, as revealed by functional magnetic resonance imaging. *Neuropsychologia*, **41**, 1410–1421.

Moore, S. A. (2009). Cognitive abnormalities in posttraumatic stress disorder. *Current Opinion in Psychiatry*, **22**, 19–24.

Naismith, S. L., Longley, W. A., Scott, E. M., & Hickie, I. B. (2007). Disability in major depression related to self-rated and objectively-measured cognitive deficits: a preliminary study – art. no. 32. *BMC Psychiatry*, **7**, 32.

Nakagami, E., Hoe, M., & Brekke, J. S. (2010). The prospective relationship among intrinsic motivation, neurocognition, and psychosocial functioning in schizophrenia. *Schizophrenia Bulletin*, **36**: 935–938.

Namiki, C., Yamada, M., Yoshida, H., Hanakawa, T., Fukuyama, H., & Murai, T. (2008). Small orbitofrontal traumatic lesions detected by high resolution MRI in a patient with major behavioural changes. *Neurocase*, **14**, 474–479.

Neu, P., Kiesslinger, U., Schlattmann, P., & Reischies, F. M. (2001). Time-related cognitive deficiency in four different types of depression. *Psychiatry Research*, **103**, 237–247.

Ochsner, K. N. (2008). The social-emotional processing stream: five core constructs and their translation potential for schizophrenia and beyond. *Biological Psychiatry*, **64**, 48–61.

Ochsner, K. N., & Gross, J. J. (2005). The cognitive control of emotion. *Trends in Cognitive Sciences*, **9**, 242–249.

Ostir, G. V., Berges, I. M., Ottenbacher, M. E., Clow, A., & Ottenbacher, K. J. (2008). Associations between positive emotion and recovery of functional status following stroke. *Psychosomatic Medicine*, **70**, 404–409.

Paradiso, S., Chemerinski, E., Yazici, K. M., Tartaro, A., & Robinson, R. G. (1999). Frontal lobe syndrome reassessed: comparison of patients with lateral or medial frontal brain damage. *Journal of Neurology, Neurosurgery, and Psychiatry*, **67**, 664–667.

Parikh, R. M., Robinson, R. G., Lipsey, J. R., Starkstein, S. E., Fedoroff, J. P., & Price, T. R. (1990). The impact of poststroke depression on recovery in activities of daily living over a 2-year follow-up. *Archives of Neurology*, **47**, 785–789.

Pell, M. D. (1998). Recognition of prosody following unilateral brain lesion: influence of functional and structural attributes of prosodic contours. *Neuropsychologia*, **36**, 701–715.

Pessoa, L. (2008). On the relationship between emotion and cognition. *Nature Reviews Neuroscience*, **9**, 148–158.

Piech, R. M., Hampshire, A., Owen, A. M., & Parkinson, J. A. (2009). Modulation of cognitive flexibility by hunger and desire. *Cognition & Emotion*, **23**, 528–540.

Porter, R. J., Bourke, C., & Gallagher, P. (2007). Neuropsychological impairment in major depression: its nature, origin and clinical significance. *Australian and New Zealand Journal of Psychiatry*, **41**, 115–128.

Posner, M. I., & Raichle, M. (1994). *Images of Mind*. New York: Scientific American Library, W. H. Freeman and Company.

Powell, K. B., & Voeller, K. K. S. (2004). Prefrontal executive function syndromes in children. *Journal of Child Neurology*, **19**, 785–797.

Rankin, K. P. (2007). Social cognition in frontal injury. In B. L. Miller & J. L. Cummings (Eds.), *The human frontal lobes: Functions and disorders* (2nd ed.) (pp. 345–360). New York, London: The Guilford Press.

Raymond, J. (2009). Interactions of attention, emotion and motivation. *Progress in Brain Research*, **176**, 293–308.

Reppermund, S., Ising, M., Lucae, S., & Zihl, J. (2009). Cognitive impairment in unipolar depression is persistent and non-specific: further evidence for the final common pathway disorder hypothesis. *Psychological Medicine*, **39**, 603–614.

Reppermund, S., Zihl, J., Lucae, S., Horstmann, S., Kloiber, S., Holsboer, F., & Ising, M. (2007). Persistent cognitive impairment in depression: The role of psychopathology and altered hypothalamic-pituitary-adrenocortical (HPA) system regulation. *Biological Psychiatry*, **62**, 400–406.

Rosen, H. J., Wilson, M. R., Schauer, G. F., Allison, S., Gorno-Tempini, M. L., Pace-Savitsky, C., Kramer, J. H., Levenson, R. W., Weiner, M., & Miller, B. L. (2006). Neuroanatomical correlates of impaired recognition of emotion in dementia. *Neuropsychologia*, **44**, 365–373.

Sakagami, M., & Watanabe, M. (2007). Integration of cognitive and motivational information in the primate lateral prefrontal cortex. *Annals of the New York Academy of Sciences*, **1104**, 89–107.

Scheurich, A., Fellgiebel, A., Schermuly, I., Bauer, S., Wolfges, R., & Mueller, M. J. (2008). Experimental evidence for a motivational origin of cognitive impairment in major depression. *Psychological Medicine*, **38**, 237–246.

Schultz, J., & Pilz, K. S. (2009). Natural facial motion enhances cortical responses to faces. *Experimental Brain Research*, **194**, 465–475.

Shenal, B. V., Harrison, D. W., & Demaree, H. A. (2003). The neuropsychology of depression: a literature review and preliminary model. *Neuropsychology Review*, **13**, 33–42.

Shizgal, P. (1999). Motivation. In R. A. Wilson & F. C. Keil (Eds.), *The MIT Encyclopedia of the Cognitive Sciences* (pp. 566–568). Cambridge, MA: The MIT Press.

Silverstein, S. M. (2010). Bridging the gap between extrinsic and intrinsic motivation in the cognitive remediation of schizophrenia. *Schizophrenia Bulletin*, **36**, 949–956.

Simons, C. J. P., Jacobs, N., Derom, C., Thiery, E., Jolles, J., van Os, J., & Krabbendam, L. (2009). Cognition as predictor of current and follow-up depressive symptoms in the general population. *Acta Psychiatrica Scandinavica*, **120**, 45–52.

Smith, K. S., Tindell, A. J., Aldrige, J. W., & Berridge, K. C. (2009). Ventral pallidum roles in reward and motivation. *Behavioral Brain Research*, **196**, 155–167.

Starkstein, S. E., Petracca, G., Chemerinski, E., & Kremer, J. (2001). Syndromic validity of apathy in Alzheimer's disease. *American Journal of Psychiatry*, **158**, 872–877.

Storbeck, J., & Clore, G. L. (2007). On the interdependence of cognition and emotion. *Cognition & Emotion*, **21**, 1212–1237.

Stordal, K. I., Lundervold, A. J., Egeland, J., Mykletun, A., Asbjornsen, A., Landro, N. I., Roness, A., Rund, B. R., Sundet, K., Oedegaard, K. J., & Lund, A. (2004). Impairment across executive functions in recurrent major depression. *Nordic Journal of Psychiatry*, **58**, 41–47.

Surguladze, S. A., Young, A. W., Senior, C., Brebion, G., Travis, M. J., & Phillips, M. L. (2004). Recognition accuracy and response bias to happy and sad facial expressions in patients with major depression. *Neuropsychology*, **18**, 212–218.

Taylor, S. F., & Liberzon, I. (2007). Neural correlates of emotion regulation in psychopathology. *Trends in Cognitive Science*, **11**, 413–418.

Tonks, J., Slater, A., Frampton, I., Wall, S. E., Yates, P., & Williams, W. H. (2009). The development of emotion and empathy skills after childhood brain injury. *Developmental Medicine and Child Neurology*, **51**, 8–16.

Tonks, J., Williams, W. H., Frampton, I., Yates, P., Wall, S. E., & Slater, A. (2008). Reading emotions after childhood brain injury: Case series evidence of dissociation between cognitive abilities and emotional expression processing skills. *Brain Injury*, **22**, 325–332.

Van Overwalle, F. (2009). Social Cognition and the Brain: A Meta-Analysis. *Human Brain Mapping*, **30**, 829–858.

Vecera, S. P., & Rizzo, M. (2004). What are you looking at? Impaired 'social attention' following frontal-lobe damage. *Neuropsychologia*, **42**, 1657–1665.

Vuilleumier, P. (2005). How brains beware: neural mechanisms of emotional attention. *Trends in Cognitive Sciences*, **9**, 585–594.

Watts, A. J., & Douglas, J. M. (2006). Interpreting facial expression and communication competence following severe traumatic brain injury. *Aphasiology*, **20**, 707–722.

Westermann, R., Spies, K., Stahl, G., & Hesse, F. W. (1996). Relative effectiveness and validity of mood induction procedures: A meta-analysis. *European Journal of Social Psychology*, **26**, 557–580.

WHO (1993). *The ICD-10 Classification of Mental and Behavioral Disorders. Diagnostic Criteria for Research.* Geneva: World Health Organization.

Wildgruber, D., Ackermann, H., Kreifelts, B., & Ethofer T. (2006). Cerebral processing of linguistic and emotional prosody: fMRI studies. *Progress in Brain Research*, **156**, 249–268.

Wildgruber, D., Riecker, A., Hertrich, I., Erb, M., Grodd, W., Ethofer, T., & Ackermann, H. (2005). Identification of emotional intonation evaluated by fMRI. *Neuroimage*, **24**, 1233–1241.

Zihl, J., Groen, G., & Brunnauer, A. (1998). Cognitive deficits in schizophrenia and affective disorders: evidence for a final common pathway disorder. *Acta Psychiatrica Scandinavica*, **97**, 351–357.

Zupan, B., Neumann, D., Babbage, D. R., & Willer, B. (2009). The importance of vocal affect to bimodal processing of emotion: Implications for individuals with traumatic brain injury. *Journal of Communication Disorders*, **42**, 1–17.

5

The Impact of Anxiety on Cognitive Performance

Michael W. Eysenck

INTRODUCTION

This chapter is concerned mainly with the effects of individual differences in anxiety as a personality dimension on various kinds of cognitive performance. More specifically, the emphasis will be on trait anxiety (a dimension relating to general susceptibility to anxiety) and test anxiety (a dimension relating to susceptibility to anxiety specifically in test situations). Not surprisingly, there is typically a negative association or correlation between anxiety and performance. For example, Hembree (1988) reviewed hundreds of studies and found that the mean correlation between anxiety and aptitude or achievement was −0.29. There are obvious issues here concerning the direction of causality: does anxiety impair performance or does poor performance create anxiety? The evidence from intervention studies strongly suggests that much of the association occurs because anxiety impairs performance. For example, Schwarzer (1990) reviewed the findings from 137 intervention studies. Participants who received treatment for test anxiety had higher scores on test performance and grade point average than participants in placebo or waiting list groups.

There is another issue that needs to be addressed at this point. In addition to the causality issue, there is an additional problem of interpretation with studies, in which it is found that individuals scoring high in trait or test anxiety perform significantly worse than those scoring low. There is typically a moderate correlation between trait measures of anxiety and state measures (assessing current levels of anxiety). Accordingly, the findings may reflect the direct influence of trait or test anxiety on performance or the influence may be indirect via state anxiety. Surprisingly, this issue has been addressed in relatively few studies, so it is not possible to adjudicate between these two possibilities. However, it would be useful in future research to use experimental designs including low and high stress conditions to clarify the respective roles of trait and state anxiety in affecting performance.

PROCESSING EFFICIENCY AND ATTENTIONAL CONTROL THEORIES

Several theories have been put forward over the years to account for the negative effects of trait and test anxiety on performance (see Eysenck, 1992, for a review). These theories vary in terms of the extent to which they are explicitly cognitive in their approach (i.e., having an explicit focus on the specific cognitive mechanisms most affected by anxiety). In my opinion, such cognitive theories offer the best prospect of understanding the effects of anxiety on performance. In view of space limitations, I will focus mostly on two cognitive theories that I developed with colleagues. The first one is processing efficiency theory (Eysenck & Calvo, 1992) and the second is a development of that theory known as attentional control theory (Eysenck et al., 2007).

Two theoretical assumptions are of crucial importance within processing efficiency theory. First, a distinction is drawn between performance effectiveness and processing efficiency. Performance effectiveness simply refers to the quality of performance (e.g., number of items correct). In contrast, processing efficiency is based on the relationship between performance effectiveness and the resources used to achieve that level of performance. Processing efficiency (especially in high-anxious individuals) can be reduced by task-irrelevant thoughts (e.g., worries, self-preoccupations). It is assumed that anxiety has a greater adverse effect on processing efficiency than on performance effectiveness. The reason is that anxious individuals will often attempt to *compensate* for the negative effects of anxiety on processing efficiency by deploying additional processing resources or effort.

Second, it was assumed within processing efficiency theory that the adverse effects of anxiety on processing efficiency are mediated by the working memory system proposed by Baddeley (1986). This theoretical approach was developed further by Baddeley (2001), but we will focus on the earlier version of the theory, according to which the working memory system consists of an attention-like, domain-free central executive plus two 'slave' systems. One of these slave systems (the phonological loop) is involved in the rehearsal of verbal information and the other slave system (the visuospatial sketchpad) is involved in the processing and temporary storage of visual and spatial information. It was predicted that there would be strong negative effects of anxiety on the functioning of the central executive plus smaller negative effects on the functioning of the phonological loop. Why were these predictions made?

It was assumed that anxiety is associated with task-irrelevant thoughts such as worry, and that these task-irrelevant thoughts utilise some of the limited processing capacity of the central executive and phonological loop.

Attentional control theory (Eysenck et al., 2007) incorporates the major assumptions of processing efficiency theory, but provides a more comprehensive account of the effects of anxiety on performance. This theory (also discussed by Derakshan and Eysenck, 2009) makes several new assumptions, but we will consider only the most important one in detail. It was argued that the assumption that anxiety impairs the functioning of the central executive is imprecise in view of the accumulating evidence that the central executive fulfils various functions. For example, Miyake et al. (2000) applied latent-variable analysis to the data obtained from several executive tasks and identified three functions. One was the inhibition function, which involves using attentional control to resist disruption or interference from task-irrelevant stimuli or responses. Another was the shifting function, which involves using attentional control to shift attention in a flexible way to maintain focus on currently relevant task stimuli. Finally, there was the updating function, which is concerned with updating and monitoring information contained within working memory. According to attentional control theory, anxiety impairs attentional control in two different ways. First, it impairs the efficiency of the inhibition function, which involves using attentional control in a negative way to prevent attention being focused on task-irrelevant stimuli and responses. Second, it impairs the efficiency of the shifting function, which involves using attentional control in a positive way to redirect attention to respond appropriately to changing task demands.

There is one other assumption of attentional control theory that merits a brief mention at this point. There has been much research on attentional bias, which is a tendency to attend to threat-related stimuli rather than neutral ones. In a recent meta-analysis (Bar-Haim et al., 2007), there was convincing support for the hypothesis that high-anxious individuals are significantly more likely than low anxious ones to exhibit attentional bias. As a consequence, the performance of high-anxious individuals in the presence of distractors is especially more likely to be impaired than that of low anxious ones when the distractors are threat-related (e.g., an angry face) than when they are neutral. Most of the available evidence supports that prediction (Eysenck et al., 2007).

In what follows, we consider the research relating to the three major assumptions discussed above. The relevant evidence was reviewed by Eysenck et al. (2007). Accordingly, the focus here will mostly be on recent research postdating that review, but will also include some of the most important earlier research.

Working Memory

According to processing efficiency theory, anxiety is associated with worry, and worry utilises some of the processing resources of the working memory system. The assumption that worry requires working-memory capacity was tested by Hayes, Hirsch, and Mathews (2008). They asked high and low worriers to think about a current worry or a positive personally relevant topic when attempting to press keys in a random order. High levels of performance on this task require considerable use of the resources of working memory. The key finding was that high worriers performed worse than low worriers on the random key-press task only when engaged in worry. The implication is that worry consumes some of the available attentional resources of working memory and thus impairs task performance.

Evidence that the anxiety reduces the available capacity of working memory was reported by Derakshan and Eysenck (1998). They used a load paradigm, in which participants performed a primary task concurrently with a secondary or load task that imposed low or high demands on working memory capacity. The primary task involved simple reasoning, and the main dependent variable was response latency on this task. There was no difference between the low- and high-anxious groups on this measure when the secondary task imposed low demands on working memory capacity. However, the adverse effects of a concurrent highly demanding secondary task on response latency on the reasoning task were substantially greater for high-anxious than for low-anxious participants. These findings suggest that individuals high in trait anxiety had fewer available working memory resources to process the reasoning task.

Additional evidence that the effects of anxiety on performance depend in part on working memory capacity was reported by Johnson and Gronlund (2009) in a study using a dual-task paradigm. They considered four groups of individuals based on the two dimensions of trait anxiety and working memory capacity. There was a significant interaction between anxiety and working memory capacity: the adverse effects of high trait anxiety on dual-task performance were especially great among those individuals low in working memory capacity. This is consistent with the notion that reduced available working memory capacity is in part responsible for anxiety's impairment effect on performance.

Eysenck, Payne, and Derakshan (2005) reported one of the most direct attempts to test the prediction that anxiety impairs central-executive functioning more than that of the other components of the working-memory system. High- and low-anxious participants performed a primary complex visuospatial task concurrently with a secondary task that varied in its demands on the working memory system. More specifically, the secondary task predominantly required use of the central executive or the phonological loop or the visuospatial sketchpad. The key finding was that the high-anxious group performed the primary visuospatial task significantly worse than the low-anxious group only when the secondary task involved the central executive. These findings suggest that anxiety reduces the available capacity of the central executive but has small or nonexistent effects on the capacity of the phonological loop or the visuospatial sketchpad.

Owens et al. (2008) used a different experimental approach to show that adverse effects of anxiety on performance depend on working memory. They assessed verbal working memory (central executive + phonological loop) and academic performance in individuals varying in their level of trait anxiety. Anxiety was negatively associated with academic performance. However, the key finding was that this association was mediated by verbal working memory. In other words, much of the negative effect of anxiety on academic performance occurred indirectly because anxiety impaired verbal working memory.

Findings apparently discrepant with those of Owens et al. (2008) were reported by Shackman et al. (2006). They found that threat-induced anxiety impaired performance on a task involving spatial working memory but not on one that involved verbal working-memory performance.

In sum, there is considerable evidence (much of it not discussed here) indicating that high levels of trait anxiety are associated with impaired working-memory functioning. Of the components of working memory, anxiety most consistently impairs the central executive as predicted by processing efficiency theory. However, there are apparently inconsistent findings concerning the effects of anxiety on the phonological loop and the visuospatial sketchpad. In principle, the most direct approach to identifying the components of the working memory system adversely affected by anxiety is to use a dual-task design with secondary tasks predominantly involving a single component (Eysenck et al., 2005). It is more difficult to interpret the findings when the effects of anxiety on a single task involving two separate components of the working memory system are assessed (e.g., Owens et al., 2008; Shackman et al., 2006).

Efficiency versus Effectiveness

One of the major predictions of processing efficiency theory is that the adverse effects of anxiety will typically be greater on processing efficiency than on performance effectiveness. The same prediction follows from attentional control theory, but that theory makes the slightly more specific prediction that this processing inefficiency relates primarily to attentional control mechanisms. Several studies over the years have tested this prediction. However, it has proved difficult to operationalise processing efficiency because of problems with assessing an individual's use of processing resources.

Nearly all of the relevant research until comparatively recently involved behavioural data only. Some of this research involved the probe technique, in which a primary task is performed either on its own or concurrently with a secondary task (e.g., responding as rapidly as possible to sporadic auditory probes). The instructions for the latter dual-task condition emphasise that the primary task should be performed as well as possible with only spare processing capacity being used to perform the secondary task. It is assumed that reaction times to the probes provide an approximate measure of processing efficiency: participants who are relatively inefficient in their processing of the primary task will have fewer spare processing resources than those who are more efficient, and will thus respond more slowly to the probes. The prediction is that high-anxious individuals will have slower reaction times to the probes than low anxious ones.

Eysenck and Payne (in preparation) used the probe technique in two experiments. In one experiment, the main task was a verbal one and in the second experiment it was mathematical. In both experiments, the demands of the main task on working memory increased as participants worked their way through each trial, and the probe could be presented at any point during a trial. There were no effects of anxiety on performance effectiveness on the primary task in either experiment.

The two main findings relating to probe reaction time were obtained in both experiments and were as predicted theoretically. First, there was a significant main effect with high-anxious individuals having longer reaction times to the probe than low anxious ones. Second, there was an interaction between anxiety and task demands at the moment the probe was presented: high-anxious participants performed especially slower to the probes relative to low anxious ones when task demands were high.

Murray and Janelle (2007) carried out a study resembling the experiments of Eysenck and Payne (in preparation) in some ways. Participants were exposed to conditions designed to produce high or low levels of anxiety. They carried out a simulated driving task and responded periodically to a target light. The anxiety manipulation had very little effect on performance effectiveness as reflected in driving speed. However, participants in the high-anxiety condition had a reduced P3 to cue onset on the light-detection task. The implication is that participants in this condition had reduced processing efficiency and so had impaired processing of the cue.

Nearly all of the research discussed so far has focused on behavioural evidence. An alternative way of assessing processing efficiency is to make use of various techniques for assessing brain activity during task performance. There would be evidence that anxiety is associated with impaired processing efficiency if there were no effects of anxiety on performance effectiveness but high anxiety was associated with greater increases in brain activation in areas involved in attentional control. Several recent studies have used approximately this approach. For example, Savostyanov et al. (2009) compared individuals high and low in trait anxiety using the stop-signal paradigm, in which participants need to inhibit a dominant motor response on those trials on which a stop signal is presented. There were no effects of anxiety on reaction times or on error rate, so anxiety did not affect performance effectiveness. However, Savostyanov et al. also considered event-related perturbations of EEG spectral power in two analyses. In the first analysis, they focused on EEG desynchronisation before and after the button press on trials on which participants were required to respond. High-anxious participants showed significantly greater alpha and beta desynchronisation before and after the button press than low-anxious participants. In the second analysis, the focus was on EEG desynchronisation on stop trials in the time period following onset of the stop signal. High-anxious participants had greater EEG desynchronisation during the first 600 ms after stop-signal onset, predominantly in 8–13 Hz. These findings suggest that high-anxious participants exhibited greater processing inefficiency than low anxious ones by engaging in prolonged attempts at cognitive control.

Fales et al. (2008) presented their participants with the three-back task, in which they had to indicate whether a given word was the same as (or different from) the word displayed three words back. There were no effects of anxiety on performance effectiveness on this task. However, high-anxious participants had greater transient activation in brain areas such as dorsolateral and ventrolateral prefrontal cortex that are associated with attentional control, which is suggestive of impaired efficiency.

Telzer et al. (2008) carried out a study on attentional bias in individuals high and low in trait anxiety. They considered brain activation in conditions differing in their demands on attentional control, focusing on the difference in brain activation between the more demanding and the less demanding condition. This difference was significantly greater in the right dorsolateral prefrontal cortex in high-anxious individuals than in low anxious ones. This is consistent with the hypothesis that anxiety reduces processing efficiency.

In sum, the use of functional neuroimaging and event-related potentials is making it easier to compare processing efficiency in high-anxious and low-anxious groups. It is easiest to relate the findings to processing efficiency theory and attentional control theory when there are no effects of anxiety on performance effectiveness. When that is the case, greater brain activation in areas associated with attentional control among high-anxious rather than low-anxious individuals is suggestive evidence that anxiety has impaired processing efficiency. The studies by Savostyanov et al. (2009) and Fales et al. (2008) exhibit this discrepancy between the behavioural and neuroimaging findings. Another study discussed later in the chapter (Santos, Wall, & Eysenck, submitted) also fits that pattern.

It is often more difficult to relate the findings to the theories when anxiety impairs performance effectiveness. For example, Bishop (2009) found that when using a target-detection task high-anxious individuals took longer than low anxious ones to detect the targets. The high-anxious individuals also showed reduced prefrontal activity compared to the low-anxious individuals. *Processing efficiency* is defined approximately as performance effectiveness divided by use of resources. With Bishop's data, the numerator and the denominator were both significantly less for high-anxious than low-anxious individuals. That means that it is difficult to decide whether high-anxious participants had less or more processing efficiency than low anxious ones. It is possible that high-anxious individuals find it harder than low anxious ones to modulate attentional control. In other words, they may engage in excessive attempts at attentional control in some circumstances (e.g., Savostyanov et al., 2009), but may show deficient attempts at attentional control in other circumstances (e.g., Bishop, 2009).

Inhibition and Shifting Functions

There has been much more research on the effects of anxiety on the inhibition function than the shifting function. Most research on the inhibition function has focused on the effects of distraction on performance. The obvious prediction from attentional control theory is that anxious individuals will be more susceptible to distraction because of their impaired inhibition function. Nearly 20 studies have obtained support for this prediction (see Eysenck et al., 2007, for a review). However, there is a limitation with most of these studies in that they do not reveal the mechanisms responsible for the greater susceptibility to distraction among high-anxious individuals.

The above issue was addressed by Derakshan et al. (2009). They assessed the inhibition function by using the antisaccade task. On this task, participants are presented with a peripheral cue to the left or right of the fixation point. They are instructed to avoid looking at the cue and instead to fixate on the other side of the fixation point as rapidly as possible. What is of interest is the latency of the first correct saccade to the side opposite that to which the cue was presented. There is also a control condition (the prosaccade task), in which the requirement is to fixate the cue as soon as it appears.

Derakshan et al. (2009) assumed that the antisaccade task requires use of the inhibition function, whereas the prosaccade task does not. Accordingly, they predicted that high-anxious individuals would take longer than low anxious ones to make a correct saccade on the antisaccade task, but that anxiety would have no effect on this dependent variable on the prosaccade task. This was precisely what Derakshan et al. found in their first experiment, in which the cue was an oval shape. In their second experiment, they used angry, happy, and neutral facial expressions as cues. In view of the evidence that anxious individuals have an attentional bias for threat-related stimuli (e.g., Bar-Haim et al., 2007), it was predicted that the slowing effects of anxiety on the antisaccade task would be greatest when the cue was an angry face. That prediction was supported.

As mentioned earlier, there has been very little research on anxiety and the shifting function. However, Ansari, Derakshan, and Richards (2008) recently reported findings from a task-switching study involving the antisaccade and prosaccade tasks. There were two conditions. In the single-task condition, there were separate blocks of antisaccade and prosaccade trials. In the mixed-task condition, antisaccade and prosaccade trials were interspersed. In line with findings previously reported by other researchers, they found that there was a paradoxical improvement in that the latency of the first correct saccade on the antisaccade task was faster in the mixed-task condition than in the single-task condition. The precise reasons for this paradoxical improvement when the shifting function is required are not known, although it is likely that it reflects a greater level of task engagement in the task-switching condition. The key finding reported by Ansari et al. was that this paradoxical improvement in the task-switching condition was not obtained from high-anxious participants but only from low anxious ones. The implication is that high-anxious individuals are less efficient than low anxious ones at using the shifting function.

Derakshan, Smyth, and Eysenck (2009) carried out the most thorough study to date. What is required in order to assess the effects of anxiety on the shifting function in a relatively direct way is to have two conditions differing only in terms of the demands on the shifting function. Derakshan et al. used pairs of tasks (e.g., multiplication and division). In the switching condition, the task alternated on every trial. In the non-switching condition, in contrast, each block of trials was devoted to a single task. The problems used were the same in the switching and non-switching conditions.

Derakshan et al. (2009) obtained a highly significant interaction between anxiety and task switching, and the nature of this interaction was as predicted by attentional control theory. The high-anxious participants performed much more slowly when task switching was required than when it was not, whereas the low-anxious participants were relatively unaffected by the presence versus absence of task switching.

Santos et al. (submitted) also investigated the effects of anxiety on the shifting function. Participants performed three simple tasks under high-switching, low-switching, and no-switching conditions. The fact that the tasks were all simple probably explains why there were no effects of anxiety on performance effectiveness in terms of reaction times and error rate. In order to assess processing efficiency, Santos et al. used fMRI to record brain activity. It was assumed that the increase in brain activation in the high- and low-switching conditions compared to the no-switching condition was due to greater use of processing resources when the shifting function was required. The further assumption that high-anxious individuals would make more inefficient use of the shifting function than low anxious ones led to the prediction that there should be a greater increase in brain activation for individuals high in anxiety. It was also predicted that the effects of anxiety on brain activation should be especially pronounced in areas activated when the shifting function is used (e.g., BA9/46; anterior cingulate: see Wager, Jonides, & Reading, 2004, for a review). Both of these predictions were confirmed.

In sum, there is accumulating evidence that anxiety impairs the inhibition and shifting functions. This is of considerable importance. Both of these functions relate to attentional control, and both are required to perform a very wide range of tasks. Accordingly, many of the negative effects of anxiety on processing efficiency and performance effectiveness can be interpreted in terms of adverse effects of anxiety on those two functions.

Miyake et al. (2000) also identified an updating and monitoring function. There are various tasks that can be used to assess that function. For example, there is the N-back task, in which a series of items is presented. As soon as the series has finished, the participant has to indicate the identity of the item presented a given distance back in the series (e.g., three back, four back). It is assumed within attentional control theory that this function involves basic memory processes and is essentially unaffected by anxiety. Some support for this assumption was discussed by Eysenck et al. (2007). There is also a more recent study by Walkenhorst and Crowe (2009), in which they considered the effects of trait anxiety on verbal and spatial N-back tasks. They found that their high-anxious participants responded faster than the low anxious ones on both of these tasks, suggesting that anxiety does not impair the updating and monitoring function.

CONCLUSIONS

Much progress has been made in understanding the various ways in which the effects of anxiety on processing efficiency and performance effectiveness are mediated by the cognitive system. As we have seen, there is convincing support for several of the major assumptions incorporated within processing efficiency theory and attentional control theory. First, anxiety impairs the efficiency of the working memory system, especially the central executive component of that system. Second, more specifically, anxiety adversely affects the efficiency of at least two of the functions associated with the central executive, namely, the inhibition and shifting functions. Third, anxiety has a greater negative effect on processing efficiency than on performance effectiveness.

What issues remain to be investigated systematically in future research? Two issues seem to be of special importance. First, it is assumed that anxiety impairs processing efficiency more than performance effectiveness because high-anxious individuals often utilise more processing resources or effort than low anxious ones. As yet, we have little understanding of the processes responsible for this enhanced motivation. Eysenck and Calvo (1992) speculated that high-anxious individuals attempt to reduce their negative self-thoughts (e.g., 'I can't do this task properly'; 'I am doing really badly') by increasing effort to produce a reasonable level of performance. The notion that negative self-thoughts can have motivational consequences remains plausible, but there is as yet a dearth of directly relevant evidence.

Second, attentional control theory made much use of Miyake et al.'s (2000) identification of three central executive functions based on their impressive empirical research. However, there is no consensus as yet concerning the number and nature of executive functions. Collette and van der Linden (2002) reviewed brain-imaging studies of executive functions, and concluded that there was support from such studies for the three functions identified by Miyake et al. In addition, however, they argued persuasively that dual-task coordination should be added to the list of executive functions. It is an important task for the future to see whether anxiety impairs the efficiency of dual-task coordination in the same way that it impairs the efficiency of the inhibition and shifting functions.

References

Ansari, T. L., Derakshan, N., & Richards, A. (2008). Effects of anxiety on task switching: Evidence from the mixed antisaccade task. *Cognitive Affective & Behavioral Neuroscience*, **8**, 229–238.

Baddeley, A. D. (1986). *Working memory*. Oxford: Clarendon Press.

(2001). Is working memory still working? *American Psychologist*, **56**, 851–864.

Bar-Haim, Y., Lamy, D., Pergamin, L., Bakermans-Kranenburg, M. J., & van Ijzendoorn, M. H. (2007). Threat-related attentional bias in anxious and nonanxious individuals: A meta-analytic study. *Psychological Bulletin*, **133**, 1–24.

Bishop, S. J. (2009). Trait anxiety and impoverished prefrontal control of attention. *Nature Neuroscience*, **12**, 92–98.

Collette, F., & van der Linden, M. (2002). Brain imaging of the central executive component of working memory. *Neuroscience and Biobehavioral Reviews*, **26**, 105–125.

Derakshan, N., Ansari, T. L., Hansard, M., Shoker, L., & Eysenck, M. W. (2009). Anxiety, inhibition, efficiency, and effectiveness: An investigation using the antisaccade task. *Experimental Psychology*, **56**, 48–55.

Derakshan, N., & Eysenck, M. W. (1998). Working memory capacity in high trait-anxious and repressor groups. *Cognition & Emotion*, **12**, 697–713.

(2009). Anxiety, processing efficiency, and cognitive performance: New developments from attentional control theory. *European Psychologist*, **14**, 168–176.

Derakshan, N., Smyth, S., & Eysenck, M W. (2009). Effects of state anxiety on performance using a task-switching paradigm: An investigation of attentional control theory. *Psychonomic Bulletin & Review*, **16**, 1112–1117.

Eysenck, M. W. (1992). *Anxiety: The cognitive perspective*. Hove, UK: Erlbaum.

Eysenck, M. W., & Calvo, M. G. (1992). Anxiety and performance: The processing efficiency theory. *Cognition & Emotion*, **6**, 409–434.

Eysenck, M. W., Derakshan, N., Santos, R., & Calvo, M. G. (2007). Anxiety and cognitive performance: Attentional control theory. *Emotion*, **7**, 336–353.

Eysenck, M. W., & Payne, S. (in preparation). *Trait anxiety, processing efficiency and performance effectiveness.*

Eysenck, M. W., Payne, S., & Derakshan, N. (2005). Trait anxiety, visuo-spatial processing and working memory. *Cognition and Emotion*, **19**, 1214–1228.

Eysenck, M. W., & Santos, R. (2006). Anxiety and depression: Past, present, and future events. *Cognition and Emotion*, **20**, 274–294.

Fales, C. L., Barch, D. M., Burgess, G. C., Schaefer, A., Mennin, D. S., Gray, J. R., & Braver, T. S. (2008). Anxiety and cognitive efficiency: Differential modulation of transient and sustained neural activity during a working memory task. *Cognitive Affective & Behavioral Neuroscience*, **8**, 239–253.

Hayes, S., Hirsch, C., & Mathews, A. (2008). Restriction of working memory capacity during worry. *Journal of Abnormal Psychology*, **117**, 712–717.

Hembree, R. (1988). Correlates, causes, effects, and treatment of test anxiety. *Review of Educational Research*, **58**, 47–77.

Johnson, D. R., & Gronlund, S. D. (2009). Individuals lower in working memory capacity are particularly vulnerable to anxiety's disruptive effect. *Anxiety, Stress, & Coping*, **22**, 201–213.

Miyake, A., Friedman, N. P., Emerson, M. J., Witzki, A. H., Howerter, A., & Wager, T. D. (2000). The unity and diversity of executive functions and their contributions to complex 'frontal lobe' tasks: A latent variable analysis. *Cognitive Psychology*, **41**, 49–100.

Murray, N. P., & Janelle, C. M. (2007). Event-related potential evidence for the processing efficiency theory. *Journal of Sports Sciences*, **25**, 161–171.

Owens, M., Stevenson, J., Norgate, R., & Hadwin, J. A. (2008). Processing efficiency theory in children: Working memory as a mediator between trait anxiety and academic performance. *Anxiety, Stress, & Coping*, **21**, 417–430.

Santos, R., Wall, M., & Eysenck, M. W. (submitted). *Anxiety and task switching: A functional neuroimaging study*.

Savostyanov, A. N., Tsai, A. C., Liou, M., Levin, E. A., Lee, J.-D., Yurganov, A. V., & Knyazev, G. G. (2009). EEG correlates of trait anxiety in the stop-signal paradigm. *Neuroscience Letters*, **449**, 112–116.

Schwarzer, R. (1990). Current trends in anxiety research. In P. J. D. Drenth, J. A. Sergeant, & J. R. Takens (Eds.), *European perspectives in psychology* (pp. 225–244). Oxford: John Wiley & Sons.

Shackman, A. J., Sarinopoulos, I., Maxwell, J. S., Pizzagalli, D. A., Lavric, A., & Davidson, R. J. (2006). Anxiety selectively disrupts visuospatial working memory. *Emotion*, **6**, 40–61.

Telzer, E. H., Mogg, K., Bradley, B. P., Mai, X., Ernst, M., Pine, D. S., & Murk, C. S. (2008). Relationship between trait anxiety, prefrontal cortex, and attention bias to angry faces in children and adolescents. *Biological Psychology*, **79**, 216–222.

Wager, T. D., Jonides, J., & Reading, S. (2004). Neuroimaging studies of shifting attention: A meta-analysis. *Neuroimage*, **22**, 1679–1693.

Walkenhorst, E., & Crowe, F. (2009). The effects of state worry and trait anxiety on working memory processes in a normal sample. *Anxiety, Stress, & Coping*, **22**, 167–187.

6

Biological Foundations

The SEEKING System as an Affective Source for Motivation and Cognition

Jeff Stewart & Jaak Panksepp

... whatever elements an act of cognition may imply ... it at least implies the existence of a *feeling*.

William James, 1909 (1987), p. 833

This chapter will focus on how the most basic motivational urges – those essential for all goal-directed actions – may be instantiated in brain systems. We will first focus on dopamine as a principal factor in the embodied mechanisms that bring about exploratory behavior in mammals; secondly, we will focus on one core emotional-motivational command system that is energized by dopamine, namely the SEEKING/Expectancy system as described in *Affective Neuroscience* (Panksepp, 1998a, 2005a). We will introduce research findings and theoretical perspectives that make clearer the meaning of motivation/exploration/SEEKING as a mental-affective function that intrinsically helps us penetrate the many predictive relationships hidden in environments – especially social ones – that are complex and often constantly in flux. With the SEEKING system, animals can extract causal convictions to guide behavior from predictive correlations among environmental events. We will also suggest that the SEEKING system contributes a fundamental phenomenal dimension of primary process consciousness, one that is affectively full of positive zest and enthusiasm for life – essential ingredients for effective learning.

Let us be clear at the outset: Our reading of the evidence is that felt dimensions of certain basic (primary-process) brain activating systems lead to psychological states that are accompanied by phenomenal experiences, namely affectively experienced states. Further, we take these basic systems as crucial to the developmental unfolding of higher order cognitive systems (i.e., those based on learning and thoughts, or secondary and tertiary processes as we conceptualize them). Specifically, the core emotional command systems appear to generate specific affects essential for learning and thereby guaranteeing and fine-tuning the appropriate behavioral sequences and timings necessary for diverse survival-promoting behaviors. The emotional command systems accomplish this partly by having evolutionary representations of the body coded in neural circuits, yielding and experientially sensitising the mind and the whole body into an affective action state that is immediate and undeniable and pervasive. Human infants, like most animals, live in the immediacy of this felt world, and similar to other animals, they gradually develop complex behavioral patterns that are learned responses to the affective MindBrain promptings experienced as bodily states. Unlike most other animals, however, human children develop the capacity to cognitively reflect on the unceasing patterns of emotional activations of their brains and bodies as higher-order mental states. That is, they learn how to interpret the language of their embodiment as a language of representations – elements of experience that appear as discontinuous with the virtual body representations that gives rise to them. There is much work to be done in researching this remarkable transformation of affective commands into higher-order cognitive structures, and in this chapter we will provide an account of the originating brain states that need to be understood before there can be any full account of the developmental transitions that depend on them.

Motivation. Animals appear to be endowed with their own purposive agency. Evolution has seen to it that they possess an innate group of emotional mechanisms that are essential for the survival of animals by generating "intentions in action," which command sets of behaviors and supportive autonomic changes that coordinate organismic actions needed for survival. Irving Kupferman, in *Principles of Neural Science* (1991), writes: "Specific motivational states, or drives, represent urges or impulses based upon bodily needs that impel humans and other animals into action." However, as Kupferman later adds:

> Drives or motivational states are inferred mechanisms postulated to explain the intensity and direction of a variety of complex behaviors.... Behavioral scientists posit these internal states because observable stimuli in the external environment are not sufficient to predict all aspects of these behaviors.... As more is learned about the actual physiology of hypothetical drive states, the need for invoking these states to explain behavior may ultimately disappear, to be replaced by more precise concepts derived from physiology and systems theory. (pp. 750–751)

Kupferman is suggesting that the scientific use of the ideas of motivation and drive is only a case of substituting provisional terms for behaviors and brain mechanisms that are not yet understood. The same can be said for the inference that reinforcement is a real brain process. We believe this type of radical eliminative reductionism is fatally flawed, for it fails to recognize levels of neuromental complexities that have causal efficacy in the control of behavior arising from neural activities. We prefer a view that is as materialistic as ruthless reductionism but accepts emergent complexities, such as affective feelings, in our aspirations to understand what the MindBrain really does. Let's consider this situation.

There is no doubt that specific behaviors are built into the action repertoires of animals to automatically take care of their survival needs. These include seeking water, food, comfort, and the perpetuation of the species. The problem Kupferman notes is that a term such as "motivation" is not sufficient for clarifying how a biological mechanism can produce the purposeful behaviors that unfailingly lead to the satisfaction of survival needs. We put the question this way: How is it that animals reliably act on various states of their bodies and brains (e.g., energy and water depletion) as if they were commanded to act in ways perfectly fitted to meeting its needs? Specifically, is it true, as assumed by a self-appointed committee of behaviorists early in the twentieth century, that the concepts of affective "urges or impulses" are difficult to cash out in sufficient detail to clarify what it means for them to function in the way they do. In fact, we believe those "mental" entities are true and fundamental neural functions of the BrainMind and that animal models can illuminate such neuro-evolutionary foundations (Panksepp, 1998a, 2010). How did we reach a point where mind was eliminated from the brain?

Jacques Loeb was one of the earliest transplants from the Berlin biophysics school that sought to bring a totally mechanistic view of behavior, with no mental processes, into scientific psychology. For him, motivation was a "tropism" that could be explained by specifying how it was engineered in the physiology of a particular animal. It was Loeb's intention to eliminate the metaphysical elements that were common in the scientific debates of his time (Pfaff, 1999), and to base the study of behavior on mechanical practicalities such as those of physics. Loeb's engineering mentality contributed to the mind-eliminating behaviorism of Watson and Skinner (Panksepp, 2005a) and greatly influenced how scientific inquiries were conceptualized, leading to the elimination of psychological processes in work on animal – and at times human – motivations. The engineering orientation that Loeb introduced, along with the scientific shunning of terminology based on human mental characterizations of animal states, has led to the situation where researchers such as Kupferman disdain the concepts of motivation and drive mechanisms and hope to replace all that kind of talk with functional neural diagrams. To this day, there are few researchers in animal behavior who are willing to go against this state of affairs in describing the mechanisms that drive behaviors and that seem to parallel in unmistakable ways the urges or impulses found in humans. Things are slowly changing, however, and some are calling for better conceptual approaches, such as that enunciated in the rapidly growing field of affective neuroscience (Panksepp, 1998a, 2005b).

Affective Neuroscience. The core thesis of *Affective Neuroscience* (Panksepp, 1998a, 2005a) is that emotional processes and subjectively experienced feelings do play a fundamental role in the unfolding neural events – large-scale brain network functions – that organize the actions of humans and animals alike. Various basic emotional systems provide a variety of internal values upon which complex behavioral choices are based. However, such internally experienced states are not simply mental events derived from higher cognitive appraisals; rather, they are generated through neurobiological events that directly shape instinctual emotional behaviors. This provides a straightforward empirical strategy to study how basic affective processes emerge from brain activities: Affective feelings are part and parcel of the unconditioned responses generated by the primary-process emotional networks of the brain.

This is a revolutionary idea. Since Darwin's era, there has not been a more coherent strategy for advancing our understanding of how we come to have the kinds of core emotional feelings that we do, which highlights our deep psychological connection with other animals. *Affective Neuroscience* offers the detail Kupferman was calling for – it spells out the physiology behind the ideas of motivation and drive through empirical research. It accomplishes more than that, however. It brings back psychological processes as meaningful brain events that cannot be discarded in our attempt to understand behavior. Here are a few of the key points developed in the book.

Decades of empirical study have led to the proposal made in *Affective Neuroscience* that there exist at least 7 primary-process emotional "command systems" found in all mammals. We first go over criteria for selecting the 7, and then briefly describe them. The idea of a command system or "emotional circuit" is based on 6 neural-systems criteria: (1) Core emotional systems are "genetically prewired" to function in relevant situations, and do not need higher brain functions for activation (empirical verification is based on studies of direct electrical brain stimulation to specific brain areas arousing coherent emotional states); (2) relevant motor subroutines and autonomic processes controlled by specific neurochemical processes reflect internal regulations of these evolutionarily ancient circuits; (3) these circuits concentrate arousal and behavioral specificity by changing the sensitivities of sensory systems; (4) arousal often continues in the neural circuits after the initial elicitations; (5) the circuits may contribute to other behavioral outcomes than those called emotions; and (6) the "[e]motive circuits have reciprocal interactions with brain mechanisms that elaborate higher decision-making processes" (Panksepp, 1998a, p. 49) and conscious awareness. A further corollary is that raw emotional feelings are generated by the neurodynamics of these coherently operating, functionally unified, BrainMindBody functions.

The 7 primary-process command systems that have been reasonably firmly established (with secondary and tertiary manifestations once the systems interact with cognitive structures) are:

1) SEEKING (motivation, expectancy, investigation)
2) RAGE (anger to frustration and hatred)
3) FEAR (anxiety to worry)
4) LUST (sexual eroticisms to obsessions)
5) CARE (nurturant social relationships to empathy)
6) PANIC (separation distress, loneliness, and grief)
7) PLAY (joyful social engagements to humorous delights)

The names of the core systems are written in the upper case to remind us that the vernacular or folk-psychological terms are to be understood in an explicitly scientific way. These circuits are the "*executive*, *command*, and *operating* systems" because "*executive* implies that a neural system has a superordinate role in a cascade of hierarchical controls; *command* implies that a circuit can instigate a full-blown emotional process; *operating* implies that it can coordinate and synchronize the operation of several subsystems" (Panksepp, 1998a, p. 49). The neural systems are concentrated in the subcortical regions of the brain, but clearly they operate throughout the entire web of the brain/body and regulate emotion-specific learning whereby neutral world events are imbued with affective meaning (e.g., we are not just angry, we are angry at someone).

The *SEEKING* system, which we describe in greater detail below, is the biggest background emotional system that also participates in the control of all the other emotions and it is a spontaneous generator of expectancies. This "appetitive motivational system" (Panksepp, 1998a, p. 51) should be thought of as a default active-waking state of the brain/body that initially simply promotes forward movement and exploration. Dopamine facilitates the "anticipatory eagerness" (Panksepp, 1998a, p. 54) that is a characteristic feature of the SEEKING system.

The *RAGE* system energizes the body to angrily defend its territory and resources. When conflicts or frustrations are present, this system contributes the psychomotor responses that are crucial for resolving the situation.

The *FEAR* system includes a variety of states from terror to anxiety, and acts in a general way to help an animal avoid danger. It is evident in several instinctual behavioral patterns in most mammals, but as documented by many investigators (e.g., LeDoux, 2002), it is also tightly interconnected with learning systems that support its safety features for obvious survival reasons. FEAR brings about freezing and hiding when danger is some distance away, but it leads to rapid fleeing when danger is nearby.

The remaining four systems mediate primary social emotions, highlighting their difference in function from the basic emotional and motivational processes of SEEKING, RAGE, and FEAR. The social emotions are responsible for behaviors that are relevant to survival among conspecifics.

The *LUST* system relates to mate selection (fitness evaluation and courting behaviors, among others), reproduction, and many gender-specific behaviors. LUST should be differentiated from nurturance, but it has many linkages with it neurochemically and behaviorally, and may well have been its evolutionary progenitor (Panksepp, 1998a).

The *CARE* system concerns the bonding and nurturing behaviors that dramatically increase with mammals. This affiliative capacity, generally, "refers to social behaviors that bring individuals closer together" (Carter, Lederhendler & Kirkpatrick, 1997, p. xiii). One of the most powerful activities of this system may be the opioid and oxytocin-mediated mother/child bond, but it is also prominent in the expressions of love, altruism, empathy, and maintaining social tolerance.

The *PANIC* system becomes aroused when young animals are separated from their social support system. It has evolutionarily emerged from the pain circuits of the brain (Panksepp, 2003) and plays a significant role in human loneliness, sadness, grief, and depression. PANIC is meant to ensure survival by means of painful internal alerts when contact is lost with important social supports.

The *PLAY* system remains the least studied of the above systems and is still deemed a frivolous area of inquiry among many neuroscientists. Still, this may be a crucial emotional circuit for helping developmentally in the organization of the mature social brain. Early rough-and-tumble play may be essential for determining subtle synaptic connections required for social knowledge and sustaining joyful attitudes in mammals. It is widely recognized that laughter is most common during playful social interactions, and the possibility has emerged that other animals, from rats and dogs to other primates, also exhibit an ancestral form of laugher (Panksepp, 2007b; Panksepp & Burgdorf, 2003), accompanied by the capacity for joy (Burgdorf & Panksepp, 2005). Children who are not given sufficient daily rough-and-tumble play may become prone to a variety of psychobehavioral deficits, perhaps explaining the ever-increasing incidence of attention deficit hyperactivity disorders in Western cultures (Panksepp, 1998b, 2001, 2007b)

These 7 emotional systems have their own dedicated pathways (interactive with many other brain systems, of course) that have been examined experimentally in a number of mammalian species. They have an intrinsic organization that maintains *comfort zones* for a given animal – evolutionarily coded values that organize behaviors for maintaining the necessities of living. It is our position that affects are the psychological signatures of the different evolutionary comfort zones, and that the fundamental nature of reinforcement may be deeply affective, an issue that behaviorism has chosen to ignore throughout its past and continuing history. Based on this short sketch of the circuits, it seems easy to think of them as programs that command the basic behaviors of survival, but it is not so simple to understand how or why raw affects are functional aspects of the instinctual affective apparatus. Let us attempt to clarify.

Emotion and affect should not be thought of as being the same. The activities of basic emotional operating systems of the brain generate intrinsic affective values, but other brain-mind systems also possess affective properties. Although the core affects or felt characteristics of basic emotional and motivational systems are generated by lower functions in the brain, some may also be generated by other, higher neocortical functions such as those arising from specific sensations, perceptions, or even cognitions; however, it is likely that even those mental states require subcortical participations. The fact that any specific process is *felt* does not make it an emotion. On the other hand, whenever there is an emotional motor expression, there seems to be an affiliated affective component, whether it is evident or suppressed. Affects, then, appear to participate in *moving* animals to facilitate survival-oriented behaviors. Indeed, because emotion has such an evident etymological base in motion (e-motion), it is understandable that many have thought of such brain states as primary organizers of psychobiological actions. Basic emotions are clearly pre-wired action programs for survival that incorporate affective features to help effectively orchestrate the onset and course of behavior sequences, with the affects being similar to compasses or gyros for guiding behavior. Because the primary-process emotional affects are organized in the lower portions of the neuroaxis, there is reason to believe that they are fundamental to many if not all subsequent organizational developments and are therefore critically important for learning as well as other guidance characteristics afforded by higher brain functions. All of this will become clearer as we consider one of the most important basic emotional command systems in more detail – the SEEKING system, which figures heavily in every other emotional process.

It should be briefly noted here that this research on the emotional command systems – and especially the SEEKING system – is consistent with experimental work in psychology generally called functional emotion theory. Frijda (1987, 1988), Lazarus (1991), and Fischer et al. (1990), among others, have given evidence for how emotions help elaborate general organizations of bodily activity. The guiding concept that cognitive, motivational, and relational dimensions of emotion are found in a spectrum of activities from biological organization to social organization offers a helpful extension in our understanding of emotion from its more general psychological and behavioral manifestations to the evolutionarily "given" neural foundations. The focus here on the research described in *Affective Neuroscience* is a further exploration of functional emotion theory, developing in greater detail the neurophysiological and neurochemical pathways of the emotional and affective organizing of behavior.

The SEEKING System. *Affective Neuroscience* envisions the appetitive motivational SEEKING system (SS) to be "a goad without a goal" (p. 144) at the onset of psychological life. (When quotes are followed by page numbers, they refer to Panksepp, 1998a). This highlights the main function of the system: It drives the animal forward into its environment, with no other directive than to explore, investigate, and ultimately forage for resources in the initially unpredictable environments in which organisms find themselves. A more fully elaborated designation for this the system might be "a 'foraging/exploration/investigation/curiosity/interest /expectancy/SEEKING' system" (p. 145). This system is especially active when animals are experiencing various homeostatic imbalances such as hunger, thirst, and sexual arousal, but it is also set to go when there are no special bodily urges to be fulfilled. It appears that the SS is a default mechanism that activates (when other demands, such as resting or eating, are satisfied) to arouse the animal to actions that may potentially lead to future rewards. Thus, it is not surprising that positive affect accompanies the SEEKING urge – getting to know the world should be an intrinsically positive activity, at least until the organism encounters danger. Why should it be so positively engaging to be in such a state of arousal?

It is not easy to contemplate how affective experiences participate in the control of animal behavior without using our own types of felt emotions as comparisons. This kind of anthropomorphism has been frowned on, but a scientific variant of this kind of thinking is about the only way to fathom the many homologies that exist in the brains of all mammals. The affective qualities of human SEEKING states – those of intense interest, engaged curiosity, and eager anticipation – make sense to us through the simple fact that we can readily understand – almost feel – the meaning of such words. However, are they in fact valid descriptors of the affective states of the SEEKING system as manifested in the minds of animals? The answer appears to be yes, at least in a class-similar way (i.e., nothing across species is precisely the same, which led to the novel affective nomenclature of capitalizing the emotional primes). Indeed, at present there is no other language that is available to help us articulate with any precision what is presumed to be happening in the core of the behavioral expressions of the other animals. Researchers who caution against anthropomorphizing animal behavior are, more often than not, the ones who also tend to write about animals as if they felt no pain or have no consciousness or are too simple (i.e., machinelike) to justify having homologous psychological concerns for their own well-being as humans have.

When your pet dog sees you put your coat on and ready its leash, the energetic tail wagging accompanied by rambunctious jumping and barking *is* eager anticipation! It seems indisputable, unless one is in denial about the emotional subtlety of emotional life, that the animal is in the grip of a strongly felt state. You could say that the dog is exhibiting high motor activity, repeated vocalizations within a specific range, increased respiratory function, and so on. Why should the fact that the animal is eagerly anticipating going outside for a walk *not* qualify as a perfectly reasonable description? Because this state has to be inferred only from behavioral signs, but following traditional Cartesian skepticism, scientists to this day typically do not deem behavioral changes to be sufficient evidence for any quality of mind. Still, every aspect of the state of the animal suggests increased positive affect, and by all measures imaginable, animals seek out such states, including via self-administration of artificial stimuli (electrical and chemical stimulations) directly into the relevant regions of the brain but not others (such as neocortex). Thus, a very reasonable working hypothesis is that a distinct emotional feeling is either primed or instantiated by arousal of the SEEKING system, and that with a little experience, this system induces a positive anticipation of the exploring of a world that is filled with potentially important information about the psychic state of dogs. Before reaching any definitive conclusions, however, we are well advised to go deeper into the neural nature of the SEEKING affect, beyond outer behavioral expressions, to the underlying functional components. Such work now definitively indicates the existence of affect in all mammals that have been studied.

The SEEKING system, along with its affective intensity, coaxes each animal to explore its environment: It makes a cow investigate anything new showing up in her pasture; at times it makes us seek sweets when we should have no more, and perhaps even wonder whether we should look for a different job. It also promotes the addictive qualities of various activities from compulsive drug consumption to obsessive web-browsing. How does the core biology of the Seeking system "make" all these behaviors happen? Specifically, how does the motivation that is intrinsic to SEEKING (or any of the basic emotional systems) generate the strong feeling that appears to encourage all animals to seek and explore?

The Neurobiology of SEEKING. The origins of the motivating energy of SEEKING "are concentrated in the extended lateral hypothalamic (LH) corridor," which contains an enormous pathway connecting midbrain and lower brain stem regions to the forebrain. Through most of its course, it is very enriched in neuromodulators such as dopamine. The LH dopamine continuum runs from the ventral tegmental area (VTA) to the nucleus accumbens. This includes most areas of the brain where local application of electrical stimulation will promptly evoke the most energized exploratory and search behaviors an animal is capable of exhibiting (and the animals like to self-administer stimulation into such regions of the brain) (Panksepp, 1998a). A critically important energizer of appetitive behavior and desire in these brain areas is the modulatory neurotransmitter dopamine (DA).

There is growing acceptance that this emotional function of the brain [the SS] – the basic impulse to search, investigate, and make sense of the environment – emerges from the circuits that course through the LH. The anatomy of brain DA circuits corresponds to the general trajectory of this psychobehavioral system, and brain DA itself is an essential ingredient in allowing the circuitry to operate efficiently, although many other brain chemistries are involved in the overall construction of the SEEKING response. (Panksepp, 1998a, p. 145)

Here, we will first go over a few details about the brain regions involved, and then we will discuss the work of dopamine in those areas as well as in the extended areas that form the larger dopamine-energized SEEKING systems. Readers wishing more details are directed to a variety of recent reviews (Alcaro, Huber, & Panksepp, 2007; Berridge, 2007; Ikemoto & Panksepp, 1999; Panksepp & Moskal, 2008).

Hypothalamus. The hypothalamus and the thalamus make up the diencephalon, a large and functionally diverse brain region situated in the uppermost part of the brain stem just under the neocortex and the other telencephalic structures. The thalamus processes information coming from the external world to the cerebral cortex and also has intrinsic midline systems for elaborating social emotions and sustaining and amplifying cognitive consciousness. The hypothalamus is concerned with the internal milieu – the regulation of the autonomic, endocrine, and visceral systems as well as a host of emotional urges. The regulation of those systems requires monitoring the internal environment and bringing about appropriate changes in the heart, lungs, viscera, musculature, and the exocrine and endocrine glands. The hypothalamus regulates the moment-by-moment conditions in the body, and thereby has a very sophisticated and diffuse intrinsic map of the viscera, the state of which is essential for the nature of many emotional feelings. The hypothalamus incorporates several nuclei (neuronal clusters), and more complex tissues where many nuclei and pathways intersect (reticular regions), that are dedicated to a variety of functions, among which is the temporal orchestration of psychological and behavioral expressions (Card, 2002; Swanson, 2003). One of those reticular regions is the lateral hypothalamic area (LH), which provides a "superhighway" for extensive intercommunication with other regions up and down the neuroaxis – this is part of the medial forebrain "corridor" we have described. The corridor is a network that extends from lower midbrain regions such as the ventral tegmental area (VTA) through to regions of the basal ganglia such as the nucleus accumbens, and further upward to medial cortical regions. If this system is damaged on both sides of the brain, an animal's capacity for normal motivated behavior and affective consciousness is terminally compromised, and if the damage is not complete, the organism has to be nursed for a long time before it will again sustain itself, albeit much more weakly and inconsistently than before.

The ventral tegmental area (VTA). The ventral tegmental area is a brain region that proceeds from the midbrain upward to the diencephalon. This area is critical to SEEKING because it is a point of origination for mesolimbic and mesocortical dopamine circuits, which we will consider in a moment.

The nucleus accumbens and ventral pallidum. This region of the basal forebrain is instrumental in reward and various kinds of pleasures (which are the foundations of reinforcement processes), and it is the prime target of mesolimbic dopamine activity from the VTA. It is also rich in endogenous opioids, and thus plays an important role in practically all drug addictions (Berridge & Robinson, 1998).

The Extended Reticular Activating System (ERTAS). This is another corridor, consisting of a number of nuclear and reticular regions running from the medulla and up the neuroaxis to thalamic regions of the diencephalon and regions of the cortex. At the core of this system is the midbrain and pontine reticular formation, which is necessary for generating the state of ordinary waking arousal. It is also continuous with the VTA, regions of the diencephalon, parabrachial and raphe nuclei, the nucleus coeruleus, and the periaqueductal gray, all of which play a significant part in generating a *global state* of consciousness (Watt & Pincus, 2004; Solms & Turnbull, 2002). Activations of these instinctual emotional systems (with continual regulation by the global neurochemistries of the ERTAS such as acetylcholine, norepinephrine, and serotonin) generate the behaviors of the instinctual survival actions (with the addition of cortical supports for learning and remembering), but their activation also possesses a sense of embodiment – a global state of arousal that functions as a felt dimension. One particular system – the periaqueductal gray (PAG) – is essential in generating the characteristic sense of embodiment that acts as a primitive self-representation essential for many emotional feelings (Panksepp, 1998a; Solms & Turnbull, 2002) shared by all mammals (Northoff & Panksepp, 2008; Panksepp & Northoff, 2009).

The periaqueductal gray (PAG). We describe the PAG as the "central coordinator" of emotion; it contains "the most massive convergence of brain emotional systems," and by means of electrical stimulation, it can facilitate nearly all emotional actions and the corresponding feelings (Panksepp, 1998b). There is a characteristic of the PAG that may help us understand how global states are brought about through the function of the affects. The PAG is adjacent to regions of the brain stem that map both the visceral body (inner functions) and the musculoskeletal body (movement). In general, the PAG helps generate positive emotional feelings in its ventral regions and various negative, distressing feelings in its dorsal ones (Panksepp, 1998b). When these two functional characteristics of body maps and the pleasure/displeasure spectrum are thought about as dynamically interactive, we begin to perceive a fundamental organizing principle of the affective systems. The sense of embodiment is generated as an integrated whole so that advantage can be taken by responding to any survival requirement by a comprehensive and robust activation of the whole brain and body in order to advance enthusiastically into the environment (with the potential for pleasure) or to pull back (with feelings of displeasure) from it, decisively and unequivocally. The PAG is very richly connected to the higher centromedial cortical regions that are critically important in cognitive self-representation (Northoff et al., 2006).

Several issues become clearer by thinking about them in light of this picture of structural organization. First, it helps us understand why a global state is essential to the operation of some affective processes. Coordinating body-movement maps with visceral-state maps through their interconnection within the PAG explains how there might be a unified sense to the felt nature of affect. Second, the reason that "motion" is so central in emotional responding implies that the musculoskeletal inputs are coordinated with homeostatic and instinctual requirements for the execution of behaviors that must satisfy needs. For instance, survival demands are coupled with the action plans that are necessary for guaranteeing appropriate behaviors. Third, the reason SEEKING is a "goad without a goal" before learning is that early in development it cannot know what it is seeking (it is objectless). The systems that support it are geared to approach or avoid at the most basic level (and this command level is fundamental to all of the other emotional operating systems, making SEEKING a base-level operator for the other 6 systems), at the same time requiring different brain mechanisms to facilitate more extensively elaborated action repertoires for more specific behaviors. Fourth, it may be clearer how a primitive sense of SELF can start to form from the neural matrix that embodies raw affective states (Panksepp, 1998b, 2005b; Panksepp & Northoff, 2009). Fifth, we begin to understand how the raw affects of globally felt states become organized by the necessity of moving an organism into interactions with its environment. So far we have only really been looking at the "hardware" that supports all this organization – at the biological structures that are involved. We should now ask what actually does the moving; how do these structures bring about their motivation? To do that, we must now turn to the substances that are involved in the communicating that takes place between the brain regions. A major neurochemical facilitator for SEEKING is dopamine. (Please note that many other substances – amino acids, neuropeptides, and other monoamines – are also necessary for normal brain function. We limit our discussion here to dopamine because of its specific importance to the SEEKING urge.)

The Dopamine (DA) Pathways. Dopamine is a chemical that acts as a neurotransmitter and hormone; it is found in the nervous system and body of many, many organisms, from invertebrates to humans. DA is studied under 2 main aspects: First, as how it operates in the four major DA pathways, which are dedicated neural circuitries involved in specific functions; and second, for its different roles in the 5 types of DA receptor sites, which help define the varieties of DA functions.

DA receptors are classified as D_1-types (including D_1 and D_5 variations) and D_2-types (including D_2, D_3, and D_4 variations) (Civelli & Zhou, 2001). The D_1-type receptors are excitatory; the class of D_2-type receptors are inhibitory (Bannon, 2002). The various types, and the molecular and chemical differentiations that serve them, suggest an evolutionary history of the development of DA chemistries for modulating behavioral and regulatory activities (Kapsimali, LeCrom, & Vernier, 2002). The recent developments in histological staining techniques has permitted a better understanding of receptor subtypes, and has led to an increasing awareness of how DA operates in different systems and organisms as well as to a more effective approach to treating DA-related pathologies. For decades, many hundreds of research papers have been published annually on these receptor sites (Bannon, 2002). The study of receptor locations and densities has contributed greatly to the understanding of the various functions of the DA pathways, which is helpful in discovering just how DA regulates the global states we are interested in here. The four major DA pathways are the mesocortical, mesolimbic, nigrostriatal, and the turberoinfundibular, but there are minor circuits in other diencephalic and basal forebrain regions as well as regions of the retina and olfactory bulb (Bannon, 2002).

The Turberoinfundibular Pathway. This DA pathway connects the hypothalamus to the pituitary gland. It also plays a role in the regulation of a number of hormones responsible for some maternal behaviors and sensory processes, most prominently prolactin, which is important not only in reproduction and maternal behaviors but also in social attachments (Panksepp, 1998a).

The Nigrostriatal Pathway (NP). This pathway has its source in the substantia nigra (SN) and proceeds through the striatum (caudate-putamen). It is important in the regulation and production of movement, and is part of a larger motor system found in the basal ganglia. A loss of DA in this system leads to Parkinson's disease, characterized by irregular motor functions. The initiation of motor sequences and their smooth execution can become compromised when DA is reduced, and may lead to "freezing," where the ability to initiate movement is stopped (Sacks, 1990). Schultz (2001) has demonstrated that DA activations in the substantia nigra and VTA are related to reward, especially reward prediction (but these systems also need to be characterized in terms of their unconditional-instinctual capacities: Panksepp & Moskal, 2008). Because the nigrostriatal pathway facilitates movements, it is interesting to consider what reward prediction really means. Although cognitive assessments seem to be indicated for prediction (and we will discuss that part of it in a moment), there is an insight offered here from the fact that the substantia nigra and striatum are both deeply concerned with movements and their inception. In the exploratory activities that are characteristic of SEEKING, it makes perfect sense that the elicitation of an anticipatory affect would be part and parcel of those intrinsic motor acts allowing organisms to investigate their environments. Also, when neural developments (and evolution) have permitted memory and cognition to formulate explicit representations of rewards, SEEKING continues to function as a source for the motivation to explore, with the same affect of anticipation and expectation being aroused, but utilized in expanded ways. So the goad-without-a-goal function of the SEEKING system should be underscored as a generalized motivation and action-initiating system.

It is also important to note that the receptor-site analysis of the nigrostriatal pathway shows that DA has both excitatory and inhibitory functions (*vide supra*). There are several implications here (particularly for the types of motor impairments Sacks describes), but there appears to be a suggestion that temporal organization may somehow be facilitated in this pathway. There are 2 ideas that bring this question up. First, is the idea of *initiating* an action or action sequence. Here, the nature of motivation is emphasized as a "turning on" of movement, and the result of that action in the organism points to a temporally oriented phenomenon. Second, the idea of a *smooth execution* appears to demand the temporal fine-tuning of systems that require coordination over spatiotemporal dimensions (or else they become the akinesias that Sacks documents). Such types of temporal dynamics may be the bedrock of phenomenal consciousness.

The Mesolimbic Pathway (MLP). Originating in the midbrain's VTA and continuing to the nucleus accumbens, amygdala, and septal structures within the limbic system, this pathway is described as modulating states of motivation, pleasure, and reward. The feeling of euphoria is promoted by the MLP as an important component of motivation, and it is not only the anticipatory pleasure of SEEKING but also nearby opioid systems that mediate the reward pleasures derived from activities such as sex, eating, and drug use. The mesolimbic pathway, along with the mesocortical innervation of the medial frontal regions, are often considered together in discussions of motivation and reward and in the study of addiction and psychosis, so we will move on to a view of the two systems together.

The Mesocortical Pathway (MCP). This pathway proceeds from the VTA to the general region of the frontal lobes, especially to the medial areas of the prefrontal and cingulate cortex. The DA activity of this pathway is important in planning, attention, general arousal, and the systemic changes that come about from learning. DA innervation of the orbitofrontal cortex contributes to some of the exciting-pleasurable qualities of social interaction (Rolls, 2004; Schore, 1994); negative social feeling, such as separation distress involving the anterior cingulate cortex (Panksepp, 1998a), can promote depression through overarousal (Watt & Panksepp, 2009). Several aspects of schizophrenia are also amplified by the mesocortical-mesolimbic (MLMC) pathways, leading to hallucinations, dreams, and other loose associations, and chemicals that are antagonistic to the action of DA are widely used in treating such problems in living. One of the central functions of these pathways is believed to be reward processing, in a very general way.

Although DA activity in the MLMC pathways is now believed to "code the rewarding aspects of environmental stimuli" (Schultz, 2001, p. 293), one alternative is that it is necessary for 'wanting' various stimuli, but not for 'liking' them (Berridge & Robinson, 1998). Much experimental work has been dedicated to clarifying why the DA function is not concerned specifically with the simple reward of pleasurable feeling, but rather has much more to do with fine-tuning the prediction and anticipation of rewards. This is not all it does, however. DA facilitates the incentive values of the SEEKING system, but not simply by focusing them on specific environmental objects; DA relies on the stimulation of internal, affective motive states to bring about behaviors that are most likely to lead to consummatory rewards that can sustain bodily homeostasis. It is likely these same systems are active when children learn about new and exciting relationships that exist in their environments.

Let us now consider how the DA pathways integrate with other brain systems to yield a "psychobehavioral integrative system" (Panksepp, 1998a) for the elaboration of SEEKING urges. Essentially, the nigrostriatal pathway contributes motor-sequence arousal and synchronization, the mesolimbic pathway contributes much of the emotional valence, and the mesocortical pathway contributes to the organization of the cognitive and memory programs important in appetitive behavior and related affective experiences. The cognitive components are largely mediated by glutamatergic systems originating in the cortex, providing downward control of SEEKING urges by knowledge representations. We can think of these various components as the acting, feeling, and thinking constituents of SEEKING urges. From a global perspective, these components represent the evolutionary development of the Triune Brain (MacLean, 1990), with the reptilian core dedicated to movements, the mammalian limbic system orchestrating various social emotions, and the mammalian frontal neocortex committed to episodic and working memory that allow for planning and cognitive processing of changing world events, with all being coordinated with each other. Mechanistically, this is an oversimplification, but it helps to see how the motivational systems have their sources in deep strata of the brain that evolved a long time ago, and how they have been conserved and elaborated in each species as especially efficient for behavioral organizing functions aimed at particular survival needs. Even the happy sounds that rats make when they are playing and tickled are strongly influenced by brain dopamine dynamics (Burgdorf et al., 2007), and these dynamics contribute to our mirthful joy related to humor and laughter (Panksepp, 2007a).

Chemical precursors of DA have also been found in insects, where they appear to function in parallel ways with the DA functions of mammalian SSs. There is a neurochemical in bees called octopamine that is active in reward seeking, and its action in the bees' neural connections underscores an organization that "sends projections to every nook and cranny of the bee brain" (Blakeslee, 1996, p. 2). When the earliest animals began moving about on the ancient sea floors, there presumably already existed a family of motivation-generating molecules that assisted in the coordination of motor activity with homeostatic and consummatory requirements, and that were conserved all the way up to us and all the other mammals. It is remarkable that crayfish still exhibit conditioned place preferences where they received drugs that promote DA activity (Nathaniel, Panksepp, & Huber, 2009; Panksepp & Huber, 2004). The SEEKING system highlights a general principle of brain function – the primitive affective regions of the brain generate global affective-state functions that are essential tools for living and survival. We will now take a closer look at some of the specifics of such global brain-body states as possessing affective dimensions.

Motivation and "Experience." When we think about the dopamine-energized SEEKING states, we begin to glimpse how motivational urges arise from bodily activation states that support specific types of action plans. These global states are not simply tropisms or reflex arcs that mindlessly reflect behavior programs triggered by environmental cues. Rather, such states reflect wide-scale neural network activations and inhibitors that integrate multiple brain/body processes in a global-dynamic brain-body entrainment process. If we envision the evolutionary import of this kind of system-wide engagement, we can begin to see an integrative strategy that seems to base the guarantee of appropriate survival activities on the coherence of action plans and psychological salience that transpires in animals as a recognizable aspect of its own activity.

This is not simply proprioception, which is based in its own specific somatic pathways, and which gives the animal information about its body positioning. The global states that arise from SEEKING urges help to ensure that the animal itself, as a single integrated entity, responds in the right way to a variety of specific needs. The surest way of conferring this type of imperative was to imbue it with brain functions that register as undeniable calls to action, felt with unmistakable and unambiguous positively valenced salience. This characterization of the global body state can most parsimoniously be called a raw phenomenal "affective experience." It is possible to go one step further into the operation of the DA-energized SEEKING states, however, to discover a final element in the search for clarifying how the physiology of motivation is responsible for the felt, affective quality that generates subjective experience and consciousness.

As noted earlier, there is reason to suspect that the temporal dynamics of some dopaminergically driven SEEKING functions may be central in producing important dimensions of consciousness. We now introduce some research supporting that idea.

Schultz (2001) notes that "dopamine neurons subserve different functions at different time scales" (p. 293). He points out the contrast between the "tonic enabling function" of some DA circuits and the "short, phasic increases" that are triggered by reward-predicting stimuli. However, we should point out that electrophysiological studies of DA neuronal activities during learning tell us much more about the various cognitive inputs into the DA systems than what the outputs of those systems necessarily do, a nuance often forgotten by electrophysiologists (Panksepp & Moskal, 2008).

There are many lines of evidence that DA neurons, especially in the VTA, promote a general-purpose SEEKING urge that can control the emergence of cognitive states in higher regions of the brain (Alcaro et al., 2007; Ikemoto & Panksepp, 1999). In a study concerning vocal learning in finches, Ding and Perkel (2002) found that some neurons utilize combined DA receptor types, and that this mixing "enables the DA system to fine-tune the dynamics of the song system" (p. 5210). Expanding on the author's use of the term "dynamic" here, we might envision it as an intricate organization of on/off timing, relevant in the construction of a complex sequence of behavior. Gao, Krimer, and Goldman-Rakie (2001), working with monkeys, found that "persistent activity in prefrontal neurons is modulated by dopamine," and they describe "sustained activity during the time a stimulus is held in memory" (p. 295). Of course, there is feedback from the medial frontal cortex, a major target of the mesocortical system, back onto dopamine terminal fields in the nucleus accumbens, the main target of the mesolimbic DA system. This suggests that beyond questions of receptor differentiation or simple on/off mechanisms there is a kind of looping DA activity that facilitates a durational, sustaining mode: DA may act as enabling the holding-on-line of various psychobehavioral tendencies. Hollerman and Schultz (1998), also working with monkeys, demonstrated that "dopamine neurons display unique response characteristics, which can be conceptualized as the coding of temporal-prediction error," and that "the predictions influencing dopamine neurons include not only the occurrence but also the time of reward" (p. 308). This seems to support the idea that DA is far more than a simple on/off facilitator: DA may be significant in permitting a sustained attention to events unfolding during a structured time course. Working with computational models, Durstewitz, Seamans, and Sejnowski (2000) have argued that VTA DA modulation of higher brain regions may be important in maintaining information relevant to reward in working memory. Here again we can see DA activities that appear to be functioning in an on-line, time-sensitive, sustained unfolding of processing. These few examples of the research on temporal aspects of DA function appear to support the idea that DA can augment the dynamic flow of not only behavior but conscious experience, which is filled with enthusiasm, interest, and zest for life.

If it is true that, along with the felt characteristics central to each global-state emotional command system there is also a range of moment-by-moment processing distinctions available to each system, then it could be said that these systems have a felt aspect that is significant for the proper behavior of the animal *in its present moment*. By definition, the ordered progression of present moments is a characteristic of *experience*, at least in an incipient form. By a remarkable evolutionary twist, it seems that DA and its precursors hit upon the idea that the addition of the dimension of time could induce the kind of psychological salience needed to make brain emotional operating systems experientially functional. It may be possible that the goading quality of such emotional/motivational command systems has a rough equivalence to the degree of "now-ness" and the types of affective psychological pressure that the systems can exert on cognitive processing. Indeed, it may be that the "ticking" of DA neurons, which represents their background activity, amounts to a clocking system for present moments, and when the ticking speeds up, as in dopamine (DA) bursting, the passage of psychological time speeds up.

This may be better explicated through the main story line in two groundbreaking books. In *The Remembered Present* (1989) and *Bright Air, Brilliant Fire* (1992), Gerald Edelman explored how animals might have come to possess "primary consciousness," an apparently necessary precursor to "higher order consciousness." His analysis of the neural organization of primary consciousness resonates in striking ways with the systems described in *Affective Neuroscience*; however, Edelman seems to think that the psychobehavioral imperatives of the systems he describes emerge from the combinatorial interactions within higher brain cognitive systems and are not, as we have described, inherently powered by a few systems that remain continually operating at the base of all higher cognitive processes (without which those higher processes could not effectively operate). Regarding the temporal aspect we described above, Edelman (1992) says of primary consciousness:

> It is limited to a small memorial interval around a time chunk I call the present. It lacks an explicit notion or a concept of a personal self, and it does not afford the ability to model the past or the future as part of a correlated scene. An animal with primary consciousness sees the room the way a beam of light illuminates it. (p. 122)

Edelman calls this spotlight-like interval the "remembered present," the "tyranny" of which had to be broken by evolutionary advancements in "symbolic memory" in order for "higher order consciousness" to arise, including autonoetic consciousness, namely our ability to do mental time travel in episodic working memory (Vandekerckhove & Panksepp, 2009). There are two interrelated problems in Edelman's picture, however. First, he limits the sense of self to a personal self, whereas there may be an evolved nomothetic self-like characteristic inherent in the way the command systems are organized, which gives rise to idiographic selves through living in the world (Northoff & Panksepp, 2008; Panksepp, 1998a; Panksepp & Northoff, 2009). Second, Edelman downplays the dimensions of the present moment as if it were no more than a frozen percept, a beam of light that was unable to differentiate anything it illuminated. The present, for him, is a scene built up through dynamic processes, but nonetheless a relatively simple percept that carries no particularly affective salience in a global sense; it is a frozen present that has no durational force. What does that mean for the sustained nature of our moods and emotional lives, so important for what we do in the world?

What Edelman may be missing by placing the perceptual binding of the scene beyond the dynamism of the affective dimensions, is the real impact on the animal of the present. As we have suggested, the force of the systems involved in bringing out the salience of the present is not for the purpose of reaping information about specific environments (spotlighting), but rather to compel specific behaviors aimed at exploiting the environment. Edelman may be right about primary perceptual consciousness as establishing a cognitive present, but he misses the true function of the affective present, which requires the postulation of a distinct form of affective consciousness (Panksepp, 2007c) The present we have endeavored to shed light upon is a durational intensification of affective salience, which promotes incentive salience and is a highly effective way of channeling the unfolding behavioral repertoires – the dynamic motivational states of the body. Those states persist over the time course of their behavioral sequences due to the enduring affective grip of the moment. The on/off DA controls are necessary, but it is the unavoidable tug of the body state specific to its command system program that is the direct cause of the durational present for the animal. These body states may also act as a primitive sense of self for mammals because of how their integral organization generates a characteristic experience of the body-wide state – a situation that Edelman could not have permitted due to his external focus on the way the present appears.

In describing present affective experience in the core self and cognitive experiences in developmentally crafted incipient idiographic selves (Panksepp & Northoff, 2009) it should not be forgotten that we have to think of them with the experience and self that we ourselves possess. It is impossible to know what the precise experiences of each present moment might be for, say, a mouse or a monkey. However, common sense allows us to realistically infer their affective experiences from their instinctual emotional behaviors as a sense of their *now*, perhaps as we watch them explore or otherwise respond to new environments – cautious and alert, but with an evident determination to discover what is there. We should not mistakenly anthropomorphize the inner world of the animal, but neither should we make the mistake of remaining oblivious to the nature of animal experience or of underestimating what biology is capable of in the service of optimal survival.

It is worth considering the truth diagram that must be fully considered as we attempt to relate human experiences and the nature of the animal estate, because detailed functional neuroscience can only be done with animal models. We would like to have more accurate views of animal emotional experiences because that is the only way to ever really obtain detailed neuroscientific insights into how primary-process human emotional brains might operate. As summarized in Figure 6.1, we have some hard choices to make about the true-world emotional nature of animal minds and our scientific decisions about those minds. We want to avoid Type I and Type II errors, and to accept anthropodenial when it is valid and anthropomorphism when it is valid. Radical behaviorism made a shambles of this decision-making process by following time-honored pre-neuroscientific Cartesian opinions that such issues are outside the realm of science, a bias sustained to the present day (Panksepp, 2005a), as opposed to recognizing that because of advances in our ability to study psychobiological homologies, we must now consider and weight all of the available evidence in our decision-making processes (e.g., Panksepp, 1998b, 2005b, 2010). There is now abundant evidence indicating that there is much in the animal mind that will inform us of our own mentality, especially in terms of the core processes such as basic emotional urges. We believe that at the basic (primary-process) emotional level, anthropomorphism is a valid strategy for revealing the affective ground of being that is common to all animals. Our primate and mammalian relatives may surprise us with insights that will provide understanding of the nature of our own affective experiences.

Such analyses of core emotional and motivational processes may also have relevance for understanding the functions that support cognition. Cognition is traditionally studied as a large set of relatively high-level processes that inform and constitute the basic material of thinking; "cogito" means "I think." However, just as this chapter has looked into the basic-level processes that not only shape specific behavioral repertoires but add to them a dimension of felt activation that engages the entire mind and body, it might be helpful to

Avoidance of Anthropomorphism

(e.g., "Anxiety-Like Behavior")

The True Nature of the World

Our Judgements About the World	Animals Experience Emotional Feelings	Animals have No Emotional Feelings
Animals Experience Emotional Feelings	**Valid Anthropomorphism**	**Avoid** Type I Error
Animals have No Emotional Feelings	**Avoid Type II Error**	**Valid Anthropodenial**

FIGURE 6.1. Validity of anthropomorphism.

consider the operations of cognitive processes by looking for deeper sources, and for any parallels with the body-wide activations of motivation.

Very few researchers would argue with the idea that the vast majority of operations contributing to cognition are beneath the level of conscious awareness. Myriad computational elements, from sensory, motor, perceptual, and other processing domains, converge in neocortical layers that integrate "thoughts" for us. If we want to get a better understanding of this, we should conceptualize thought not simply as higher-order intelligence; rather, we should also ask about the *function* of thought – what is it actually doing for us? At the simplest level, thinking is a process whose real objective concerns successful performance in an environment containing complexity. It is an anticipatory strategy for adaptively meeting the challenges of survival facing each animal. This may seem a long way from human problem-solving, but it is the core function of cognition. At this level, it is easy to see how the relation to motivation comes about. In essence, one set of processors must compute details about internal states and external affordances, and another set of processors must organize actions and their execution. Cognitive processing ultimately provides much of the context for the detailed expression of internally motivated processes. The inborn emotional processes reflect strategies that do not know much about the world initially, except simple-minded strategies to behave and feel in certain ways. Although the emotional feelings are born largely objectless, they become connected to world events through learning, and the resulting developmental cognitive-affective landscapes tell organisms how specifically to behave. Let's take a moment to think how prevalent this is in living systems, and how in some organisms the resulting "cognitive" processes may be deeply unconscious.

Research tells us that plants possess remarkable abilities for evaluating details of their environment (Narby, 2005). They can determine which species of parasite is chomping on their leaves by analysis of chemicals in the saliva of the pest (Buhner, 2002) and in response, they can release chemicals that attract a specific predator that will feed on the pest the plant has targeted (Whitfield, 2001). Plants can even notify their neighbors to prepare for attack by chemical means. These behaviors are sophisticated responses to specific environmental challenges, and from the perspective of information processing, they resemble cognitive processes. If plants are this sophisticated in their precognitive operations, then maybe we should rethink the view that wants to conceptualize cognition merely as thought. Maybe cognition has roots that draw upon the same extensive activating networks of the body that grounds our various emotional and motivational systems? Maybe cognition is far more complex in nonhuman animals than our verbal thought-based view has allowed us to appreciate? Surely, creatures can think in terms of visual images, perhaps even in more strict affective terms. Maybe cognition, at its base, is not simply what we thought it was – the apotheosis of neocortical function through language – but also a system of systems, computing vast amounts of information and delivering appropriate output to motivational systems at every step of the response sequence geared to specific environmental demands. That would mean that cognition, too, may be rooted in a body-wide network (and is not just highest-level neocortical processing alone), and that it, too, has ancient evolutionary origins (and is not dependent on "big" brains alone) – that it too is ultimately subservient to the bodily survival needs of organisms and hence cannot do much unless it is nourished, more than just metabolically, by affectively resilient brain-bodily states.

In some sense, we are subject to seeing cognition and motivation as distinct because of the history of science. Of course, different neural systems do contribute different types of processes to the behaviors we parse as observers, but functional parsing seems to have led to assumptions about living systems, such as the idea that plants are the ultimate in passivity (and mindlessness) and humans have exclusive access to top-quality problem solving because they "think." It may be that these assumptions are severely skewing our ability to see the extraordinary solutions nature has provided to all her creatures. In addition, if we have mistaken the neocortical origins of our own ways of knowing, it appears likely that what we are trying to accomplish in educating our children may be subject to biases that emphasize our species centrism over a kind of knowledge that would help us find our place in nature – and our responsibility as natural beings within the matrix of living things. It is long past the time to pretend our children only deserve cognitive education (the flawed central tenet of No Child Left Behind), and time to begin recognizing that it is only through new and sophisticated forms of emotional education that breeds social intelligence (Goleman, 2006) that we will truly leave no child behind.

Education appears to divide children up along the lines of the sciences we have used to study them. Because cognition is the domain of the "highest" abilities, we devise a curriculum to enhance their thinking ability by training them to organize and memorize facts, and to look for new ways to use the facts. Far behind the perceived importance of cognition, so important for making a buck, are the emotional, motivational, and physical domains that make us truly human. Such issues are grudgingly or barely considered in mainstream educational practice, but perhaps the times they are a changing (Sunderland, 2006). Yet, from what we have tried to focus on in this chapter, those deep and pervasively felt domains are the very foundation of what we *experience as* thinking and cognizing. This subtle affective fabric of mind should be brought back into the understanding of human behavior, and that understanding might then take the fair measure of each child as the breathtakingly sensitive open experiencer he or she is, needing little extra motivation to explore, act, express, and learn … if only given the opportunity to employ their natural enthusiasms. Clearly, the computer revolution has opened up a world of information that they like to explore, and helped them become self-motivated learners. Albeit, we must take care to help ensure they do not become addicted to the crap that is also abundantly available on the web. They should also have plenty of time and be allowed to play freely with each other, so their social brains are allowed to grow and connect up as a result of rich engagements with others. Obviously, these engagements will often lead to trouble and dissention, but bright young adults should be sitting at the edges of our playgrounds (or play sanctuaries) to help assure that all the kids learn the one important rule without which no human society can thrive – do not hurt another. Do not do unto others what you would not have done unto you. In this age when parents consider drugging their children with Ritalin so that they will settle down enough to be filled up with facts, we have to consider whether we have gotten the science about ourselves right in any essential way (Panksepp, 1998b, 2007b). If not, can we use our deep mammalian motivations and cognitions, along with a few profoundly and uniquely human insights, to do better?

EDUCATIONAL APPLICATIONS

We have looked at how aspects of the core emotional command systems, especially SEEKING urges, shape behaviors and play an essential role in their execution and timing as well as holding their expressions in robust and dynamic experiential states. It may well be that almost all learning must be accompanied by dynamic affective experiential states in order for lasting and deeply positive behavioral-psychological change to occur. Cashing out this suspicion in appropriate research is likely to have ramifications for how learning is conceptualized – both in homes and in schools, and possibly in social programs for workplace retraining. A clear recognition of how brain dopamine dynamics and the resulting energizing of SEEKING urges interface with our educational aspirations will be an interesting future chapter of educational psychology. Perhaps we can see the importance of emotional energies, especially the role of PLAY, most clearly during the preschool years, when our children are supposed to become socialized, with emerging clear ideas of what they can or cannot do to other people.

It may be that the best way to advance the healthy emotionally sensitive socialization of our children, so as to promote increasing empathy and concern for others – hopefully toward an "Empathic Civilization" (Rifkin, 2010) – is to better deploy one of our most underutilized social resources – joyous childhood physical PLAY – to train each generation about what good humans can and cannot do to each other. Let us re-emphasize the darker side of the point just made: During the competitive joys of childhood play, kids will "naturally" hurt each other. We adults should be there, more consistently, at many critical moments, to gently intervene with sincere and nonpunitive guidance encouraging the children toward pro-social options. If from the earliest ages we fostered more independent, playful social engagements, under the watchful eye of those who realize that playful joy brings children to the perimeters of their emotional knowledge, might we more consistently train the young of our species not to hurt each other? If at many critical moments, more of our young promptly heard some good advice from above – "You shouldn't have done that.… If you want to play, don't do that anymore. OK?" – might we be able to construct better pro-social minds/brains? Can we diminish the potential for cruelty inherent in our human bloodline through the promotion of more empathic touch/speech and equitably joyous social policies? It's at least worth a try.

Our raw emotions need to be used skillfully to educate our children. We should reopen our playgrounds as perhaps the most important classrooms that our children will ever have, as long as the instructors of the young are sympathetically observing and assuring that no child is marginalized in those all-important playful experiences that help construct social brains. Then, when the SEEKING system takes over in full force, we can also guide that joyful energy into optimal educational programs.

Clearly, there is much at stake in our better understanding of the interplay of cognition and emotion. The other animals, that also lead rich affective lives, still have much to teach us.

References

Alcaro, A., Huber, R., & Panksepp, J. (2007). Behavioral functions of the mesolimbic dopaminergic system: An affective neuroethological perspective. *Brain Research Reviews*, **56**, 283–321.

Bannon, M. J. (2002). Dopamine. *Encyclopedia of Life Sciences*. U.K.: Nature Publishing Group.

Berridge, K. C. (2007). The debate over dopamine's role in reward: The case for incentive salience. *Psychopharmacology*, **191**, 391–431.

Berridge, K. C., & Robinson, T. E. (1998). What is the role of dopamine in reward: hedonic impact, reward learning, or incentive salience? *Brain Research*, **28**(3), 309–369.

Blakeslee, S. (1996). How brain may weigh the world with simple dopamine system. *Science Desk March 19, 1996*. New York: The New York Times Company.

Buhner, S. H. (2002). *The Lost Language of Plants: The Ecological Importance of Plant Medicines to Life on Earth*. White River Junction, VT: Chelsea Green Press.

Burgdorf, J., & Panksepp, J. (2005). The neurobiology of positive emotions. *Neuroscience and Biobehavioral Reviews*, **30**, 173–187.

Burgdorf, J., Wood, P. L., Kroes, R. A., Moskal, J. R., & Panksepp, J. (2007). Neurobiology of 50-kHz ultrasonic vocalizations in rats: Electrode mapping, lesion, and pharmacology studies. *Behavioral Brain Research*, **182**, 274–283.

Card, J. P. (2002). Hypothalamus. *Encyclopedia of Life Sciences*. U.K.: nature Publishing Group.

Carter, C. S., Lederhendler, I. I., & Kirkpatrick, B. (Eds.) (1997). *The Integrative Neurobiology of Affiliation. Annals of the New York Academy of Sciences, v. 807*. New York: The New York Academy of Sciences.

Civelli, O., & Zhou, Q. (2001). Dopamine receptors: Molecular pharmacology. *Encyclopedia of Life Sciences*. U.K.: Nature Publishing Group.

Ding, L., & Perkel, D. J. (2002). Dopamine modulates excitability of spiny neurons in the avian basal ganglia. *Journal of Neuroscience*, **22**(*12*), 5210–5218.

Durstewitz, D., Seamans, J. K., & Sejnowski, T. J. (2000). Dopamine-mediated stabilization of delay period activity in a network model of prefrontal cortex. *Journal of Neurophysiology*, **83**, 1733–1750.

Edelman, G. M. (1989). *The Remembered Present: A Biological Theory of Consciousness*. New York: Basic Books.

(1992). *Bright Air, Brilliant Fire: On the Matter of the Mind*. New York: Basic Books.

Fischer, K. W., Shaver, P. R., & Carnochan, P. (1990). How emotions develop and how they organize development. *Emotion and Cognition*, **4** (*2*), 81–127.

Frijda, N. H. (1987). *The Emotions*. Cambridge: Cambridge University Press.

(1988). The laws of emotion. *American Psychology*, **43**, 349–358.

Gao, W., Krimer, L. S., & Goldman-Rakic, P. S. (2001). Presynaptic regulation of recurrent excitation by D1 receptors in prefrontal circuits. *Proceedings of the National Academy of Sciences*, **28**(1), 295–300.

Goleman, D. (2006). *Social Intelligence: The Revolutionary New Science of Human Relationships.* New York: Bantam Dell (Division of Random House).

Hollerman, J. R., & Schultz, W. (1998). Dopamine neurons report an error in the temporal prediction of reward during learning. *Nature Neuroscience*, **1**, 304–309.

Ikemoto, S., & Panksepp, J. (1999). The role of nucleus accumbens dopamine in motivated behavior: A unifying interpretation with special reference to reward-seeking. *Brain Research Reviews*, **31**, 6–41.

James, W. (1987). The meaning of truth: A sequel to "Pragmatism." In B. Kuklick, (Ed.), *William James: Writings 1902–1910* (pp. 821–978). New York: The Library of America.

Kapsimali, M., LeCrom, S., & Vernier, P. (2002). A Natural history of vertebrate dopamine receptors. In A. Sidhu, M. Laruelle, & P. Vernier (Eds.), *Dopamine Receptors and Transporters: Pharmacology, Structure, and Function (2nd Ed.)*. New York: Marcel Dekker Inc.

Kupferman, I. (1991). Hypothalamus and limbic system: Motivation. In E. R. Kandel, J. H. Schwartz, & T. M. Jessell (Eds.), *Principles of Neural Science. (3rd Ed.* (pp. 750–760)). Norwalk, Connecticut: Appleton & Lange.

Lazarus, R. S. (1991). *Emotion and Adaptation*. New York: Oxford University Press.

LeDoux, J. (2002). *Synaptic Self: How Our Brains Become Who We Are*. New York: Viking.

Loeb, J. (1918). *Forced Movements, Tropisms and Animal Conduct*. Philadelphia: Lippincott.

MacLean, P. D. (1990). *The Triune Brain in Evolution*. New York: Plenum Press.

Narby, J. (2005). *Intelligence in Nature: An Inquiry into Knowledge*. New York: Tarcher/Penguin.

Nathaniel, T. I., Panksepp, J., & Huber, R. (2009). Drug-seeking behavior in an invertebrate system: evidence of morphine-induce reward, extinction an reinstatement in crayfish. *Behavioural Brain Research*, **197**, 331–338.

Northoff, G., Heinzel, A., de Greck, M., Bermpohl, F., & Panksepp, J. (2006). Our brain and its self – the central role of cortical midline structures, *NeuroImage*, **31**, 440–457.

Northoff, G., & Panksepp, J. (2008). The trans-species concept of self and the subcortical-cortical midline system. *Trends in Cognitive Sciences*, **12**: 259–264.

Panksepp, J. (1982). Toward a general psychobiological theory of emotions. *The Behavioral and Brain Sciences*, **5**, 407–467.

(1998a). *Affective Neuroscience: The Foundation of Human and Animal Emotions*. New York: Oxford University Press.

(1998b). The periconscious substrates of consciousness: Affective states and the evolutionary origins of the SELF. *Journal of Consciousness Studies*, **5**, 566–582.

(2001). The long-term psychobiological consequences of infant emotions: prescriptions for the 21st century. *Infant Mental Health Journal*, **22**, 132–173.

(2005a). On the embodied neural nature of core emotional affects. *Journal of Consciousness Studies*, **12**(8–10), 158–184.

(2005b). Affective consciousness: Core emotional feelings in animals and humans. *Consciousness and Cognition*, **14**, 30–80.

(2007a). Neuroevolutionary sources of laughter and social joy: Modeling primal human laughter in laboratory rats. *Behavioral Brain Research*, **182**, 231–44.

(2007b). Can PLAY diminish ADHD and facilitate the construction of the social brain. *Journal of the Canadian Academy of Child and Adolescent Psychiatry*, **10**, 57–66.

(2007c). Affective Consciousness. In M. Velmans & S. Schneider (Eds.), *The Blackwell Companion to Consciousness* (pp. 114–129). Malden, MA: Blackwell Publishing, Ltd.

(2010). Perspectives on passages toward and affective neurobiology of mind? Foreword to the *Encyclopedia of Behavioral Neuroscience.* Amsterdam: Elsevier.

Panksepp, J., & Burgdorf, J. (2003). "Laughing" rats and the evolutionary antecedents of human joy? *Physiology and Behavior*, **79**, 533–547.

Panksepp, J. B., Huber, R. (2004). Ethological analyses of crayfish behavior: a new invertebrate system for measuring rewarding properties of psychostimulants behavioral. *Brain Research*, **153**, 171–180.

Panksepp, J., & Northoff, G. (2009). The trans–species core self: The emergence of active cultural and neuro-ecological agents through self related processing within sub-neocortical-cortical midline networks. *Consciousness & Cognition*, **18**, 193–215.

Panksepp, J., & Moskal, J. (2008). Dopamine and SEEKING: Sub-neocortical "reward" systems and appetitive urges. In A. Elliot (Ed.), *Handbook of Approach and Avoidance Motivation* (pp. 67–87). Mahwah, NJ: Lawrence Erlbaum Associates.

Pfaff, D. W. (1999). *Drive: Neurobiological and Molecular Mechanisms of Sexual Motivation*. Cambridge, MA: MIT Press.

Rifkin, J. (2010). *The Empathic Civilization: The Race to Global Consciousness in a World in Crisis.* New York: Penguin Group.

Rolls, E. T. (2004). The functions of the orbitofrontal cortex. *Brain and Cognition*, **55**, 11–29.

Sacks, O. (1990). *Awakenings*. New York: Vintage Books.

Schore, A. N. (1994). *Affect Regulation and the Origin of the Self: A Neurobiology of Emotional Development*. Hillsdale, NJ: Lawrence Erlbaum Associates.

Schultz, W. (2001). Reward signaling by dopamine neurons. *Neuroscientist*, 7(4), 293–302.

Solms, M., & Turnbull, O. (2002). *The Brain and the Inner World: An Introduction to the Neuroscience of Subjective Experience*. New York: Other Press.

Sunderland, M. (2006). *The Science of Parenting.* London: DK Publishing Inc.

Swanson, L. W. (2003). *Brain Architecture: Understanding the Basic Plan.* New York: Oxford University Press.

Vandekerckhove, M., & Panksepp, J. (2009). The flow of anoetic to noetic and autonoetic consciousness: A vision of unknowing (anoetic) and knowing (noetic) consciousness in the remembrance of things past and imagined futures. *Consciousness & Cognition*, **18**, 1018–1028.

Watt, D. F., & Pincus, D. I. (2004). Neural substrates of consciousness: Implications for clinical psychiatry. In J. Panksepp (Ed.), *Textbook of Biological Psychiatry* (pp. 627–660). Hoboken, NJ: Wiley.

Watt, D. F. & Panksepp, J. (2009). Depression: an evolutionarily conserved mechanism to terminate separation-distress? A review of aminergic, peptidergic, and neural network perspectives. *Neuropsychoanalysis*, **11**, 5–104.

Whitfield, J. (2001). Making crops cry for help. *Nature*, **410**, 736–737.

7

Motivation, Cognition, and Emotion

A Phylogenetic-Interdisciplinary Approach

Manfred Wimmer

INTRODUCTION

Compared to behaviourism, cognitive psychology has largely neglected motivational issues. With the cognitive revolution, the whole topic of motives and motivations moved out of the focus of scientific mainstreams. Except for some social psychologists, the cognitive revolution did not consider basic motivational forces seriously (LeDoux, 1996, p. 323).

The working hypothesis for explaining the functional principles of cognition in general have been deeply influenced by the computer sciences. The concept of the brain as a computer has become the leading idea, and a lot of metaphors from computer sciences influenced the view of cognitive functions, which were treated as purely neocortical processes. Emotional and motivational factors were considered as neutral energy or unspecified arousal processes (Schachter & Singer, 1962).

In the course of the last decade, the situation changed as research from the booming fields of neurobiology and neurophysiology increasingly provided evidence that cognitive functions are being seriously influenced by deeper layers (motivational as well as emotional) of the brain. The view of cognitive processes as purely neocortical functions more and more appears as one-sided and insufficient (e.g., Ciompi, 1988, 2003; Damasio, 2003; LeDoux, 1996, 2002; Panksepp, 1998; Wimmer & Ciompi, 1996). The necessary extension that integrates emotional as well as motivational factors leads to a deeper understanding of cognition in general, and clearly demonstrates the linkages between cognitive processes and their emotional-motivational bases. This shift has a deep impact on cognitive sciences and related fields of research as well as on philosophy in general. Neglecting the whole emotional-biological-motivational substructures of brain functions and reason in general leads to one-sided and insufficient conceptions.

The following approach attempts to shed light on the emotion-motivation-cognition interactions from a phylogenetic perspective. Intended is an integrative approach devoid of any reductionistic attitudes. This means that the demonstrated levels of emotional-motivational-cognitive interactions will be analysed from two perspectives:

(a) The bottom-up perspective focusing on the constitutive elements (e.g., physiological processes; neurobiological structures and functions; genetically based, hardwired behavioural programs, etc.)
(b) A perspective focusing on the internal dynamics of the analysed level (e.g., the level of a single cell is different from the level of tissues, whose dynamics are integrated within the whole of the organism's processes).

Bottom-up and top-down processes as well as horizontal dynamics within a specific level need to be separated clearly in order to avoid the traps and serious failures of 'nothing else but' kinds of reductionism (Campbell, 1974, p. 180; Riedl, 2000).

WHERE TO BEGIN?

A serious challenge for each phylogenetic approach is the problem of the starting point. It is a question located near the borderline between scientific and more metaphysical issues. For the framework of this article, I will take into account the perspectives from K. Lorenz and J. Piaget. Lorenz's approach is close to general phylogenetic considerations; Piaget's frame is closer to ontogeny.

Concerning cognition, for Lorenz, as an evolutionary thinker, 'life itself is a process of acquiring knowledge' (Lorenz as cited in Weiss, 1971, p. 231). This statement was one of the basic ideas for Evolutionary Epistemology (Lorenz 1973; Lorenz & Wuketits, 1983; Riedl, 1984; Vollmer, 1981), which was designed to enable a kind of naturalization of cognition in general. This means that the typical frame of analysis for cognitive processes in general – containing symbols, consciousness, language, rationality, and so forth – is enlarged to include biological-evolutionary processes in a broad sense. Life itself and evolution in general are considered as processes close to cognition.

From another perspective, J. Piaget, the founder of Genetic Epistemology, argues, that 'cognitive processes are the result of organic autoregulation, whose main mechanisms they reflect' (Piaget, 1967, p. 27; trans. M. W.). Piaget also tried a specific kind of naturalization of cognitive processes beyond Lorenz's evolutionary naturalization with emphasis on autoregulative processes (Piaget, 1967; Vuyk, 1981; Wimmer 1998, p. 181f).

Although Lorenz and Piaget have quite different views on evolution in general (Wimmer, 1998) both propose a deep continuity from the biological-organic processes to cognitive functions (see also Heschl, 1990; Lorenz, 1977).

In order to emphasise the special features of cognitive processes at different levels, Oeser and Riedl propose two levels of cognition:

> (a) The level of organic processes, dominated by the basic biological tendencies of self-preservation and preservation of the species, where cognition is considered as gain of information; and (b) more complex levels, characterised by higher brain activity, consciousness, and reflexivity, where it is useful to speak about gain of knowledge. (Oeser, 1987, p. 9; Riedl, 1984, pp. 2, 15)

One major approach that serves as background for both kinds of arguments is Bertalanffy's General Systems Theory, which considers organisms as open systems whose permanent interactions with the environment establish a dynamic equilibrium (or steady-state). This means that specific internal structures are kept stable over a permanent change of matter and energy (Bertalanffy, 1968, p. 149). These structures are maintained by regulative processes, and it is these processes that are the main signs of life (Piaget, 1967, p. 27). A deeper understanding of motivational processes in general (i.e., basic motivational as well as higher motivational processes) requires considering these regulatory activities.

For a phylogenetic-evolutionary approach to motivation and related emotional-cognitive fields, it is necessary to distinguish between three kinds of regulative activities: structural, functional, and cognitive regulations. According to Piaget and Bertalanffy, these different kinds of regulatory activities are closely interrelated, depending on the level of phylogenetic or ontogenetic development.

a) *Structural regulations*: At the base of structural regulation there are regulatory activities without any specified regulatory organs. This kind of regulatory activity depends on dynamic interactions, 'where the order is effectuated by a dynamic interplay of processes … e.g., embryonic regulations where the whole is re-established from the parts in equifinal processes' (Bertalanffy, 1968, p. 43). Further structural regulations are based on the endocrine system and lead to changes of an 'anatomical or histological kind' (Piaget, 1967, p. 31; trans. M. W.). Essentially, this type of regulation involves concrete physiological parameters (e.g., body temperature, cellular dehydration) that have to be kept stable in relation to permanently changing environmental conditions.

b) *Functional regulations* deal with the 'activity or the physiological (or psychophysiological) reaction of the organs' (Piaget, 1967, p. 31; trans. M. W.). These processes are based on activities of the nervous system and are responsible for regulating behavioural patterns or actions in a broad sense. In contrast to concrete structural regulations (e.g., digestion), the main characteristic of functional regulation is a functional integration, which integrates objects not to organs but to behavioural schemes. The grasping scheme of a baby can serve as an example for a behavioural scheme. When grasping for an object, the child is integrating this object (the ball) into a behavioural scheme (the grasping scheme).

   Similarly, within ethology, the 'innate releasing mechanisms' (IRM) (Lorenz, 1981, p. 175f) can be considered as one main element of functional–behavioural regulations. The IRM is a functional concept, describing the sensory capacities, which enable the organism to perceive and react to specific stimuli.

c) *Cognitive regulations* appear as regulations with maximal flexibility including reversibility. They are active within the functional-mental field and do not directly rely on environmental stimuli or physiological parameters. In contrast to functional regulations whose stability is due to behavioural schemes or physiological schemes and related desired values, cognitive regulations are organized around so-called invariances providing stability within cognitive structures. According to Piaget, Platt formulates, 'It seems possible that the dynamic search for invariances may even be a general principle of organization in the higher order processes in the brain' (Platt, 1970, p. 38). In organizing cognitive activities, these invariances are closely related to Kant's aprioris (Wimmer, 1998, p. 190ff).

Taking into account these basic assumptions about the roots of organic-cognitive processes, it becomes evident that bodily changes or disturbance of balance and re-establishment of this balance are basic to biological organization and seem to be a fundamental bipolarity inherent in life (Ciompi, 1982, p. 96). The common root of motivation, emotion, as well as cognitive processes can be found in this bipolarity and the associated regulative processes.

According to H. Spencer, who characterised evolution as 'a change from an indefinite, incoherent homogeneity to a definite, coherent heterogeneity through continuous integration and differentiation', these primarily unified regulative processes, containing motivational, emotional, and cognitive components during ontogeny as well as phylogeny, get differentiated without ever losing their close relations (Spencer, cited from Hillman, 1992, p. 158). This view contradicts and reveals as totally artificial the widespread separation of cognition and emotion, which rests on a long philosophical (especially rationalistic) tradition and is reflected also in the isolated status of cognition within AI research and cognitive psychology.

In this chapter, I will outline emotion-motivation-cognition interactions at four different levels. The first and most basic kind of interaction is the *kinesis reaction*, which is a kind of behavior manifested especially in unicellular organisms. Increasing complexity shows the second kind of interaction, which is the taxis reaction. The third level is that of instincts and related primary emotions. Finally, some characteristics of the human – symbolic level – will be discussed briefly. The main goal is to show that an evolutionary approach (also including ontogeny) clearly demonstrates the reciprocal relations between emotional, cognitive, and motivational processes. This means that a deeper understanding of all these processes has to take into account the interactions within this triangle as well as its specific dynamics on different levels of phylogenetic and ontogenetic development.

LEVELS OF MOTIVATION: COGNITION–EMOTION INTERACTION

Kinesis

Dealing with a behaviour of this kind may probably look inadequate for a discussion about motivation and cognition. For a phylogenetic approach, however, it seems necessary to elaborate on such a basic kind of behaviour. Kinesis behaviour is a very simple kind of behaviour in unicellular organisms. For the observer, it appears as increase of locomotor activities when reaching worse environmental conditions. (e.g., high temperature). This behaviour can be analysed quite well on a physiological level: Disruption of the physiological homoeostasis (which may be perceived by specific receptor organs) automatically leads to increased locomotor activities, and is reduced if homoeostasis is re-established. If there is cognition, it is only in this basic sense of gain of information, as mentioned above in regard to Lorenz and Piaget.

The organismic structure gets to 'know' the changes of homoeostasis and compensatory mechanisms (e.g., locomotion) are induced. That which the organism perceives is a change of the internal conditions. Something such as an outside world does not exist yet. Obuchowski (1982, p. 236; trans. M. W.)

describes this behavioural pattern as the homoeostatic code that is characterised by the following features:

1) Information reaches the organism without the mediation of receptor organs;
2) Information is not identified by a specific apparatus;
3) The behaviour of the organism is modified by homeostatic changes;
4) A lot of information gets lost;
5) The simplicity of orientation mechanisms compensates for the loss of information.

Following Obuchowski, one of the basic functions of emotions can be considered as 'being a marker which signals a disruption of homoeostasis' (Obuchowski, 1982, p. 233; trans. M. W.). In the framework of this kind of behaviour, there appears the almost inseparable unity of motivation, cognition, and emotion (Leeper, 1970). The cognitive aspect can be found in the organism's capacity to perceive the change of the internal conditions, or in the words of Bateson, to find a difference that makes a difference (Bateson, 1983, p. 582). This kind of perception includes the tendency to locomotor activity, which represents the component of motivation. I would place emotional-affective components somewhere in between perception and locomotion.

On a more general level, Sylvan Tomkins' concept of motivation and emotions presents a similar argument: 'The affect system is therefore the primary motivational system because, without its amplification, nothing else matters and, with its amplification, anything else can matter. It thus combines urgency and generality. It lends its power to memory, to perception, to thought, and to action no less than to the drives' (Tomkins, 1980, p. 147).

Taxis

On this level, the undirected locomotor activity of kinesis is replaced by a type of behaviour that is 'directly determined by the impinging stimulus' (Lorenz, 1981, p. 227). The main characteristic that differentiates taxis from kinesis is the goal directedness of this kind of behaviour. Examples are positive phototaxis of moths and negative phototaxis of wood lice. Compared to kinesis, which in case of homoeostatic disruption leads to undirected increase of locomotor activities, taxis is characterised by different kinds of goal-directed behaviours, such as, 'away from light'.

Higher forms of taxis reactions can be seen for example in the behaviour of turbellarian worms. Their movement towards an olfactorily located feeding site depends on their actual internal state (Holzkamp-Osterkamp, 1975,

p. 156). The hungry animal will move towards the feeding site; the satiated organism does not react to the same olfactory stimulation.

It has to be emphasised, that on this level the differentiation of the internal conditions of the organism leads to different kinds of motoric patterns and perceptions. Different types of internal states (e.g., hungry, satiated) render the organism sensitive towards different kinds of external stimuli, connected with corresponding motoric patterns, leading to appetitive (approach) or aversive (avoid) reactions. Perceptive as well as motoric capacities are highly dependent on the actual internal state. Compared to kinesis reactions, in which stimulus and response are closely interrelated, in taxis behaviour a new internal component appears between perception and reaction, which seems to be one of the precursors of emotions.

This dependence of perceptive and motoric activities on the internal organismic state appears as a fundamental functional principle within the emotion-motivation-cognition triangle. In anticipation of later statements, the internal organismic state may be considered as close to emotions, and perceptions as close to cognitions. Each cognitive activity is closely connected to the emotional-internal base, providing the necessary connection to the basic organismic layers.

Primary Emotions: Instincts, Emotions, and Motivation

The next phylogenetic level that will be discussed is the level of the so-called primary emotions and accompanying instincts. The close relations between instincts and emotions were emphasised especially by W. McDougall, W. James, and more recently by evolutionary approaches such as Plutchik's psychoevolutionary theory (Plutchik, 1980).

Thus:

> [McDougall regarded an emotion] as a mode of experience which accompanies the working within us of instinctive impulses. It was assumed that human nature (our inherited inborn constitution) comprises instinct; that the operation of each instinct, no matter how brought into play, is accompanied by its own peculiar quality of experience which may be called a primary emotion.... The human emotions were then regarded as clues to the instinctive impulses, or indicators of the motives at work in us. (McDougall, 1933, p. 128)

Plutchik's psychoevolutionary theory, which is closely related to Darwin's approach, considers emotions within biologically relevant functional areas, where they 'serve an adaptive role in helping organisms deal with key survival issues posed by the environment' (Plutchik, 1980, p. 8).

In relation to neurobiological research, Panksepp considers primary emotions as 'emotional systems' or 'executing, command and operating systems' including strong motivational forces, which are defined by the six following criteria (Panksepp, 1998, p. 52):

1. The underlying circuits are genetically predetermined and designed to respond unconditionally to stimuli arising from major life-challenging circumstances;
2. These circuits organise diverse behaviours by activating or inhibiting motor subroutines and concurrent autonomic-hormonal changes that have proved adaptive in the face of such life-challenging circumstances during the evolutionary history of the species;
3. Emotive circuits change the sensitivities of sensory systems that are relevant for the behavioural sequences that have been aroused;
4. Neural activity of emotive systems outlasts the precipitating circumstances;
5. Emotive circuits can come under the conditional control of emotionally neutral environmental stimuli;
6. Emotive circuits have reciprocal interactions with the brain mechanisms that elaborate higher decision-making processes and consciousness (Panksepp, 1998, pp. 48–49).

In order to get closer to the overlapping fields of emotional-motivational dynamics, it is useful to take a look at classical ethology, which dealt with motivational issues in a very intensive manner. In contrast to the behaviourist tradition, which considered motivations from an external point of view (stimulation theory) (LeDoux, 2006, p. 312ff), the European tradition considers motivation rather from an internal point of view, closer to the notion of drives.[1]

Within classical ethology, the notion of instincts is very broad and heterogeneous. Generally speaking, most proponents of classical ethology consider instincts as complex behaviours, including the following three elements (Lorenz, 1981; Tinbergen, 1952): (a) perceptive components; (b) a central coordinating part; and (c) specific motor components (a fixed action pattern). Notably, all three elements form a functional unit. Each component has different possibilities for modifications by external influences.

The perceptive component. Within classical ethology, the perceptions of organisms are triggered by the so-called innate releasing mechanism (IRM), which allows organisms to perceive specific and biologically relevant stimuli (Lorenz, 1981, p. 175f). The IRMs is a functional concept demonstrating high sensitivity for specific classe of stimuli, for example, mates are recognized by a specific colour pattern and prey by their shape. Compared to the motor component, which appears as highly rigid, this sensory part is a major target of learning processes and evolutionary changes (Lorenz, 1963).

The IRM appears as a function of the nervous system and shows increasing specialization with growing complexity of neuronal activities. Invertebrates, especially insects and spiders (*Arachnidae*), have IRMs not modifiable by learning (Lorenz, 1981, p. 175). In higher animals, especially vertebrates, all IRMs can be modified by learning, which O. Storch calls 'receptor learning', demonstrated, for example, by Schleidt (1962). Examples of further modifications of this sensory component appear in conditioned learning procedures, such as conditioned appetitive behaviour, conditioned aversion, and conditioned action (Hassenstein, 1987, p. 274ff; Lorenz, 1981, p. 289ff; Wimmer, 1996, p. 49).

All these modifications of behavioural schemes cannot be properly understood if the emotional components are not taken into account. In general, they provide the organism with a necessary feedback for behavioural acts, which emotionally colour specific actions or situations. It seems evident that with growing behavioural flexibility, these emotional capacities grew, allowing for the evaluation of the outcomes of actions and their attendant conditions. 'We consider these evaluations as the most general character of emotional qualities of life.' (Holzkamp-Osterkamp, 1975, p.155; trans. M. W.)

These evaluations emotionally colour the sensory as well as the motor component, clearly demonstrating that one main function of increasing emotional capacities is the evaluation of internal as well as external stimuli in relation to the organismic actual state (Holzkamp–Osterkamp, 1975, p. 155; Obuchowski, 1982, p. 238ff; Panksepp, 1998a; Scherer, 1981, p. 311). According to Panksepp (1998, p. 48), 'Each emotion has a characteristic "feeling tone" that is especially important in encoding the intrinsic values of these interactions, depending on whether they are likely to promote or hinder survival'. Notably, evaluative processes are primarily not manifested as conscious deliberations. They refer to relations between the internal state and external conditions (Holzkamp-Osterkamp, 1975, p. 157). The sensitivity of the IRMs depends on the internal-central-motivational state (a component of the central part) of the organism, making the organism sensitive in regard to these categories of stimuli that are relevant for its actual state (for a comparison with the ontogenetic level, see Wimmer, 1998).

The central coordinating part: The central part can be viewed as a mediator between a sensory surface and motor pattern. In general, the main function of the central component, which is also considered as internal state, is mediation between the sensory surface and behavioural (motoric) programs.[2]

In contrast to the behaviouristic tradition, which emphasized mainly that organisms are determined primarily by environmental conditions and physiological disturbances, in classical ethology, internal as well as external factors are responsible for generation of specific internal states and related behavioural tendencies. A major example is Lorenz's notion of 'endogenous built up excitability', which beside tissue needs and external stimulation plays an essential part in generating behaviour (Lorenz, 1981, p. 187). This perspective also includes the assumption that all types of learning processes contain inherited mechanisms providing severe biases for the content of learning, determining *what* gets learned (Ohman, 1993).

In greater detail, the functions of the central coordinating part are to: (1) motivate (i.e., affects as energisers of cognitive activities); (2) sensitise receptor organs; (3) evaluate the input in relation to the internal needs and preferences; (4) facilitate storage, whereby it should be emphasised that especially the hippocampus formation in the brain is essential for the so-called affective memory; and (5) enable organization of cognitive elements (cognitive elements are stored depending on the actual affective background). This leads to so-called integrated feeling-thinking-behaving programs (Ciompi, 1988; Wimmer & Ciompi, 1996).

From a more physiological point of view, J. D. Vincent considers the central component as a 'fluctuating central state' (Spector, 1982; trans. by M. W.) providing the basis for behavioural acts as well as learning processes. This concept is defined as predominantly physiological, but it contains more than merely elements of physiological homoeostasis (Vincent, 1990). The assumption of internal tendencies to actions performed without any actual physiological disturbance shows close correspondence to ethological results.

The 'fluctuating central state' in animals as in humans is a global phenomenon, appearing as the 'readout' of the internal physiological state, the actual perceptions of the surrounding conditions (which in higher mammals and humans also include imagination and anticipations) and contents of memory (ontogenetically established memory patterns as well as evolutionarily fixed schemes of evaluation, etc.) These three components significantly determine attention, perception, and storage of experiences as well as the mode of cognitive processes (Vincent, 1990, p.183f).

Concerning the motivational component of these behavioural programs, it is one of the main merits of ethology to have clarified that organisms are not just reacting to external stimulation or to present tissue needs. Although both components must be taken into account, there is also an internal, endogenous production of excitability, preparing the organism for a specific behaviour (appetitive behaviour) before actual deficiencies in the physiological field become dominant (Changeux, 1984; Holzkamp–Osterkamp, 1975, p. 86f; Lorenz, 1981; Vincent, 1990).

The basic level of these evaluative mechanisms can be found in the inborn teaching mechanisms and the related reward and punishment systems. The inborn teaching mechanisms proves to be a very useful concept for discussing the functional components of the feeling part on this level. The *built-in teacher* is defined as 'checking on the exteroceptor and proprioceptor input coming in as re-afference of a fixed motor pattern … a physiological mechanism in many ways comparable to an IRM' (Lorenz, 1981, p. 299). Thus, the built-in teaching mechanisms provide the organism with a kind of scale for the evaluation of behavioural patterns.

As Livesey points out, the basic affects are generated by these mechanisms, which appear as 'products of genetically established neural systems and accompany such stimuli as the taste and smell of food and drink, the tactual sensations of sexual intercourse, the pain of a burn and so on. These feelings are immediate perceptual correlates of the particular stimuli and constitute affects without cognitive interaction, though they are vital for the establishment of cognitive associations' (Livesey, 1986, p. 251).

If an executed motor pattern conforms to this teaching mechanism, it is combined with pleasure or, at a more basic level, does not cause any disturbances. Deviations from this prefixed standard lead to feelings of disharmony and disturbance. 'Without any known exception, animals that have evolved a centralized nervous system are able to learn from the consequences produced by their own actions, success acting as a "reward" or "reinforcement", failure acting as "punishment" tending to "extinguish" the animal`s readiness to repeat the action just performed' (Lorenz, 1981, p. 289). Within the human sphere, much more complex and socially transmitted norms and standards function as evaluative criteria of performed actions, having their origins in these basic mechanisms.

The behavioural part: The motor component: The basic level of behavioural acts can be found in the so-called fixed-action patterns leading to highly complex voluntary movements. In a search for the building blocks of behaviour in general, different levels of analysis can be chosen. The most elementary one is the level of motor activities as, for example, the muscular pattern necessary for a specific movement (e.g., to fly, to walk, to cry). As shown by v. Holst and v. St. Paul (1960), muscular-motoric patterns of this kind can be released by higher command centres, such as the centre for flight or attack.

The low-level units (muscular-motoric pattern) are also called multipurpose activities because of their guidance by different higher 'command areas' (Baerends, 1958; Lorenz, 1981, p. 220). For example, the same pattern of muscular activity can be released by fight or flight impulses. The dependence of the motor pattern on different behavioural ambits shows the difficulty of drawing clear lines between separate instincts.

Ethological research clearly demonstrates that the building blocks of animal behaviour are quite rigid, hierarchically organized, and strictly combined with specific patterns of internal or external releasing mechanisms, forming a linear hierarchy. A big phylogenetic step towards a more flexible stock of these building blocks is the so-called relative hierarchy of moods, as shown by Leyhausen (1965), especially in cats (*Felidae*).

> The acts of lying in ambush, stalking, catching, killing, and finally eating prey form a sequence which is obligatory only with regard to their common teleonomic function. Physiologically, each of the motor patterns involved retains the character of a consummatory act that possesses its own appetitive behavior independently of whether it is performed under the pressure of the higher level of tissue need or acted out in play for its own sake. (Lorenz, 1981, p. 203)

The step forward towards increasing flexibility of behaviour consists in the possibility to perform single elements of the behavioural range of prey catching for its own sake and the ability to combine elements of different behavioural ranges. This can be seen in play activities and most clearly in curiosity behaviours. Curiosity leads to performance of different behavioural elements in relation to exciting objects, which results in an immense growth of experience.

This excursion into the fields of classical ethology was designed to shed some light upon the emotional-motivational dynamics in different periods of phylogenetic development. Due to its strong cognitive biases, recent ethology seems not to be deeply interested in motivational issues (Hurley & Nudds, 2006; Wassermann & Zentall, 2006). In contrast, classical ethology was focused on motivational questions, and has exerted a deep impact on human psychology (see, for example, the intense discussions about K. Lorenz's book *On Aggression*, 1966).

Without taking all results from classical ethology for granted, it has to be emphasised that for motivational dynamics, internal as well as external factors play an essential role. Animals as well as humans are neither totally dependent on internal drives and forces nor directed exclusively by external stimuli.

Human Level

'With the disintegration of instincts, the hereditary programming disappears. There follow two new types of cognitive self-regulation, which are mobile and constructive' (Piaget, 1967, p. 59; trans. M. W.). Among the numerous factors leading to a fundamental change of behavioural organization in humans, symbol usage can be considered as one of the core elements. Its tremendous impact on emotional-motivational and cognitive issues in general (Deacon, 1998) will be discussed in relation to some specific topics.

The present context is not adequate for dealing with the issues of human ontogeny and the developmental processes leading from concrete senso-motor processes to symbolic behaviour. Piaget´s naturalistic theory of symbol formation provides a detailed framework for these highly complex stages of human ontogenetic development, emphasizing in particular the idea that symbols arise from concrete actions (Piaget, 1967; Wimmer, 1995, p. 46f).

In contrast to basic assumptions of AI research and linguistically orientated philosophical positions, within this context symbols are not taken as neutral signs computed by specific rules and governed by language. This idealised view of symbol manipulation is adequate only for so-called discursive modes of symbolic expression, appearing very late in human ontogeny, representing in its most developed version something such as an ideal language, which most probably is realised only in mathematics. Symbols in these areas are clearly defined and their usage follows generally accepted grammatical rules (Langer, 1967, p. 155). The main advocates of discursive symbolisms, such as Carnap, Russel, and Wittgenstein, drew clear boundaries between scientific or discursive symbol usage and other more subjective ways of symbol usage, in domains such as metaphysics, art, and emotions.

Susan Langer's concept of presentational symbols plays an important role in the latter type of symbolisation. Presentational symbols differ from discursive symbols mainly in that they have implicit meaning as well as perceptual and emotional qualities. Consequently, the semantic relations of this type of symbols are not stable and fixed (as, for example, in scientific language or mathematics), and depend more on the whole context (Lachmann, 2000, p. 73).

Presentational symbols also have some affinity to metaphors, namely, 'the power of seeing one thing in another', which is of major importance in regard to feelings and language (Langer, 1962, p. 153). The concept of presentational symbolism also embeds the arts and emotions within a framework of articulated experiences and expressions, which are not irrational but follow another kind of rationality.

Symbolic behaviour in this broad sense and its relations to the underlying motivational bases was one of the major topics of H. Furth's research. In contrast to Freud, he tries to embed the Piagetian cognitivist view in a more dynamic motivational-energetic framework (Furth, 1987, 1998; Wimmer, 1998). This view emphasises the affective transitions between concrete behavioural acts and emerging symbolic systems. According to Furth (1987, p. 26ff), there is an essential difference between the concrete motor output of behaviour, as it can be seen in animal behaviour, and human behaviour, where concrete motoric action patterns are replaced by symbolic forms of behaviour.

In early prehuman as well as most animal behaviour patterns, the connection between cognition (perception), motivations, and related (motoric) action patterns is very close. As discussed previously, classical ethology has demonstrated in detail how the internal states (drives), cognitive activities, and action patterns are related and activated (Lorenz, 1981; Tinbergen, 1952). In most cases of animal behaviour, activated behavioural programs include specific motor patterns. The major gap arises when the close relations between perception, motivation, and action get lost. When this occurs, the genetically fixed sensory and motor components can escape from their organizing frame.

Concerning motivational processes, Furth proposes that the energetic dimensions of the motoric activities that have not been spent in concrete behavioural acts remain active and are redirected into the symbolic sphere. Therefore, the energy that normally supports concrete behavioural acts (i.e., sensorimotor actions) is now used within the symbolic domain for the generation and manipulation of symbols. This means that impulses to actions that are no longer part of concrete actions are transformed in the symbolic domains, opening up a new field of human experience. Increasing symbolic capacities lead to a large expansion of motivationally relevant objects as well as changing problem-solving strategies. The range of concrete stimuli guiding behaviour gets broader through mentally constructed stimuli.

The new organizing principle is essentially guided by emotions, evaluating or colouring symbolic as well as sensory and motor components. These emotional guidelines provide something such as a guarantee or yardstick that the increasing (symbolic) freedom of behaviour keeps in touch with basic biological necessities (Wimmer, 1995).[3]

According to Piaget, Furth considers object constancy as a major fact which provides the basis for all kinds of symbolizing processes. An object attains a permanent character, because 'it is recognised as continuing to exist beyond the limits of the perceptual field, when it is no longer felt, seen or heard etc.' (Piaget, 1953, p. 9). Thus, an object is no longer just a 'thing of action', but becomes an 'object of contemplation' (Werner & Kaplan, 1963, p. 67).

Within human ontogeny, object constancy appears in the sixth stage of the sensorimotor period (between eighteen and twenty-four months) and implies serious changes in affective as well as cognitive dynamics. To take only one example, releasing stimuli – which were normally concrete stimuli configurations – eliciting concrete behavioural acts (e.g., fight, flight, mating) are now effective also in the mental domain. This means that imagined situations and those projected in the future are now able to seriously influence behaviour and probably destabilise the whole psychic domain.

Object constancy may be considered as leading to a stabilization of the whole affective life because the mentally represented symbols as well as the related affective qualities can remain active, even if the relevant object is out of range for providing concrete input. Thus, affective qualities colouring the mental entities remain active in absence of the concrete object.

In general, object constancy leads to a stabilization and expansion of internal, mental representations and the corresponding affective qualities. If these representations are paired with phonetic cues, stabilization as well as storage qualities seem to improve greatly. When phonetic entities such as words are expressed, they can have strong effects on the affective as well as cognitive bases.

A word – that is, a symbolic utterance – stored within a specific affective-cognitive context, can be reproduced beyond this primary context with weaker affective intensities. This leads to increasing flexibility and increasing abstract modes of symbol usage and representation. Beside abstract usage of symbols, the same word – produced in a more or less neutral atmosphere – can evoke the primary, context-related original feelings and cognitions. This opens a new dimension of sociocultural development, because words can be representatives for specific events, persons, and situations and can thus generate strong emotions – with related cognitions – which are now beyond the primordial, concrete context (Wimmer, 2004).

There is strong evidence that language arises after symbolisation, and that the phonologic dimension appeared after the semantic one. Semantic and phonetic dimensions together seem to have a reciprocal feedback, resulting in the phenomenal development of human language capacities.

According to Tomasello (1999, p. 96), 'The central theoretical point is that linguistic symbols embody the myriad ways of constructing the world inter-subjectively that have accumulated in a culture over historical time, and the process of acquiring the conventional use of these symbolic artifacts, and so internalizing these construals, fundamentally transforms the nature of children´s cognitive representations'. The core of the argument is that this new symbolic dimension underlies two major influences: vertical and horizontal conditions. The vertical dimension can be found in all the necessary cognitive, social, and neuronal preconditions, providing the basis for the ability to produce and handle symbols.

The empirical evidence for the deep impact of the underlying emotional-motivational forces on higher cognitive processes (e.g., decision making) opens up new perspectives in regard to reason and rationality in general (concerning the relations between rationality and emotions see also Nussbaum, 2001; De Sousa, 1987). In relation to decision processes, Damasio claims that two different mechanisms exist. One is based on conscious deliberations including anticipations and various options of the actual situation. The second mechanism, functioning partly subconsciously, activates ontogenetically acquired emotional experiences that had been made in similar situations (Bechara, 2000; Damasio, 2005, p. 174f; Tversky & Kahnemann, 1973). This second mechanism underlying decision processes can also refer to the whole evolutionarily acquired pattern of evaluations, which makes the outcomes much more complex (compare Ben-Ze'ev, 2000, p. 164). Thus, in each decision process beside rational thinking modes, the whole current psychophysiological state as well as the phylogenetically and ontogenetically established experiences enter the stage.

Ciompi calls this kind of vertical influence 'operator–like organizing and integrating functions of affects on cognitions',[4] which come into play at different levels (Ciompi, 1982, 2003, 2005). For example, Wimmer and Ciompi claim:

> The focus of attention is continually conditioned by basic emotional states. These states have a decisive influence on selection and linkage of relevant cognitive stimuli in learning processes. Specific types of logic … are thus generated by different emotional states [leading to]… a specific 'fear logic', 'anger logic', 'sadness logic', 'happiness logic' etc.… In melancholic states, for example, only negatively connoted cognitions are selected and combined into an entirely negative view of the world. (1996, p. 42)

The horizontal dimension takes into account all of the pre-existing symbolic universes, into which the individual human mind gets socialised (e.g., Assmann, 2000; Luckmann, 1967; Luhmann, 1980). These symbolic systems have their internal coherence, their history, and social foundation.

In this field, culture, in a broad sense – including symbols, language, and all kinds of meaning – functions as the necessary interface, intersubjectively coordinating the arising subjective fields of symbolic experience, and adjusting human spheres of life and biological programs (Eibl, 2009). It is especially concepts originating in sociology and the cultural sciences that emphasise the existence of something such as a 'cultural memory' (Assmann, 2000, p. 11f), a 'sociohistoric apriori' (Knoblauch, 1996, p. 16) reaching far beyond individual memory and forming a necessary frame for human ontogeny. This frame provides basic dimensions of meaning and sense for each individual and also transcends individual memory. Language can be considered an essential component of this frame, which contains specific world views, contexts of meaning, and versions of understanding (Luckmann, 1967, p. 91f). It is this frame, which forms a layer upon which basic, biological motivational forces are integrated, leading to new kinds of motivational dynamics without ever loosing the ties to phylogenetic history.

Notes

1. The author considers classical ethology as the early period of ethological research mainly situated in Europe with the major figures of N. Tinbergen, E.v. Holst, and K. Lorenz. Their ideas contradicted those of behaviourism.
2. The relations between this central, coordinating part and feelings is a controversial topic. One line of argument interprets the feeling part merely as accompanying the completion of these instinctive behavioural patterns (McDougall, 1933; Sullivan). In the framework of this tradition, the feeling part is a secondary phenomenon, an epiphenomenon, appearing as the result of brain and motor activities and neurophysiological changes. These are the primary sources of feelings, which arise as a side effect of such activities.

   A similar position was held by W. James who likewise proposed a close connection between instincts and emotions: 'Instinctive reactions and emotional expressions thus shade imperceptibly into each other. Every object that excites an instinct excites an emotion as well' (1890, p. 442; cit. from Hillman, 1992, p. 49).

   The core thesis of James' theory of emotions is 'that the bodily changes follow directly the perception of the exciting fact, and that our feeling of the same changes as they occur is the emotion.... Every one of the bodily changes, whatsoever it be, is felt, acutely or obscurely, the moment it occurs' (James, 1890, p. 449f; cit. from Hillman, 1992, p. 50). Thus, for James, feelings are just perceptions of physiological-motor changes.

   Other, more functionalist models view emotion as a mediating phase or event between cognitive and motor parts (e.g., Plutchik, 1980, 1984). The close relation between instinctive behavioural patterns and emotions seems evident, but the hypothesis of 'emotion as an accompaniment' (Hillman, 1992, p. 45f) does not take into account the evaluative functions of emotions leading to a broad scale of experienced emotions as well as modifications of behaviour.
3. Concerning the 'decoupling' of behavioural components, Scherer also emphasizes the essential role of emotions: 'Emotions "decouple" the behavioral reaction from the stimulus event by replacing rigid reflex-like stimulus response patterns or instinctive innate releasing mechanisms' (Scherer, 1984, p. 295).
4. *Operator* is defined as a variable, influencing and changing other variables.

References

Assmann, J. (2000). *Religion und kulturelles Gedächtnis*. München: Beck´sche Reihe.

Baerends, G. P. (1958). The contribution of ethology to the study of causation of behavior. *Acta physiologica et pharmacologica neerlandica*, 7, 466–499.

Bateson, G. (1983). *Ökologie des Geistes. Anthropologische, psychologische, biologische und epistemologische Perspektiven.* (Trans. V. Holl H. G.) Frankfurt/Main: Suhrkamp

(Engl. Version: Steps to an ecology of mind: Collected essays in anthropology, psychiatry, evolution and epistemology. Chandler Publishing Company.)

Bechara, A., Damasio, H., & Damasio, A. R. (2000). Emotion, decision-making, and the orbitofrontal cortex. *Cerebral Cortex*, **10**, 295–307.

Ben-Ze'ev, A. (2000). *The subtlety of emotions*. Cambridge, MA: MIT Press.

Bertalanffy, L.v. (1968). *General systems theory: Foundation, development, application*. New York: Braziler.

Campbell, D. (1974). Downward causation in hierarchically organised biological systems. In F. Ayala & T. Dobzhansky (Eds.), *Studies in the philosophy of biology. Reduction and related problems* (pp. 179–186). New York: Macmillan.

Changeux, J.P. (1984). *Der neuronale Mensch*. Reinbeck bei Hamburg: Rowohlt.

Ciompi, L. (1982). *Affektlogik. Über die Struktur der Psyche und ihrer Entwicklung*. Stuttgart: Klett-Cotta.

(1988). *The psyche and schizophrenia. The bond between affect and logic*. Cambridge, MA: Harvard University Press.

(2003). Reflections on the role of emotions in consciousness and subjectivity, from the perspective of affect logic. *Consciousness & Emotion*, **4**, 181–196.

(2005). Grundsätzliches zu Emotion, Kognition und Evolution. In M. Wimmer & L. Ciompi (Eds.), *Emotion, Kognition, Evolution: Biologische, psychologische, soziodynamische und philosophische Aspekte*. Filander: Furth.

Damasio, A. (2003). *Looking for Spinoza: Joy, sorrow, and the feeling brain*. Orlando: Harncourt.

(2005). *Der Spinoza – Effekt. Wie Gefühle unser Leben bestimmen*. Berlin: List.

De Sousa, R. (1987). *The rationality of emotions*. Cambridge, MA: MIT Press.

Deacon, T. W. (1998). *The Symbolic species: The co-evolution of language and the brain*. New York: W. W. Norton & Company.

Eibl, K. (2009). *Kultur als Zwischenwelt. Eine evolutionsbiologische Perspektive*. Frankfurt am Main: Suhrkamp.

Furth, H. (1987). *Knowledge as Desire. An essay on Freud and Piaget*. New York: Columbia University Press.

(1996). *Desire for society: Children's knowledge as social imagination*. New York: Plenum Press.

(1998). Objekt- und Symbolbildung bei Freud und Piaget. In M. Wimmer (Ed.), *Freud – Piaget – Lorenz:. Von den biologischen Grundlagen des Denkens und Fühlens* (pp. 211–220).Vienna: Wiener Universitäts Verlag.

Hassenstein, B. (1987). *Verhaltensbiologie des Kindes*. München/Zürich: Piper.

Heschl, A. (1990). L=C (Life=Cognition). A simple equation with astonishing consequences. *Journal of Theoretical Biology*, **145**, 13–40.

Hillman, J. (1992). *Emotion. A comprehensive phenomenology of theories and their meanings for therapy.* Evanston, IL: Northwestern University Press.

Holst, E. v., & Saint Paul, U. v. (1960). Vom Wirkungsgefüge der Triebe. *Naturwissenschaft*, **47**, 409–422.

Holzkamp, K. (1983). *Grundlegung der Psychologie*. Frankfurt/New York: Campus.

Holzkamp-Osterkamp, U. (1975). *Grundlagen der psychologischen Motivationsforschung 1*. Frankfurt/New York: Campus.

Hurley, S., & Nudds, M. (Eds.) (2006). *Rational Animals?* Oxford, UK: Oxford University Press.

Knoblauch, H. (1996). Die Verflüchtigung der Religion ins Religiöse. Thomas Luckmanns Unsichtbare Religion. In Th. Luckmann (Ed.), *Die unsichtbare Religion* (pp. 7–41). Frankfurt am Main: Suhrkamp.

Lachmann, R. (2000). *Susanne K. Langer. Die lebendige Form des Fühlens und Verstehens*. München: Wilhelm Fink Verlag.

Langer, S. (1942). *Philosophy in a new key. A study in the symbolism of reason, rite and art*. Cambridge, MA: Harvard University Press

(1962). *Philosophical sketches*. Baltimore, MD: John Hopkins Press.

(1967). *Mind: An essay on human feeling*. Vol.1. Baltimore, MD: Johns Hopkins University Press.

LeDoux, J. (1996). *The emotional brain: The mysterious underpinnings of emotional life*. New York: Simon & Schuster.

(2002). *Synaptic self: How our brains become who we are*. New York: Viking Penguin.

Leeper, R. W. (1948). A motivational theory of emotion to replace emotion as disorganised response. *Psychological Review*, **55**, 5–21.

(1970). Feelings and emotions. In M. Arnold (Ed.), *Feelings and emotions: The Loyola symposium* (pp. 151–168). New York: Academic Press.

Leyhausen, P. (1965). Über die Funktion der relativen Stimmungshierarchie: In K. Lorenz & P. Leyhausen (Eds.), *Antriebe tierischen und menschlichen Verhaltens. Gesammelte Abhandlungen* (pp. 169–267). München: Piper.

Livesey, P. J. (1986). *Learning and emotion: A biological synthesis*. Hillsdale, NJ: Lawrence Erlbaum Associates.

Lorenz, K. (1963). *Evolution and modification of behavior*. Chicago: Chicago University Press.

(1966). On aggression. New York: Harvest Book. [*Das sogenannte Böse. Zur Naturgeschichte der Aggression*. München: Piper, 1963].

(1973). *Die Rückseite des Spiegels. Versuch einer Naturgeschichte menschlichen Erkennens.* München: Piper.

(1977). Behind the mirror. A Search for a natural history of human knowledge. London: Methuen&Co.

(1981). *The foundations of ethology.* New York: Springer.

Lorenz, K., & Wuketits, F. (Eds.) (1983). *Die Evolution des Denkens*. München: Piper.

Luckmann, Th. (1967). The Invisible Religion. The Problem of Religion in Modern Society. Virginia: Macmillan.

Luhmann, N. (1980). *Gesellschaftsstruktur und Semantik. Bd.1. Frankfurt: Suhrkamp.. Luckmann, Th. (1967). The invisible religion*. New York: MacMillan.

McDougall, W. (1933). *The energies of men*. New York: Scribner.

Nussbaum, M. C. (2001). *Upheavals of thought: A theory of emotions*. Cambridge, MA: Cambridge University Press.

Obuchowski, K. (1982). *Orientierung und Emotion*. Köln: Pahl-Rugenstein.

Oeser, E. (1987). *Psychozoikum. Evolution und Mechanismus der menschlichen Erkenntnisfähigkeit*. Berlin/Hamburg: Parey.

Ohman, A. (1993). Fear and anxiety as emotional phenomena: clinical phenomenology, evolutionary perspectives and information processing. In M. Lewis & J. Haviland (Eds.), *The handbook of emotions* (pp. 511–536). New York: The Guilford Press.

Panksepp, J. (1998). *Affective neuroscience. The foundations of human and animal emotions*. New York: Oxford University Press.

(1998a). The preconscious substrates of consciousness: Affective states and the evolutionary origins of the SELF. *Journal of Consciousness Studies*, **5**, 566–582.

Piaget, J. (1967). *Biologie und Erkenntnis. Über die Beziehungen zwischen organischen Regulationen und kognitiven Prozessen*. Frankfurt: S. Fischer.

Platt, J. (1970). The two faces of perception. In J. Platt (Ed.), *Perception and change* (pp. 25–73). Ann Arbor, MI: The University of Michigan Press.

Plutchik, R. (1980). A general psychoevolutionary theory of emotion. In R. Plutchik & H. Kellerman (Eds.), *Emotion: Theory, research and experience* (pp. 3–33). New York: Academic Press.

(1984). Emotions: A General Psychoevolutionary Theory. In: K. Scherer /P. Ekman (Eds.) *Approaches to Emotions*. Lawrence Erlbaum Associates Publishers: Hillsdale.

Riedl, R. (1984). *Biology of knowledge. The evolutionary basis of reason*. Chichester/New York/Brisbane: John Wiley & Sons.

(2000). *Strukturen der Komplexität*. Berlin/Heidelberg: Springer.

Schachter, S., & Singer, J. (1962). Cognitive, social and physiological determinants of emotional state. *Psychological Review*, **69**, 379–399.

Scherer, K. R. (1981). Wider die Vernachlässigung der Emotion in der Psychologie. In W. Michaelis (Ed.), *Bericht über den 32. Kongreß der dt. Gesellschaft für Psychologie in Zürich* (pp. 304–317). Göttingen/Toronto/Zürich: Hochgreve-Verlag für Psychologie.

(1984). On the nature and function of emotion: A component process approach. In K. Scherer & P. Ekman (Eds.), *Approaches to emotions* (pp. 293–318). Hillsdale, NJ: Erlbaum.

(1994). Emotions serve to decouple stimulus and response. In P. Ekman & R. J. Davidson (Eds.), *The nature of emotion: Fundamental questions* (pp. 127–130). New York: Oxford University Press.

Schleidt, W. M. (1962). Die historische Entwicklung der Begriffe "Angeborenes auslösendes Schema" und "Angeborener Auslösemechanismus". *Zeitschrift für Tierpsychologie*, **19**, 397–722.

Spector, N. H. (1982). The central state of the hypothalamus in health and disease. Old and new concepts. In P. Morgane & J. Panksepp (Eds.), *Handbook of the hypothalamus* (pp. 203–219). New York: Marcel Dekker.

Sullivan, H.S. (1953). *The interpersonal theory of psychiatry.* New York: Norton

Tinbergen, N. (1952). *Instinktlehre*. Berlin/Hamburg: Parey.

Tomasello, M. (1999). *The cultural origins of human cognition*. Cambridge, MA: Harvard University Press.

Tomkins, S. S. (1980). Affect as amplification: Some modifications in theory. In R. Plutchik & H. Kellerman (Eds.), *Emotion – Theory, research, and experience.* New York: Academic Press Inc.

Tversky, A., & Kahnemann, D. (1973). Availability: A heuristic for judging frequency and probability. *Cognitive Psychology*, **2**, 207–232.

Vincent, D. (1990). *Biologie des Begehrens*. Reinebeck bei Hamburg: Rowohlt.

Vollmer, G. (1981). *Evolutionäre Erkenntnistheorie*. Stuttgart: S. Hirzel Verlag.

Vuyk, R. (1981). *Overview and critique of Piaget`s genetic epistemology* 1965–1980. Vols. I and II. New York: Academic Press.

Wassermann, E. A., & Zentall, T. R. (Eds.) (2006). *Comparative cognition. Experimental explorations of animal intelligence*. New York: Oxford University Press.

Weiss, P. (1971). *Hierarchically organized systems in theory and practice*. New York: Hafner.

Werner, H., & Kaplan, B. (1963). *Symbol formation*. Hillsdale, NJ: Erlbaum.

Wimmer, M. (1995). Biological-evolutionary roots of emotions. *Evolution and Cognition*, **1**, 38–50.

(1998). Vergleichbares und Nicht Vergleichbares bei K. Lorenz und J. Piaget. In M. Wimmer (Ed.), *Freud – Piaget – Lorenz. Von den biologischen Grundlagen des Denkens und Fühlens* (pp. 189–210). Vienna: Wiener Universitäts Verlag.

(2004). Emotion – cognition interaction and language. In A. Carsetti (Ed.), *Seeing, thinking and knowing* (pp. 277–292). Dordrecht/Boston/London: Kluwer Academic Publishers.

Wimmer, M., & Ciompi, L. (1996). Evolutionary aspects of affective-cognitive interaction in the light of Ciompi's "affect-logics". *Evolution and Cognition*, **2**, 37–58.

8

The Social and Cultural Context of Cognition

A Knowledge Perspective

Evelyn Au , Wendy Wan, &
Chi-yue Chiu

For too long, culture has been conceptualized as a contextual variable. The key question of what culture is has not received adequate attention. In this chapter, we attempt to directly address this question. Drawing on extant research on cognitive psychology, we present a knowledge perspective on culture. First, we describe cultural differences in cognition (i.e., procedural knowledge, declarative knowledge, including cognitive representations of others, the self, the group, events, and norms). Next, we describe how social and situational contexts influence the relative accessibility of different kinds of cultural knowledge. We will conclude the chapter by highlighting the motivational base of cultural knowledge. That is, use of cultural knowledge is motivated by basic social and psychological needs. For instance, individuals activate their cultural knowledge to reduce uncertainty in social living, to manage existential terror, and fulfill the need for belongingness.

Individuals sharing the same cultural tradition incorporate similar cognitive elements into their thought systems and assimilate their cognitive processes and responses to certain culture-characteristic patterns. As such, culture's cognitive consequences bespeak the influence of context on human cognitions. At the same time, cognitive effects of culture are flexible across situations; individuals recruit the cognitive resources their culture confers to achieve valued social and personal goals in concrete settings. Contemporary research on culture and cognition has taken a trait approach to culture, focusing on overt expressions of culture-characteristic cognitive traits in designated populations. On the one hand, this approach illuminates chronic group differences in cognition. On the other hand, it obscures the situational flexibility of the cognitive effects of culture and the agentic nature of cultural cognition (Hong & Chiu, 2001). In this chapter, we take a knowledge perspective to culture, likening enculturation to an expertise building process (Chiu & Hong, 2006, 2007). We begin by describing how culture is conceptualized in this perspective, and proceed to explain the different kinds of knowledge structures individuals living in the same cultural environment develop to process information and grasp experiences. Next, we will review the cognitive and motivational principles implicated in the situational flexibility of culture's cognitive effects. Because comprehensive reviews of the research literature are available in other sources (Chiu & Hong, 2006, 2007; Lehman, Chiu, & Schaller, 2004), we will include only a few illustrative research examples in this chapter.

A KNOWLEDGE PERSPECTIVE ON CULTURE

From a knowledge perspective, culture is a network of knowledge shared (albeit incompletely) among a collection of interconnected individuals (Chiu & Hong, 2006). Knowledge broadly refers to all the ways of understanding that make up our experienced, grasped reality, comprising learned routines of thinking, feeling, and interacting with others as well as a corpus of assertions and ideas about many aspects of the world (Barth, 2002). In this chapter, we focus on two main types of cultural knowledge: procedural knowledge (knowing how) and declarative knowledge (know that).

Procedural Knowledge

Procedural knowledge provides us with information about how we can achieve a particular result. It is knowledge acquired through practice. When a particular sequence of cognitive operations is frequently used, its performance is automated and requires little cognitive deliberation. There is good evidence for country differences in procedural knowledge. For example, compared to each other, European Americans have a spontaneous tendency to engage attention in the focal objects in the perceptual field, whereas East Asians tend to focus on the relationship between the focal objects and the background (Masuda & Nisbett, 2001).

Cultural experiences mold the development of procedural knowledge through two major paths. First, particular aspects of the physical and social environment in a culture offer opportunities to practice certain responses repeatedly. Miyamoto, Nisbett, and Masuda (2006) illustrated this path in a series of experiments. Based on a detailed textual analysis of pictures taken of American and Japanese cities, the investigators discovered that objects are usually distinct and stand out from the background in American cities. Conversely, in Japanese cities, objects are ambiguous and tend to blend in with the background. Miyamoto et al. posit that the experience of living in the American environment may draw one's attention to the distinctive focal objects rather than on the background, whereas the experience of living in the Japanese environment may direct one's attention to the relationship between the focal object and the background. To test this hypothesis, Miyamoto et al. had Japanese and European American undergraduates view scenes from either Japan or America. As predicted, for both Japanese and American participants, viewing Japanese scenes increased sensitivity to changes in the background and viewing American scenes increased awareness of changes in the focal objects.

Second, culture shapes procedural knowledge by structuring its members' motivational environment. As members of a culture routinely pursue culturally important goals, the procedures for attaining these goals become automated and can be activated in response to the controlling stimuli without the individual's conscious awareness. For example, individuals seeking to avoid social isolation are more attentive to contextual information. Because avoidance of social isolation is a chronic concern in East Asian contexts, East Asians have ample opportunities to practice the attention strategy connected to this goal. In a series of studies, Kim and Markman (2006) showed that East-West differences in the fear of isolation mediate East-West differences in attention strategies described previously. Furthermore, experimental induction of the fear of isolation increases European Americans' sensitivity to contextual information.

Declarative Knowledge

Declarative knowledge describes whether or not a certain object and event possesses certain characteristic properties (Turban & Aronson, 1988). A piece of declarative knowledge, when activated, may constrain subsequent inferences and decisions, facilitating some and inhibiting others. Among the many types of declarative knowledge, the three that have received the most attention in culture and psychology research are representations of persons, events, and norms.

Person representations. A person representation is a network connecting a central concept with a number of individual features. The referent of the central concept can be the self, a person other than the self, a group, or a social category. The features linked to the central concept may include traits, prototypic behaviors, or physical characteristics. The associations between the central concept and the individual features differ in associative strength and may be specific to a particular type of situation.

Numerous representations may be constructed for the same referent, each having a different set of associative features. For example, a person can construct a personal self that is associatively linked to a set of personal attributes; linked to a set of social roles and role expectations; and linked to a set of collective memberships (Triandis, 1989). Each of these representations forms a separate cognitive unit that can be independently retrieved from memory (Wyer, 2004).

Among all representations of the same referent available in memory, at any given time, only the most accessible one is retrieved. Cultural differences in social perception can be understood in terms of the relative accessibility of different person representations. Although people in every culture may have constructed similar cognitive representations of a referent, cultural experiences determine the relative accessibility of these representations, which, in turn, affect how the referent is described. For example, when describing a person or the self, European Americans prefer general trait descriptions and Asians social-role descriptions (Hong et al., 2001). These cultural differences may reflect that trait-based person representations are more accessible to European Americans and role-based person representations are more accessible to Asians. As another example, European Americans tend to attribute the cause of an event to the dispositions of the individual actors ("the individual is careless"), whereas Asians to the dispositions of the group ("the group is disorganized") (Menon et al., 1999). This cultural difference suggests that the self-as-a-causal-agent representation is more accessible to European Americans and the group-as-a-causal-agent representation is more accessible to Asians.

Again, the motivational structure in a culture may constrain the relative accessibility of different person representations. Cultures that privilege personal goals have more practices promoting personal influence (Morling, Kitayama, & Miyamoto, 2002). These practices confer many opportunities of accessing the representation of the self as a causal agent. Conversely, cultures that value collective goals have many practices promoting adjustment to social constraints. These practices afford many opportunities of accessing the representation of the group as a causal agent (Kashima et al., 2005).

Event representations. People construct event representations spontaneously to envision a state of affairs or an event in specific situations, and to predict how it transforms into another state or event. A caption (e.g., "visiting a restaurant") can be attached to an event representation to capture the gist of an event sequence (Wyer, 2004).

Cultures differ in how events are represented. For example, people in different cultures construct different representations of what a typical sequence of events is like. In Confucian societies (e.g., China, South Korea), people tend to believe that change will always be cyclical: from good to bad, and then from bad to good again. This belief is grounded on a widely accepted idea in Confucian societies: two opposing forces (*yin* and *yang*) are constantly at work, each pushing oneself into the place of the other, which results in changes. These forces are assumed to manifested in various forms in nature such as weak versus strong, evil versus divine, illness versus health, coldness versus warmth, and darkness versus light. Although this conceptualization of nature's forces mandates a cyclical trajectory of changes, it also may give rise to a stable reality over the course of time because all changes are transient. The belief that changes caused by one force will be negated by changes engendered by its opposing force may reinforce the belief in a fixed reality in East Asia (Chiu et al., 1997).

In contrast, optimism and the belief in progress have dominated the social philosophy of Western Europe and the New World since the beginning of the Industrial Revolution. Witnessing the technological progress in their world led the intellectuals to be optimistic about their future. They believed that a better world was just around the corner, and the making of it was in the people's own hands (Burchell, 1966). At this time, the theories of biological evolution and economic development that surfaced predicted the extinction of unfit species and the decline of adaptive social systems; as a result, the superior species will dominate and more advanced social systems will be developed. These beliefs about the trajectory of change support a malleable view of the world and its institutions in the West (Chiu et al., 1997).

These culture-characteristic beliefs about the trajectory of change continue to have authority over Chinese and North American students. When things are moving in a particular direction, Chinese undergraduates are more likely to anticipate a change in the direction of movement than their North American peers. For example, compared to European Americans, Chinese believe more strongly that a couple who have been dating each other for 2 years will break up, a student from a poor family will become rich one day, and 2 kindergarten children who have been fighting will become friends one day (Ji, Nisbett, & Su, 2001). Following this line of logic, individuals who expect the development of events to change course should be less surprised by unexpected events than those who expect events to progress in a linear fashion. Consistent with the idea that East Asians subscribe to a cyclical theory of change and Americans to a linear one, unexpected events surprise Korean undergraduates more than they do American undergraduates (Choi & Nisbett, 2000).

The belief that opposing forces operate at the same time also increases people's sensitivity to competing concerns in conflict situations and the motivation to reconcile them (Cheung et al., 2003). In one study, Peng and Nisbett

(1999) asked Chinese and American students to analyze everyday life situations that involve intrapersonal conflicts (e.g., a conflict between having fun or going to school) or interpersonal conflicts (e.g., a conflict between mothers and their daughters). Consistent with the idea that the Confucian theory of change is more widely distributed in Asia than in the United States, Chinese responses tended to focus on the reconciliation of contradictions by considering merit and fault on both sides ("both the mothers and the daughters have failed to understand each other"). In contrast, American responses tended to come down in favor of one side or the other ("mothers should respect their daughters' independence").

Norm representations. A norm representation consists of three elements: the antecedent circumstances, norm, and consequent conditions (Lindahl & Odelstad, 2000). The first element – the antecedent conditions – specifies the circumstances under which the norm should be activated, including the range of concrete situations where the norm is applicable. The norm refers to the state of affairs that is generally believed to be the case (e.g., the shared belief that the needy will receive help). In constructing a norm representation, individuals need to have access to the distribution of social knowledge in the society (e.g., they need to know the extent of agreement in the group with the idea of helping the needy; Ho & Chiu, 1998). Finally, the consequent conditions specify the behavioral implications of the norm. When the antecedent circumstances are present in a given situation, a certain state of affairs is designated as the norm, and the individual is expected to ensure that this state of affairs will take place. Because norm representations are implicative propositions, they have direct authority over behavior.

Cultural norms are widely distributed norm representations. For example, one of the most uniform norms in the United States is one for experiencing emotions – Americans agree that they *should* feel happy (Eid & Diener, 2001). However, different cultures have different norms. For example, in resolving conflicts, the prevailing norms in East Asian societies prescribe the use of mediational and accommodating strategies to minimize interpersonal animosity. In contrast, the prevailing norms in Western countries prescribe the use of more direct, confrontational strategies to win the negotiation game (Leung, 1987).

In summary, culture-characteristic declarative knowledge are representations of people, events, and norms individuals abstracted from cultural experiences. Although people in every culture may have constructed many different cognitive presentations, the dominant motivational structure in the culture and its attendant practices render some of these representations more accessible than others. Accordingly, cultural differences can be understood in terms of the differing contents of the widely circulated and highly accessible knowledge structures in different cultures. Defining a culture tradition in terms of its component knowledge items (procedural knowledge, person representations, event representations, and norm representations) invites researchers to clearly articulate the type and nature of each knowledge item as well as its range of applicability, activation circumstances, and inferential and behavioral implications. For example, environmental affordances support the development of procedural knowledge, which is activated automatically in the presence of the controlling situational cues. Activation of a particular representation of the self (e.g., interdependent self) will call out its associated behaviors (e.g., behavioral mimicry) (Van Baaren et al., 2003). The applicability of a norm is augmented in situations where cultural identities are salient (Jetten, Postmes, & McAuliffe, 2002) and when people are accountable to their cultural group for their behaviors (Briley, Morris, & Somonson, 2000).

SITUATIONAL FLEXIBILITY OF CULTURAL INFLUENCE

Although we all possess a large body of knowledge, the information retrieved from our memories varies from situation to situation, and what is activated and used often depends on the social and situational cues in our immediate surroundings. By taking a knowledge perspective to culture, researchers can borrow the basic principles of knowledge activation to illuminate how cultural knowledge impacts behaviors in a variety of concrete situations. In this section, we describe how contextual elements can influence people's behaviors; sometimes directly and sometimes indirectly by evoking the urge to fulfill certain social and psychological needs, such as the need to manage existential terror, the need to reduce uncertainty in social living, and the need for belongingness.

Principles of Cultural Knowledge Activation

The principle of chronic accessibility. When a body of cultural knowledge has been used frequently, it gains chronic accessibility. Cultural knowledge that has been frequently used in a cultural group is usually widely shared (Lau, Chiu, & Lee, 2001), cognitively accessible to members of the group (Hong et al., 2000), more frequently reproduced in communication (Lyons & Kashima, 2003), and widely represented in external or public carriers of culture (Menon & Morris, 2001). In the previous section, we discussed how cultural variations in the chronic accessibility of procedural and declarative knowledge may mediate a wide range of cultural differences.

The principle of temporary accessibility. After individuals of a particular cultural group have engaged in a new culture for a prolonged period of time, their new experiences may render a previously inaccessible cognitive representation more accessible (Hetts, Sakuma, & Pelham, 1999). Furthermore, research findings have shown that cues in one's immediate environment could make an otherwise less accessible representation temporarily more accessible. For example, as mentioned, the role-based representation of the self is less accessible to Westerners than Easterners. However, after being primed with an interdependent self, Westerners increased the tendency to use group memberships to describe oneself (Trafimow, Triandis, & Goto, 1991).

That cultural cues can increase the temporary accessibility of a body of cultural knowledge suggests that people with bicultural experiences can switch their cultural frames flexibly in response to the changing demands in the environment. Flexible switching of cultural frames is an experience familiar to people with a multicultural background. When individuals who have engaged in both Chinese and American cultures (e.g., Chinese Americans, Westernized Hong Kong Chinese undergraduates) are primed with either a Chinese cultural icon (e.g., the Chinese dragon) or American cultural icon (e.g., Mickey Mouse), they assimilate their responses to the primed culture (Hong et al., 2000). For example, when primed with Chinese (instead of American) cultural icons, these bicultural individuals make more group attributions and fewer individual attributions.

The principle of applicability. The likelihood of applying a knowledge item also depends on its applicability in the immediate context. Knowledge applicability is defined by the extent of mapping between "the features of a stored construct and the attended features of a stimulus" (Higgins & Brendl, 1995, p. 220). Several studies have illustrated the importance of applicability for knowledge usage. For instance, Hong et al. (2003) found that, among Chinese-American bicultural individuals, culture priming only influences the likelihood of making group attribution or individual attributions when the tension between group and individual agency in the stimulus event is highlighted. By highlighting this tension, the cultural theory of group versus individual agency becomes applicable in the judgment task, and thus, is used. Similarly, previous research has shown that in Chinese societies, the norm of cooperation applies to friends, but not to interactions with strangers (Ho & Chiu, 1994). Consistent with the principle of applicability, Hong Kong Chinese who are primed with Chinese (vs. American) culture icons make more cooperative choices when they play a prisoner's dilemma game with friends, but not when they play it with strangers (Wong & Hong, 2005).

Self-relevance and contrast effect. Although priming a culture often leads to assimilative responses, culture priming may lead to contrastive responses if the participants feel that they do not belong to the primed culture. Bond and his colleagues have reported contrast effects in a study that used languages to prime culture. For example, in one study (Bond & Cheung, 1984), Cantonese-speaking Hong Kong Chinese undergraduates filled out a survey of traditional Chinese beliefs. Mainland Chinese are generally seen as more traditional than Hong Kong Chinese. Participants who received oral instructions in Putonghua (the spoken language in Mainland China) responded more like Westerners than those who received instructions in Cantonese (a dialect used in Hong Kong). For the participants who received instructions in Putonghua, the presence of an out-group language reminded the participants that they did not belong to the primed culture group of Mainland Chinese, and as a consequence, a contrast effect was found.

Among bicultural individuals, whether they view their dual cultural identities as oppositional (e.g., I cannot be both a Chinese and an American at the same time) or as independent or complementary (e.g., I am both a Chinese and an American) influences their responses to culture priming (Benet-Martinez et al., 2002). Those who view their dual identities as independent or complementary tend to assimilate their responses to the primed culture, whereas those who view their dual identities as oppositional may feel ambivalent about either cultural identity, and respond reactively to the culture primes, displaying contrastive responses. In summary, activation of cultural knowledge follows the basic principles of knowledge activation, which govern the dynamic interactions between cultural knowledge, the situation, the individuals' current cognitive and motivational states, and cultural identities.

Situational Factors that Accentuate (or Attenuate) Cultural Differences

Cognitive load. Culture has been likened to a collection of chronically accessible cognitive tools, always ready for use (Chiu & Hong, 2005). Consistent with this analogy, research has shown that people are likely to use these tools when the problem solver lacks the capability or resources to consider alternative solutions. For example, European Americans have a greater tendency to make individual attributions than the Chinese under cognitive load. However, when individuals are not cognitively busy, this cultural difference is significantly diminished (Knowles et al., 2001).

Need for firm answers. Culture confers well received, conventionalized solutions to everyday problems. Individuals who prefer firm answers to questions in life tend to rely more heavily on cultural knowledge for answers. For instance, European American undergraduates with a high need for firm answers were more likely to attribute the causes of an event to the actor's personal dispositions, whereas their Hong Kong Chinese counterparts were more likely to make group attributions (Chiu et al., 2000). Similar effects are found when a need for firm answers is externally induced by having research participants make speeded causal judgments. When participants were put under time pressure, the cultural differences in attributions described above were amplified: the Chinese participants made more group attributions and the European American participants made individual attributions (Chiu et al., 2000).

Additionally, Koric et al. (2004) found that some immigrants migrated together and therefore are surrounded by other members of their ethnocultural group. These immigrants perceive the knowledge of their home culture as valid. For them, a higher need for firm answers is associated with a stronger motivation to adhere to the knowledge from the culture of origin. However, some immigrants migrated alone and are surrounded by members of the host country. They no longer perceive knowledge of their home culture as valid. For them, a higher need for firm answers is associated with a stronger motivation to assimilate to their host culture.

Mortality salience. Reminding people of their own inevitable demise is likely to prompt one to question the purpose of one's existence. According to the terror management theory (Greenberg, Solomon, & Pyszczynski, 1997), the thought of one's own death will induce a sense of existential terror. Until the purpose of one's own existence can be satisfactorily established, one will experience psychological disturbance. Terror management theorists propose two strategies that individuals use to allay this sense of terror: by defending one's own cultural worldviews or distancing oneself from those who hold worldviews that are dissimilar to one's own.

These strategies enable individuals to mitigate fears of death because by embracing one's cultural worldviews, one now has an organized system of beliefs from which answers to questions of life and death can be drawn (e.g., what is the meaning of life?) and a sense of immortality through concepts introduced by religion (e.g., heaven and afterlife). Furthermore, a strict adherence to cultural convention can offer individuals a sense of symbolic immortality, by seeing oneself as a valued member of an imperishable culture and by perceiving one's actions as a contribution to the culture (Solomon, Greenberg, & Pyszczynski, 1991).

Therefore, if holding strongly onto cultural worldviews serves as a protection against people's fear of death, then reminders of one's mortality should motivate them to maintain their cultural worldviews. This is referred to as the mortality salience hypothesis. Numerous studies have provided support for the mortality salience hypothesis. For instance, American undergraduates who were reminded of death were more negative towards writers of essays that openly criticize the United States than the writers of essays that explicitly praise the United States (e.g., Harmon-Jones et al., 1997).

The need to belong. The desire to establish bonds with others or a group is regarded as a fundamental motive that drives human behavior (Baumeister & Leary, 1995), and this need is intensified when individuals see themselves as being different from other members of the in-group or similar to members of an out-group (Brewer, 1991). One way of satisfying this need to belong is by participating in a culture. For example, research has shown that when the need to belong is activated, individuals who strongly identify with their in-group were motivated to attribute the qualities that are associated with the group to the self (Pickett, Bonner, & Coleman, 2002). Jetten et al. (2002) also showed how the use of cultural knowledge can be motivated by the need to express or defend one's social identity. Individuals from Indonesia (which is associated with collectivism) and North American (which is associated with individualism) participated in their first study. The investigators found that Indonesians who identify with the Indonesian culture adhered more strongly to collectivism (an important Indonesian value) than those who did not. Americans who identified with the American culture adhered more strongly to individualism (an important American value) than those who did not. These findings illustrate how individuals can use cultural knowledge to derive a sense of belongingness.

CONCLUSION

The cognitive effects of culture illustrate the contextual nature of human cognitions: First, individuals acquire a habitual pattern of performing cognitive operations and representing the reality as they develop expertise in a certain culture. Second, individuals change their mental habits when they assimilate into a new culture. Taking a knowledge perspective to culture, researchers can go beyond viewing cultural differences as manifestations of culture-characteristic latent cognitive traits and start to examine the situational flexibility of culture's cognitive consequences. Furthermore, our review emphasizes the important role of motivation in cultural cognition. On the one hand, the dominant motivational structure in a cultural context (e.g., the kinds of goals privileged in a culture) affords opportunities for practicing certain mental operations and accessing certain cognitive representations. On the other hand, culture can be likened to a pool of cognitive resources individuals in a culture have acquired to meet basic epistemic needs (having firm answers), existential needs (finding meanings in life), and social needs (forging social bonding). In all these, the social and motivational context determines to a large extent how likely certain cultural knowledge items are and which items will be activated and applied.

References

Barth, F. (2002). An anthropology of knowledge. *Current Anthropology*, **43**, 1–18.

Baumeister, R. F., & Leary, M. R. (1995). The need to belong: Desire for interpersonal attachments as a fundamental human motivation. *Psychological Bulletin*, **117**, 497–529.

Benet-Martinez, V., Leu, J., Lee, F., & Morris, M. W. (2002). Negotiating biculturalism: Cultural frame switching in biculturals with oppositional versus compatible cultural identities. *Journal of Cross-Cultural Psychology*, **33**, 492–516.

Bond, M. H., & Cheung, M-k. (1984). Experimenter's language choice and ethnic affirmation by Chinese trilinguals in Hong Kong. *International Journal of Intercultural Relations*, **8**, 347–356.

Brewer, M. B. (1991). The social self: On being the same and different at the same time. *Personality and Social Psychology Bulletin*, **17**, 475–482.

Briley, D. A., Morris, M. W., & Simonson, I. (2000). Reasons as carriers of culture: Dynamic versus dispositional models of cultural influence on decision-making. *Journal of Consumer Research*, **27**, 157–178.

Burchell, S. C. (1966). *Age of progress*. New York: Time-Life Books.

Cheung, T-S., Chan, H-M., Chan, K-M., King, A. Y-K., Chiu, C-y., & Yang, C-F. (2003). On Zhongyong rationality: The Confucian doctrine of the mean as a missing link between instrumental rationality and communicative rationality. *Asian Journal of Social Science*, **31**, 107–127.

Chiu, C-y., Dweck, C. S., Tong, J. Y-y., & Fu, J. H-y. (1997). Implicit theories and conceptions of morality. *Journal of Personality and Social Psychology*, **73**, 923–940.

Chiu, C-y., & Hong, Y-y. (2005). Cultural competence: Dynamic processes. In A. Elliot & C. S. Dweck (Eds.), *Handbook of motivation and competence* (pp. 489–505). New York: Guilford.

(2006). *The social psychology of culture*. New York: Psychology Press.

(2007). Cultural processes: Basic principles. In E. T. Higgins, & A. E. Kruglanski (Eds.), *Social psychology: Handbook of basic principles* (pp. 785–809). New York: Guilford.

Chiu, C-y., Morris, M. W., Hong, Y-y., & Menon, T. (2000). Motivated cultural cognition: The impact of implicit cultural theories on dispositional attribution varies as a function of need for closure. *Journal of Personality and Social Psychology*, **78**, 247–259.

Choi, I., & Nisbett, R. E. (2000). Cultural psychology of surprise: Holistic theories and recognition of contradiction. *Journal of Personality and Social Psychology*, **79**, 890–905.

Eid, M., & Diener, E. (2001). Norms for experiencing emotions in different cultures: Inter- and intranational differences. *Journal of Personality and Social Psychology*, **81**, 869–885.

Greenberg, J., Solomon, S., & Pyszczynski, T. (1997). Terror management theory of self-esteem and cultural worldview: Empirical assessments and conceptual refinements. In P. M. Zanna (Ed.), *Advances in experimental social psychology* (Vol. 29, pp. 61–141). San Diego, CA: Academic Press.

Harmon-Jones, E., Simon, L., Pyszczynski, T., Solomon, S., & McGregor, H. (1997). Terror management theory and self-esteem: Evidence that increased self-esteem reduces mortality salience effects. *Journal of Personality and Social Psychology*, **72**, 24–36.

Hetts, J. J., Sakuma, M., & Pelham, B. W. (1999). Two roads to positive self-regard: Implicit and explicit self-evaluation and culture. *Journal of Experimental Social Psychology*, **35**, 512–559.

Higgins, E. T., & Brendl, C. M. (1995). Accessibility and applicability: Some "activation rules" influencing judgment. *Journal of Experimental Social Psychology*, **31**, 218–243.

Ho, D. Y. F., & Chiu, C-y. (1994). Component ideas of individualism, collectivism, and social organization: An application in the study of Chinese culture. In U. Kim, H. C. Triandis, C. Kagitcibasi, G. Choi, & G. Yoon (Eds.), *Individualism and collectivism: Theory, method and applications* (pp. 137–156). Thousand Oaks, CA: Sage.

(1998). Collective representations as a metaconstruct: An analysis based on methodological relationalism. *Culture and Psychology*, **4**, 349–369.

Hong, Y-y., Benet-Martinez, V., Chiu, C-y., & Morris, M. W. (2003). Boundaries of cultural influence: Construct activation as a mechanism for cultural differences in social perception. *Journal of Cross-Cultural Psychology*, **34**, 453–464.

Hong, Y-y., & Chiu, C-y. (2001). Toward a paradigm shift: From cultural differences in social cognition to social cognitive mediation of cultural differences. *Social Cognition*, **19**, 118–196.

Hong, Y-y., Ip, G., Chiu, C-y., Morris, M. W., & Menon, T. (2001). Cultural identity and dynamic construction of the self: Collective duties and individual rights in Chinese and American cultures. *Social Cognition*, **19**, 251–269.

Hong, Y-y., Morris, M. W., Chiu, C-y., & Benet-Martinez, V. (2000). Multicultural minds: A dynamic constructivist approach to culture and cognition. *American Psychologist*, **55**, 709–720.

Jetten, J., Postmes, T., & Mcauliffe, B. (2002). "We're all individuals": Group norms of individualism and collectivism, levels of identification and identity threat. *European Journal of Social Psychology*, **32**, 189–207.

Ji, L-j., Nisbett, R. E., & Su, Y. (2001). Culture, change, and prediction. *Psychological Science*, **12**, 450–456.

Kashima, Y., Kashima, E., Chiu, C-y., Farsides, T., Gelfand, M., Hong, Y., Kim, U., Strack, F., Werth, L., Yuki, M., & Yzerbyt, V. (2005). Culture, essentialism, and agency: Are individuals universally believed to be more real entities than groups? *European Journal of Social Psychology*, **35**, 147–169.

Kim, K., & Markman, A. B. (2006). Differences in fear of isolation as an explanation of cultural differences: Evidence from memory and reasoning. *Journal of Experimental Social Psychology*, **42**, 350–364.

Knowles, E. D., Morris, M. W., Chiu, C-y., & Hong, Y-y. (2001). Culture and process of person perception: Evidence for automaticity among East Asians in correcting for situational influences on behavior. *Personality and Social Psychology Bulletin*, **27**, 1344–1356.

Kosic, A., Kruglanski, A. W., Pierro, A., & Mannetti, L. (2004). The social cognition of immigrants' acculturation: Effects of the need for closure and the reference group at entry. *Journal of Personality and Social Psychology*, **86**, 796–813.

Lau, I. Y-m., Chiu, C-y., & Lee, S-l. (2001). Communication and shared reality: Implications for the psychological foundations of culture. *Social Cognition*, **19**, 350–371.

Lehman, D., Chiu, C., & Schaller, M. (2004). Psychology and culture. *Annual Review of Psychology*, **55**, 689–714.

Leung, K. (1987). Some determinants of reactions to procedural models for conflict resolution: A cross-national study. *Journal of Personality and Social Psychology*, **53**, 898–908.

Lindahl, L., & Odelstad, J. (2000). An algebraic analysis of normative systems. *Ratio Juris*, **13**, 261–278.

Lyons, A., & Kashima, Y. (2003). How are stereotypes maintained through communication? The influence of stereotype sharedness. *Personality and Social Psychology Bulletin*, **85**, 989–1005.

Masuda, T., & Nisbett, R. E. (2001). Attending holistically versus analytically: Comparing the context sensitivity of Japanese and Americans. *Journal of Personality and Social Psychology*, **81**, 922–934.

Menon, T., & Morris, M. W. (2001). Social structure in North American and Chinese cultures: Reciprocal influence between objective and subjective structures. *Journal of Psychology in Chinese Societies*, **2**, 27–50.

Menon, T., Morris, M. W., Chiu, C-y., & Hong, Y-y. (1999). Culture and the construal of agency: Attribution to individual versus group dispositions. *Journal of Personality and Social Psychology*, **76**, 701–717.

Miyamoto, Y., Nisbett, R. E., & Masuda, T. (2006). Culture and the physical environment: Holistic versus analytic perceptual affordances. *Psychological Science*, **17**, 113–119.

Morling, B., Kitayama, S., & Miyamoto, Y. (2002). Cultural practices emphasize influence in the United States and adjustment in Japan. *Personality and Social Psychology Bulletin*, **28**, 311–323.

Peng, K., & Nisbett, R. E. (1999). Culture, dialectics, and reasoning about contradiction. *American Psychologist*, **54**, 741–754.

Pickett, C. L., Bonner, B. L., & Coleman, J. M. (2002). Motivated self-stereotyping: Heightened assimilation and differentiation needs result in increased levels of positive and negative self-stereotyping. *Journal of Personality and Social Psychology*, **82**, 543–562.

Solomon, S., Greenberg, J., & Pyszczynski, T. (1991). A terror management theory of social behavior: The psychological functions of self-esteem and cultural worldview. In L. Berkowitz (Ed.), *Advances in experimental social psychology* (Vol. 24, pp. 93–159). San Diego, CA: Academic Press.

Trafimow, D., Triandis, H. C., & Goto, S. G. (1991). Some tests of the distinction between the private self and the collective self. *Journal of Personality and Social Psychology*, **60**, 649–655.

Triandis, H. C. (1989). The self and social behavior in differing cultural contexts. *Psychological Review*, **96**, 506–520.

Turban, E., & Aronson, J. (1988). *Decision support systems and intelligent systems*. Upper Saddle River, NJ: Prentice Hall, Inc.

Van Baaren, R. B., Maddux, W. W., Chartrand, T., de Bouter, C., & van Knippenberg, A. (2003). It takes two to mimic: Behavioral consequences of self-construals. *Journal of Personality and Social Psychology*, **84**, 1093–1102.

Wong, R. Y-M., & Hong, Y-y. (2005). Dynamic influences of culture on cooperation in the prisoner's dilemma. *Psychological Science*, **16**, 429–434.

Wyer, R. S., Jr. (2004). *Social comprehension and judgment: The role of situated models, narratives, and implicit theories.* Mahwah, NJ: Lawrence Erlbaum.

9

Biological Models of Organisms and Their Evolutionary Change

Their Importance for Epistemology and Different Cultural Traditions

Karl Edlinger

INTRODUCTION

This chapter deals with the importance and function of various models of living organisms for epistemological concepts, on the one hand, and the philosophical and epistemological presuppositions of organismic biology, on the other hand. The objective is to show that for every epistemological approach, not only philosophy is of importance but also biology as the science of the neuronal basis of psychological as well as epistemological processes. This interdependency claims for a theory of science, which avoids a predominance of philosophy or natural sciences as well as of a vicious circle, which must occur automatically when an attempt is made to establish philosophy or biology as a so-called meta-level of cognition.

Constructive realism (CR) abstains from every meta-level of cognition and knowledge. It conceives cognition as an outcome of knowledge of practice, as a knowledge resulting from the individual's activity in the world of everyday life. Sciences function as microworlds, which contain a small sector of reality, whereby reality is understood as the world that is constructed by human beings rather than the totality of the given, in the sense of environment.

Knowledge in the sense of CR means to be able to act with competence and handle objects in accordance with some special goals. This conception does not provide any idea about the real structure of world and environment, but it lets us better understand various contexts in which human beings are engaged in acting and reflecting. In addition, the conception of CR gives us the chance to highlight some essential methodological presuppositions of scientific disciplines that are valid in every cultural context, despite differences in conceptions of nature, techniques, or society, and serve as a basis of understanding various cultural developments.

These methodologies do not result from knowledge in the ontological sense and should not be confused with the latter. The problem can be best illustrated by biology.

HISTORICAL RETROSPECTIVE

The development of European sciences during the modern age brought about an impressive predominance of the so-called empirical natural sciences over philosophy in many respects. Physics and chemistry as the classical empirical sciences presented an enormous number of scientific facts and information about nature; our most discussed models of the world are based mainly on the results of physical and chemical experiments and theories, which result from the former.

Human beings too are affected by this trend. By establishment of evolutionary theories as common sense views of the realm of organisms and their origin, humans have been incorporated definitively into the animal realm. The generally accepted fact that humans are closely related to every member of the animal realm gave rise to a different biological view of their nature and abilities, the mental and intellectual in particular, than had prevailed before.

In this manner, the discussion about the basic mechanisms of thinking and reflecting, cognition and epistemology as well as the mental construction of the world by human beings eventually changed into a discussion about biological reasons of activities in many respects. When human beings are conceived as biological organisms, their various faculties may be reduced to a biologically explicable basis. This becomes increasingly evident when the close relations between some patterns of neuronal activities and mental conditions are revealed in research.

This view of human development makes it possible to discuss and find solutions to many urgent philosophical questions and problems, such as the origin and function of consciousness, the isomorphism or non-isomorphism between the outer world and its inner representations, the relations between sensory data and physical processes affecting the human sensory system, and the biological elements that contribute to shaping our models of nature and world.

However, before attempts to solve these questions are discussed, it is necessary to clarify whether these issues concern mankind in general at all times or only a special cultural area at a special period of cultural development. In addition, we must ask whether these problems are consequences of some special ways of thinking and researching. It is possible that these questions arise out of a special view of organisms, which are in turn conditioned by cultural factors. It is necessary to consider that these questions make sense only when we accept some special kinds of polarity, such as the polarity between the individual and his or her environment as well as the polarity between physical processes and the nervous system and between biological and neuronal structures and the outcomes of their respective activity.

Polarity, as well as dualism in general, is a characteristic of European thinking at the beginnings of the so-called period of Enlightenment. It seems to be a special way of dealing with the contradiction between new experimental methods of mechanistic physics, which are interpreted only quantitatively, and the overwhelming variety of qualities in human minds in many respects. By means of a rigid separation of matter, on the one hand, and the mental experience with its various qualities, on the other hand, it was possible for early philosophers such as Descartes to establish a mechanistic science and save Christian religion as a domain of spirituality. The progress of the mechanistic sciences has led with time to an absolute predominance of science over religion and the so-called human sciences.

EVOLUTIONARY THEORIES

According to this general trend, the conception of organisms changed, too. At the end of the eighteenth century, organisms were commonly conceived by many authors, such as G. Cuvier, as some kind of mechanical working machines consisting of finely balanced components. Some vague ideas of evolutionary change and adaptation as presented by Buffon resulted in the evolutionary theories of Lamarck, Wallace, and Darwin.

Organisms, including human beings, were seen as the outcome of a long chain of step-by-step alterations. In contrast to Lamarck, who presented a theory with teleological features – which had been disproved a long time before – Wallace and Darwin elaborated ideas, which were in accordance with mechanical theories about human societies. Similarly to human beings in the period of capitalism, animals and plants were believed to be under pressure of competition for food, energy, and biotopes.

The fittest or best adapted individuals were expected to have the optimal chances for survival and reproduction. In line with this view, evolution is a play of trial and error, resulting in the extinction of the nonadapted organisms. Evolutionary change, just as natural selection, is a process of adaptation according to the well-known procedures and techniques of the breeders. The analogies with some economic and social processes as well as with the experiences of breeders may have led to serious misconceptions in the early Darwinian evolutionary theory and biology. Organisms were not conceived as active entities, but in correspondence with the analogies with breeders, were dissolved into aggregates and arrangements of features or characteristics. The so-called synthetic theory of evolution gave rise to a transformed conception of evolution, which came to be considered as a process of permanently changing frequencies of characteristics, namely, genetic alleles within animal or plant populations. According to this view, organisms as well-integrated units do not exist. All organs or characteristics were believed to be the outcome of the play of various genetic changes and rigid selection, which should result automatically in perfect adaptations. Each characteristic and feature of an organism could be conceived as possible and, because it has necessarily evolved by selection, it was viewed as a kind of reproduction or portrayal of some environmental pressures and needs. This way of thinking has left quite a number of problems unsolved, or rather, swept under the carpet. The statement that a special characteristic or feature of an organism may be of evolutionary advantage does not provide information about the reason for the real character of this advantage nor an explanation of its origin.

In this manner, a mechanistic interpretation of world and nature led to a dilemma. On the one hand, there was a world – including living beings and humans in particular – which was believed to consist of eternally existing particles of matter, pushing and attracting one another and resulting in special material arrangements. On the other hand, there was the world of human mind and consciousness, which seemed to be poised upon lifeless physical structures.

On the background of the success of materialism and mechanism, it is not surprising that the existence of mind and consciousness was denied or that they were interpreted as epiphenomena, for which no reason could be given at the time. For the future, it could be expected that reasons supporting the emergence of mind and consciousness would eventually be given by Darwinian evolutionary theory.

EVOLUTIONARY EPISTEMOLOGY (EE)

The modern evolutionary theory of cognition is a logical consequence of the theory of biological adaptation and the lack of a theoretical foundation of the Darwinian organism. A Lamarckistic antecedent theory was developed by H. Spencer (Frischeisen-Köhler, 1925), a philosopher and Lamarckist of the late nineteenth century. This view was accepted by Darwinian scientists as well as philosophers. Spencer pleaded for a view of human beings and their evolution not merely as biological subjects. Spencer reflected about the evolution of the cognitive apparatus and the nervous system, including its faculties.

Haeckel (1866), Lorenz (1941, 1978), Campbell (1974a, 1988), Campbell & Paller (1989), Riedl (1981), Vollmer (1975) and others attempted to provide new arguments for this view on a Darwinian theoretical foundation, suggesting an evolution by adaptation, which means the survival of well-adapted living beings as a result of selection by the environment. Actually, the objective was to present a biological and realistic foundation for Kant's Newtonian concepts of space and time and his *apriori* tenets.

In consideration of modern physics, Vollmer developed the ideas of Evolutionary Epistemology in terms of the very restricted concept of a so-called mesocosmos (i.e., the Newtonian world of our everyday experience). Further, Riedl revised his positions by considering the highly complicated network-like causality of ecology, human societies, and "cultural evolution" (Cavalli-Sforza & Feldman, 1981; Boyd & Richerson, 1985). Hence, it seems necessary to conceive Evolutionary Epistemology, in the Lamarckistic sense of Spencer as well as in the Darwinian sense, as a partial theory of an adaptational concept of evolution (Campbell, 1974a, 1974b, 1985, 1988; Riedl, 1981). That means that the validity of the modern Darwinian evolutionary epistemology depends on the validity of Darwinism. If the theory of adaptation is untenable, then evolutionary epistemology is also obsolete.

Also, in former periods other biologists and philosophers (e.g., Uexküll 1921, 1928; Cassirer, 1955–1957) proposed theories considering organismic conditions of human thought and cognition. Yet, Evolutionary Epistemology, just as original Darwinism, does not present concepts of organisms as subjects, which fulfill the basic requirements for consistent theories of functioning organisms.

THEORETICAL PROBLEMS OF DARWINISM AND THE SYNTHETIC THEORY

A critical revision of the theoretical and the empirical basis of traditional Darwinism and Synthetic Theory (Edlinger, Gutmann, & Weingarten, 1991; Gould & Lewontin, 1979; Linden, 2007) shows that this approach to the problem of evolutionary change of organisms lacks a consistent theory of the living organism and, as a consequence, provides no consistent view of evolutionary change. In their ultimate level of development, these theoretical concepts reduce organisms to arrangements of morphological or other characteristics or to complexes of genes (Arias, 2008; Dawkins, 1978; Nüsslein-Volhard, 2004), conceiving the organism itself as an epiphenomenon of gene expression and nothing else.

Evolution in this context means changes of frequencies of characters or genes only in animal or plant populations (Mayr & Provine, 1998). Evolutionary changes are seen as results of selection pressures, originating exclusively in the environment. The organisms, as a consequence, figure as some modes of representation or blueprints of environmental features.

Darwinian theories provide no consistent explanations of the structure, the constructional properties of living beings, and the constraints and restraints of evolutionary changes. Even this very limited view urges us to construct consistent theories of morphogenesis and the evolution of living organisms as wholes, as very complex entities, that are autonomous, spontaneous, and permanently active. It is a logical consequence of autonomy and permanent activity that organisms are not only affected and influenced by their environment but are also, and even to a greater extent, shaping their environment for themselves. This consequence is ignored by Darwinian biology.

On the other hand, there exist various "physicalist" theories, such as synergetics (Haken, 1981, 1990; Haken & Wunderlin, 1986; Meinhardt, 1978, 1987), the theory of dissipative structures (Prigogine, 1979; Prigogine & Stengers, 1981), or chaos theories (Gleick, 1987) that pretended they could provide reasons for the high order of biological arrangements, in particular for symmetry. Because these theories, at best, concern partial aspects of life that are of lesser importance, we can say that they lack any theoretical foundations for considering and explaining the organization of organisms as wholes. Physical approaches and theories show us organisms mostly as cloudy arrangements of molecules, without any operational or mechanical closeness.

Other theories conceive organisms as crystal-like or mosaic-like arrangements of molecules or cells that must fit to the others in terms of special structures of their surface. These theories can be shown as succeeding older ideas, expounded by former theorists such as E. Haeckel (1866). In contradiction to these ideas, there exists no evidence for the suggestion that organisms are organized and form-enforced as crystals or mosaics of atom-like elements. Many elementary qualities and properties of organisms are ignored by these theories.

THE THEORY OF ORGANISMIC CONSTRUCTIONS

The Theory of Organismic Constructions provides a different and more useful view of living beings as biological microworlds. This view, which may seem strange in some respects, follows out of a special way of thinking and reflecting based on the method of strangification. Strangification, as presented by Wallner (1992a, 1992b), consists in reflecting and examining one's theory by embedding it in a totally different context from the one in which it has been developed and for which it has been originally considered adequate. The result is a new and, in many cases, strange views of our prerequisites. Strangification gives us the chance to elucidate many difficulties and internal contradictions of scientific methods and theories, some of which have been mentioned previously. Evaluations of biological theories highly similar – or, in the sense of Constructive Realism, identical – to strangification were performed in regard to some traditional views of organisms and evolution by many representatives of the Theory of Organismic Constructions, also called the Frankfurt Evolutionary Theory (Edlinger & Gutmann, 2002; Gutmann & Bonik, 1981; Gutmann & Edlinger, 2002).

Evolutionary and organismic biology were discussed in many contexts. The result was a theory of organismic constructions, including many aspects of other scientific disciplines, such as physics, engineering, and medicine. In previous years, biological theories were presented, in particular theories of the organism, which meet the standards of theoretically well-founded theories in the natural sciences. In accordance with the standards of modern natural sciences and their special style of thinking, these theories are highly abstract and not illustrative for the naive observer. The reward of high abstractness is that by providing a new consistent theoretical foundation it produces the chance for stringency and understanding of the basic requirements for living organization and organismic existence.

A gap between organismic biology and physics is produced by means of the high abstractness of theories and physical laws at the lower levels of organismic constructions, while inadmissible equations between the physical and the biological processes are rejected. It should, however, be pointed out that evolution in the context discussed here means only a phylogenetic change of organisms and nothing beyond that. The theory of Organismic Constructions enables us to conceive of organisms as wholes. It gives us more and better reasons for many properties of living beings, symmetry and rhythmicity in particular, which seem to be mysterious in the light of traditional Darwinian biology. It can be shown that these properties are based on organismic presuppositions, which can be clarified only by a new consistent theory of organisms.

This theory conceives of organisms as spontaneously acting autonomous hydraulic and mechanical systems and energy converters. As energy converters, they must be operationally closed to avoid dissipation of energy. The organisms interact with one other directly and indirectly. All chemical reactions and mechanisms, on which the fundamental processes of life depend, happen in an aqueous solution. Essential requirements for all living beings are a fluid filling with surrounding membranes that is partially impermeable so as to prevent diffusion and dissolution.

Properties of living beings – in particular, special kinds of symmetry and rhythmicity – can be understood in terms of the internal needs and constructional constraints of organisms and nothing beyond these. They have nothing to do with symmetry and asymmetry or rhythmicity in a physical sense. This discussion concerns only the level of biology and organisms.

All chemical mechanisms, including the functions of enzymes and genetic substance, depend on the mechanical properties of cells, cytosols, and cytoskeletal elements and fibrous structures of intercellular spaces in a direct or indirect way (Edlinger 1991; Ghosh et al., 2008; Ingber, 1993a, 1993b; Ingber et al., 1994; Mammoto et al., 2009; Yung & Ingber, 2009). Mechanical stress can produce genetic expression directly or indirectly.

Chemical processes in whole organisms as well as in cells are highly complicated. Enzymes and other catalytic structures must be arranged in sophisticated patterns and sequences. These arrangements are possible only when there exist a mechanical framework of membranes and also tubulous and fibrous structures threading the inner liquid. Thus, the mechanical construction can be seen as an essential presupposition of the existence and endurance of organisms. It is the framework in which all partial mechanisms of living beings are enclosed and arranged. We must conceive of organisms primarily as hydraulic systems.

ANTAGONISMS AND RHYTHMICISM

As mentioned previously, every frictionless and permanent action depends on special arrangements of acting components of the body. The deformations effected by contractile elements must be reversible by antagonistic actions. When antagonisms should function frictionless, contractions and deformations must be rhythmical.

Rhythmical activity is of high importance for living beings, especially for constructional and morphological changes during ontogenetic development. Ontogenetic changes of form and rearrangements of mechanical elements consist primarily of effects of mechanical forces (Edlinger, 2004; Edlinger & Gutmann, 2002; Gutmann & Bonik, 1981). These forces result from various activities of contractile elements, inflation of fluid-filled caves, and apposition of matter. Permanent and rhythmical activity drives the highly ordered arrangement of all elements, such as muscles.

Rhythmicism depends on reversibility of contractions. As a consequence, those arrangements that can work frictionless are the symmetrical ones. This kind of symmetry is determined by the organization and function of rhythmically working organismic constructions.

STIMULATION OF MUSCULATURE

Permanent activity of contractile fibers, namely muscles, is caused by permanent interactions between the elements of the locomotor apparatus. Muscle cells and muscles can stimulate one another. In this manner, highly complicated patterns of excitation can be formed. Musculature can act as its own pacemaker system. In more complicated constructions, this task can fall to highly specialized cells of the musculature, which evolve step by step to various kinds of nerve cells.

Nerve cells stand in contact with the musculature and other nerve cells, arranging themselves in nervous systems. Synaptic connections between nerve cells and, as a consequence, the patterns of the neuronal network, are organized by trial and error processes in the neuromotor system (Edlinger, 1991). Only those connections that are ingenious for a frictionless locomotion and efficient compensatory activity of the organism can persist.

Nervous systems always function in accordance with the needs of the locomotor apparatus, which in most cases persists in being symmetrical over all evolutionary changes. So, all patterns that are generated by nervous systems must be useful for conserving the symmetrical structure of the locomotory apparatus and all adjacent and dependent structures, such as skeletons.

MOTORIUM AND SENSORIUM

As mentioned previously, the connection between sensorium and motorium is undoubtedly very close (von Foerster, 1988, 1990, 1998; Glasersfeld 1987, 1995). Because of this close connection, the adjustment of propulsor organs has the greatest influence on accumulation processes of the nervous system (Edlinger, 1991). A highly accumulated central nervous system is conditioned by a close relation with the motor system, which is functionally coordinated and controlled by the former. So, in accordance with the localization of the propulsory musculature, a central nervous system is established in vertebrates at the dorsal side of the body and in invertebrates at the ventral side. The arrangement and organization of the nervous system correspond with the construction and arrangement of the locomotor apparatus. The symmetrical motorium has a symmetrical central nervous system as its counterpart.

On the other hand, organs that are not involved in locomotor activities can become asymmetric in various degrees when their frictionless functions are unimpaired. It is possible, too, that some rhythmically active subsystems that are not directly affected and influenced by locomotion, as are the circulatory organs or the muscular and rhythmical active gut, evolve their own autonomous rhythmicity. On the basis of these presuppositions, it is possible to follow the evolution of complicated and effective central nervous systems and specialized sense organs.

Nervous systems function at first as pacemakers and coordinating structures of the musculature exclusively; they are diffuse and web-like. This organization of the nervous system persists in all organisms and spatial structures that are stressed and pulled by mechanical actions (Edlinger, 1991; Edlinger & Gutmann 2002). Notably, remarkable accumulations of neurons can happen only in those spaces that are unstressed and unperturbed. This is the case with skeletal capsules and also with liquid-filled spaces in soft bodies, such as the space around the pharynx of snails or many worms.

REDUCTION OF SYMMETRY

It can be concluded that reduction and decrease of the perfect symmetry of a globular shape to a bilateral symmetry causes the evolution of highly complicated and effective organismic constructions as well as of effective nervous systems (Linden, 2007). This aspect should also be seen in connection with the ontogenetical development. Also, prior to fertilization the organisms are complicated and permanently working constructions.

Eggs are not homogeneous, as suggested by many theories, which are focused only on molecular biology. They have a complicated structure as good as adult organisms. All transitory stages of development must function frictionless as energy converters. Formation processes are mechanical and depend on internal needs and constraints. Symmetry and asymmetry also follow very strict mechanical rules during ontogenetical development.

ORGANISMS AND THEIR ENVIRONMENT

Accumulations of neurons provide the necessary conditions for evolving medullar cords, ganglia, and brains (Edlinger 1991; Linden, 2007). These are the prerequisites of effective interactions between the organism and its environment. Responses in regard to more complex sensoric patterns indicate advanced stages of evolution. Such patterns make possible coordination and inner representation in more complicated nervous systems.

Nevertheless, all these neuronal structures, which seem to be functionally set over the other parts of the nervous system and the musculature, are the result of an evolution of the locomotor apparatus. At first they function as pacemakers for the locomotor apparatus, even when they fulfill other functions (Edlinger, Gutmann, & Weingarten, 1989; Edlinger & Gutmann, 2002).

The environment and its energy flows are to be considered at first as obstacles for the autonomous, spontaneously self-deforming, and moving organisms. They can hinder the organism's rhythmical locomotion and disturb its rhythmicity. The reactions of the organism to such disturbances are attempts to compensate by changes of its own rhythmical activity. The compensatory activity continues until the former situation – namely, the organism's own internal generated rhythm – is re-established. Thus, by their deformation, propulsion, and locomotion, animals set themselves into the energy conversion of their environment, which is affecting the organisms retroactively. Retroacting means irritations for the organisms.

Excitations and irritations represent essentially non-normal situations, which are to be compensated. Organisms must compensate for various irritations produced by obstacles, energy conversion in the environment, or chemical stimulation. In this manner, organisms stimulate themselves indirectly through the environment. This retroaction can be perceived as sensory input. In principle, we can assume a sensory input, which is reducible to autonomous actions of the organisms themselves. There are many examples for this phenomenon in the physiological sciences; the best example is the saccadic rhythm of vertebrate eyes.

The sensory input causes excitations by reaction potentials of nerve cells. These potentials are the same in the whole nervous system. Thus, one can say that the language of the nervous system is common in all its parts. The only words of the nervous system are "click-click," as formulated by G. Roth (1987).

There still remains the question about how the nervous system can produce the manifold of different modalities and qualities known by humans and, as we can suppose, also by other members of the animal kingdom. The only reason for these phenomena is a new view of the excitation – namely, of irritation and the compensatory reactions.

These new views of the sensory input and organisms shed a particularly favorable light on E. V. Holst's (1974) principles of permanent rhythmicity and reafference. These principles can be supported by the theory of organismic constructions. Accordingly, special structures of receptors determine which modalities are sensed. Many reactions are thinkable and possible, but in the special situation, defined by some very specific modalities of excitations, only a few of these reactions contribute to the further successful behavior and activity of an animal. Success or failure of compensatory actions lead to increasingly specific reactions and, as a consequence, to increasingly differentiated inner representations. In this way, at first a primitive differentiation of modalities and qualities takes place. It arises out of various reactions to the excitation of special receptors with special sensory poles.

FOR EXAMPLE: THREE-DIMENSIONAL SPACE – A NATURAL ENTITY OR A CONSTRUCTION?

The bilateral symmetry with special chances for effective locomotion causes a new structure – new dimensions of the animal's environment, in particular its space. Only elongated and bilateral symmetric organismic constructions manifest unidirectional locomotion. The structure of their body makes it possible for them to distinguish between the front and the rear of their body and also between left and right and at the very least also between up and down. By means of special sensory organs, which are evolved at a high level of organization, the situation with respect to the space and gravitation can be discerned and compensated for in a second step. Globular-shaped organisms have no possibility for a comparable differentiation.

ENVIRONMENTAL ADAPTATION OF PERCEPTION? – REFUTATION OF EVOLUTIONARY EPISTEMOLOGY

The biological reasons for the organismically determined perception and internal three-dimensional construction of the space in which bilateral-symmetrical animals live and move enable us to criticize any suggestion that this organismic three-dimensionality is an inner representation of a real situation in space – namely, in the environment. The importance of the internal and constructional needs of the animal and of the human being's activity as well as their spontaneity and autonomous action invalidate the various attempts of evolutionary epistomologies proposed by Spencer, Haeckel, Lorenz, Campbell, Riedl and Vollmer (Edlinger et al., 1989, 1991). The theory of organismic constructions clarifies that organisms are stimulating themselves indirectly by acting on their environment. All sensory inputs originating in the environment are actually consequences of the organisms' own activities.

Hence, we are led to assume that in every case, the modes of perception depend on the organisms themselves. We cannot have any knowledge of real things or processes. All we can perceive is designed and constructed by nervous systems, sense organs included. In the case of humans, the so-called reality emerges out of organismic constructions and our minds, which are attachments of the material basis of the organisms. The propounded approach concerning organisms and their interaction with the environment will be further elaborated by describing the theories and work of two prominent thinkers – the biologist Jakob v. Uexküll (1928, 1980) and the philosopher Ernst Cassirer (1944, 1946, 1955–1957).

JAKOB VON UEXKÜLL AND ERNST CASSIRER

J. v. Uexküll was a non-Darwinian biologist in the first half of the twentieth century, who focused his interests on the autonomous activity of organisms in general and animals in particular. In contrast to the dominating Darwinian view, Uexküll found out that each contact between organisms and their environment follows primarily out of the organisms' activity. Living beings require an environment that includes parts that can be used in accordance to their special nature and needs. The activity and effect of the organisms on the environment in turn cause effects on the organisms. Thus, action and reaction constitute some kind of self-reference:

> He (v. Uexküll) too wanted to draw far-reaching conclusions from the anatomical type to which an animal belongs, and he insisted that these conclusions would have perfect certainty.... We know its characteristics and its activities; we look into its "inner life" and we see its environment, for whatever it undergoes from the outer world depends strictly upon the way it is able to accept and act on external stimuli. An animal can receive only those impressions for which it is prepared by its structure and can react to stimuli only in so far as it possesses the appropriate organs (Cassirer 1944, pp. 23–24).

This highly selective approach to the environment, namely, only to some special sectors of the environment is the rationale underlying v. Uexküll's suggestions that every organism fits perfectly, from the very beginning, to its special environment, but always in accordance with its internal needs and not as a consequence of Darwinian adaptation. Darwinian adaptation cannot take place in Uexküll's and Cassirer's view. So for Cassirer every animal is closely bound up with its environment through such functional circles, of which a number are recognizable for almost every organism and which can be named by reference to their corresponding objects, such as prey, enemy, sex, and habitat. Here it is obviously erroneous to speak of an "adaptation to the environment" in the Darwinian sense, for to do so is to convert into a process which requires time something that is actually determinate and indispensible from the first to the survival of the animal. If it is the inner structure that creates the environment by its own activity, one should not say that an animal is more or less adapted to the environment. Only thanks to itself alone is each animal entirely fitted into into its environment (Cassirer 1944, p. 24).

In accordance with his non-adaptational conception, Uexküll claims that every animal has an inner world, a world specific to it, which depends on its special structure or construction and to which there is so far no access for human beings. Cassirer wrote:

> The experiences – and therefore the realities – of two different organisms are incommensurable with one another. In the world of a fly, says Uexküll, we find only "fly things"; in the world of a sea urchin we find only "sea urchin things" (Cassirer 1944, p. 23).

Because effectors and receptors are connected, on the one hand, by an internal network of nervous structures and the environment, on the other hand, Uexküll calls this circular arrangement of various activities and perceptions, the arrangement of the perception system and the effector system, the "functional circle" (*Funktionskreis*) of the animal (Cassirer 1944, p. 24). According to Uexküll, organisms are highly autonomous in all respects. They create their own worlds: the urchin an urchin world; the dog a dog world; and human beings a human world.

Ernst Cassirer supports this view of organismic autonomy, but focuses his interest on those sectors of the human world that seem to be exceptions of Uexküll's rule in some respect. Cassirer assumes that the so-called worlds of animals consist of systems of signs, whereby signs resemble symptoms of things and are defined as directly representing objects in actual situations; hence, their importance for the animal's actions and reactions. In contrast, humans are characterized by a special mental activity that results in the construction of "symbols." S. Langer, a modern representative of Cassirer's view of symbolic forms, writes: "It is only when we penetrate into the varieties of symbolic activity – as Cassirer, for instance, has done – that we begin to see why human beings do not act as superintelligent cats, dogs, or apes would act" (Langer 1957, p. 43).

Thus, in Cassirer's philosophy, symbols function as substitutes of real things, to which there is no direct access. Symbols occur within special systems of thinking and reflecting called the symbolic forms. Cassirer identifies different symbolic forms, such as language, myth, religion, the arts, and the sciences.

Because humans are endowed with the special ability of thinking in symbolic forms, Cassirer calls man the "animal symbolicum." In humans, the circle of functions is complemented through the addition of the symbolic system. It is this symbolic system that enables humans to get various views of world and reflect about the world in highly different ways, which cannot be considered as true or false in a traditional manner. This corresponds to the approach of constructivist thinking, in particular constructive realism. In this sense, Cassirer's Philosophy of Symbolic Forms is a predecessor of constructivism, especially constructive realism.

Cassirer's philosophy is based to a high degree on biological presuppositions, and in particular on Uexküll's view of the relations between organisms and the environment. The question now arises whether this basis is valid and can survive in the face of critiques from the quarters of epistomology and biology. Its survival depends on a well-founded refutation of the adaptationist view of evolution and the presence of an alternative non-adaptationist view of organisms and evolution, which can provide reasons for organismic complexity by a non-reductionist model. Notably, although one of Uexküll's books is entitled *Theoretical Biology*, he did not develop a consistent theory of the autonomous organism and its evolution.

EVOLUTION OF COGNITION

The theoretical foundations of this kind are provided by the theory of organismic constructions. As was shown previously, it is possible to reconstruct on this basis not only the evolution of organismic constructions but the evolution of mental and cognitive abilities, as well. These are, in contrast with Darwinian evolutionary epistemology, the outcome of special costructional properties of autonomous organisms. They cannot be considered without a very close connection with their organismic basis.

This holds also in regard to the evolution of complicated nervous systems and the their abilities. In some special groups of animals, in particular the vertebrates, there occur some inner spaces that are undisturbed by movement and deformation. In these spaces, some concentration effects of nervous tissues take place and enable many additional neuronal operations. With increasing concentration, primitive anticipatory operations occur increasingly. They cause the origin of some kind of an inner world, which, however, depends in accordance to Uexküll on organismic properties.

The consequence of evolution of increasingly complicated nervous systems is a continuous increase in the complication as well as autonomy of the inner world of organisms. This development also entails a growing emancipation from the organismic construction. This emancipation happened with the increase of a mechanically undisturbed brain in vertebrate head capsules and, in particular, with the evolution of special ape constructions whose emancipation enabled them to evolve a differentiated symbolic language. This is the point at which the beginning of cultural development may be identified. Although some indispensable biological and constructional needs limit every activity, no direct biological limitation is given. It follows from this that cultural activities and development should be conceived as occurring on a level of evolution that cannot be accounted for by biological theories.

CULTURAL IMPLICATIONS

As a consequence of the presuppositions of the theory of organismic constructions and the autonomy of cultural development, only a constructivist view of knowledge and cognition can be accepted. Constructivism can be considered as the outcome of various traditions of thinking, the Kantian in the European tradition in particular. Further, the suggestion of organismic autonomy has highly radical and far-reaching consequences not only for thinking about the relation between organisms and their environment but even for thinking about the approach to nature in general. Although it has to be conceded that every ontological description of nature is invalid, the mechanistic approach in the tradition of European sciences cannot be upheld. Autonomous organisms must act independently in their environment and must be pushed to activity by their own inner mechanisms. Hence, they cannot be regarded any more as some kind of cogwheels of a gigantic clockwork, as has been suggested by some models of traditional natural philosophy.

Consequently, the theory of organismic constructions accepts the philosophy of A. N. Whitehead in many respects. The acceptance of Whitehead's concepts can be seen as a strangification of traditional biology. Whitehead conceived nature as an organic and organismic-like structure that is permanently in motion, change, and development, but is always spontaneously pushed by impulses that come from within the organism. Whitehead's world consists of organisms. Organisms in the sense of Whitehead are very manifold and occur on various levels of complexity. Because of the organismic nature of the world, this philosophy is based on an all-embracing permanent process and stands in no need of a "god" such as the supernatural clockmaker so common in the European tradition. Indeed, a better understanding of the complexity of the world is provided by some physicalistic theories, such as the chaos theories, synergetics, or theory of dissipative structures, but they cannot present a consistent view of living organisms.

References

Arias, A. M. (2008). Drosophila melanogaster and the development of biology in the 20th century. *Methods in Molecular Biology*, **420**, 1–25.

Boyd, R., & Richerson, P. (1985). *Culture and the evolutionary process*. Chicago: University of Chicago Press.

Campbell, D. T. (1974a). Evolutionary epistemology. In P. A. Schilpp (Ed.), *The philosophy of Karl R. Popper* (pp. 412–463). LaSalle, IL: Open Court.

(1974b). Unjustified variation and selective retention in scientific discovery. In F. J. Ayala & T. Dobzhansky (Eds.), *Studies in the philosophy of biology* (pp. 139–161). London: Macmillan.

(1985). Pattern matching as an essential in distal knowing. In H. Kornblith (Ed.), *Naturalizing epistemology* (pp. 49–70). Cambridge, MA: MIT Press.

(1988). Popper and selection theory. *Social Epistemology*, **2**, 371–377.

Campbell, D.T., & Paller, B. T. (1989). Extending evolutionary epistemology to "justifying" scientific beliefs (A sociological rapprochement with a fallibilist perceptual foundationalism?). In K. Hahlweg & C. A. Hooker (Eds.), *Issues in evolutionary epistemology* (pp. 231–257). Albany, NY: State University of New York Press.

Cassirer, E. (1944). *An essay on man*. New Haven, CT: Yale University Press.

(1946). *The myth of the state*. New Haven, CT: Yale University Press.

(1955–1957). *The philosophy of symbolic forms*. 3 Vols. New Haven: Yale University Press.

Cavalli-Sforza, L., & Feldman, M. (1981). *Cultural transmission and evolution: A quantitative approach*. Princeton: Princeton University Press.

Dawkins, R. (1978). Replicator selection and the extended phenotype. *Zeittschrift für Tierpsychologie*, **47**, 61–76.

Edlinger, K. (1991). Organismus und Kognition – Zur Frage der biologischen Begründung kognitiver Fähigkeiten. In M. F. Peschl (Ed.), *Formen des Konstruktivismus in Diskussion* (pp. 108–150). Viena: WUV-Universitätsverlag.

(2004). Alle Evolution ist Anpassung – Ist alle Evolution Anpassung? Eine Kritik der Darwinschen Anpassungsmetapher. In G. Fleck, K. Edlinger, & W. Feigl (Eds.), *Die Theorie der Anpassung in Psychologie und Biologie*. Frankkfurt: Peter Lang – Europ. Verlag der Wissenschaften.

Edlinger, K., & Gutmann, W. F. (2002). *Organismus – Evolution – Erkenntnis. Grundzüge der Kritischen Evolutionstheorie und der Organismischen Konstruktionslehre*. Frankfurt: Peter Lang – Europ. Verlag der Wissenschaften.

Edlinger, K., Gutmann, W. F., & Weingarten, M. (1989). Biologische Aspekte der Evolution des Erkenntnisvermögens – Spontaneität und synthetische Aktion in ihrer organismischkonstruktiven Grundlage. *Natur & Museum*, **119**, 113–128.

(1991). Evolution ohne Anpassung. In W. Ziegler (Ed.), *Aufs. u. Reden Senckenb*. Naturforsch. Ges. 37.

Foerster, H. v. (1988). Constructing a reality. In Sherman (Ed.), *Adolescent Psychiatry 15: Developmental and clinical studies* (pp. 77–95). Chicago: University of Chicago Press.

(1990). Understanding understanding. *Methodologia*, **7**, 7–22.

(1998). On constructing a reality. In E. Rehfeld (Ed.), *Borderline, Lebbeus Woods* (pp. 72ff). New York: Springer.

Frischeisen-Köhler, M. (1925). Die Philosophie der Gegenwart. In M. Dessoir (Ed.), *Die Geschichte der Philosophie* (pp. 553–630). Wiesbaden: Fourier.

Ghosh, K., Thodeti, C. K., Dudley, D. Mammoto, A., Klagsbrun, M., & Ingber, D. E. (2008). Tumor derived endothelial cells exhibit aberrant Rho-mediated mechanosensing and abnormal angiogenesis in vitro. *Proc. Natl. Acad. Sci.*, **32**, 11305–11310.

Glasersfeld, E. v. (1987). *The construction of knowledge: Contributions to conceptual semantics*. Seaside, CA: Intersystems Publications.

(1995). *Radical constructivism: A way of knowing and learning*. London: Falmer Press.

Gleick, J. (1987). *Chaos: Making a new science*. New York: Penguin Books.

Gould, St. J., & Lewontin, R. (1979). The spandrels of San Marco and the panglossian paradigm. *Proceedings of Royal Society of London B*, **205** No. 1161, 581–598.

Gutmann, W. F., & Bonik, K. (1981). *Kritische Evolutionstheorie*. Hildesheim: Gerstenberg.

Gutmann, W. F., & Edlinger, K. (2002). *Organismus und Umwelt – Zur Entstehung des Lebens, zur Evolution und Erschließung der Lebensräume*. Frankfurt: Peter Lang – Europ. Verlag der Wissenschaften.

Haeckel, E. (1866). *Generelle Morphologie der Organismen*. Berlin: Georg Reimer.

Haken, H. (1981). *Erfolgsgeheimnisse der Natur*. Stuttgart: DVA.

(1990). Synergetik und die Einheit der Wissenschaft. In W. Saltzer (Ed.), *Zur Einheit der Naturwissenschaften in Geschichte und Gegenwart*. Wiss. Buchges. Darmstadt, 61–78.

Haken, H., & Wunderlin, A. (1986). Synergertik: Prozesse der Selbstorganisation. In A. Dress, H. Hendirchs, & G. Küppers (Hrgb.), *Selbstorganisation – Die Entstehung von Ordnung in Natur und Gesellschaft* (p. 35–60). München: Piper.

Holst, E. v. (1974). *The behavioural physiology of animals and man: Selected Papers* Vol. 1. (Translated from the German by Robert Martin). Coral Gables, FL: University of Miami Press.

Ingber, D. E. (1993a). The riddle of morphogenesis: A question of solution chemistry or molecular cell engineering? *Cell*, **75**, 1249–1252.

(1993b). Cellular tensegrity: Defining new rules of biological design that govern the cytoskeleton. *J. Cell Sci.*, **104**, 613–627.

Ingber, D. E., Dike, L., Hansen, L., Karp, S., Liley, H., Maniotis, A., McNamee, H., Mooney, D., Plopper, G., & Sims, J. (1994). Cellular tensegrity: Exploring how mechanical changes in the cytoskeleton regulate cell growth, migration, and tissue pattern during morphogenesis. *International Review of Cytology*, **150**, 173–224.

Langer, S. K. (1957). *Philosophy in a new key* (3rd ed.). Cambridge, MA: Harvard University Press.

Linden, D. J. (2007). *The accidental mind: How brain evolution has given us love, memory, dreams, and god*. Cambridge, MA: Harvard University Press.

Lorenz, K. (1941). Kant's Lehre vom Apriorischen im Lichte gegenwärtiger Philosophie. *Blätter dt. Philosophie*, **15**, 94–125.

(1978). *Behind the mirror: A search for a natural history of human knowledge.* London: 6.

Mammoto, A., Connor, K., Mammoto, T., Aderman, C., Mostoslavsky, G., Smith, L. E. H., Ingber, D. E., Aderman, C., & Mostoslavsky, G. (2009). A mechanosensitive transcriptional control mechanism that controls angiogenesis. *Nature*, **457**, 1103–1108.

Mayr, E., & Provine, W. B. (Eds.) (1998). *The Evolutionary synthesis: Perspectives on the unification of biology*. Cambridge, MA: Harvard University Press.

Meinhardt, H. (1978). Models for the ontogenetic development of higher organisms. *Reviews of Physiology, Biochemistry and Pharmacology*, **8**, 48–104.

(1987). Bildung geordneter Strukturen bei der Entwicklung höherer Organismen. In B. O. Küppers (Ed.), *Ordnung aus dem Chaos – Prinzipien der Selbstorganisation und Evolution des Lebens* (pp. 215–242). München: Piper.

Nüsslein-Volhard, C. (2004). *Das Werden des Lebens. Wie Gene die Entwicklung steuern*. München: Beck

Prigogine, I. (1979). *Vom Sein zum Werden*. Braunschweig: Viehweg.

Prigogine, I., & Stengers, I. (1981). *Dialog mit der Natur*. München: Piper.

Riedl, R. (1981). *Biologie der Erkenntnis*. Hamburg: P. Parey.

Roth, G. (1987). *Visual behavior in salamanders. Studies in brain function*. Vol. **14**. New York: Springer-Verlag.

Uexküll, J. v. (1921). *Umwelt- und Innenwelt der Tiere*. Berlin: Springer.

(1928). *Theoretische Biologie*. Berlin: Springer.

(1980). *Der Funktionskreis. In* Kompositionslehre der Natur (pp. 226–290). Frankfurt: Ullstein.

Vollmer, G. (1975). *Evolutionäre Erkenntnistheorie*. Stuttgart: S. Hirzel.

Wallner, F. (1992a). *Acht Vorlesungen über den Konstruktiven Realismus*. Vienna: WUV.

(1992b). *Konstruktion der Realität.* Vienna: WUV.

Whitehead, A. N. (1960). *Process and reality*. New York: Harper & Row.

(1967). *Science and modern world*. New York: Harper & Row.

Yung, C., & Ingber, D. E. (2009). *Micromagnetic – microfluidic blood cleansing microdevice*. Lab on a Chip.

10

What Do Genes Have to Do with Cognition?

Wendy Johnson

The genes sing a prehistoric song that today should sometimes be resisted but which it would be foolish to ignore.

– David Lykken (Bouchard et al., 1990, p. 228).

Cognition is a scientific term for the process, content, and quality of thought. As the rest of this book makes clear, it is a very broad concept that has very different specific meanings to different psychologists, philosophers, cognitive scientists, neurologists, and even linguists, computer scientists, and anesthesiologists. To all of them at some level, however, it refers to some faculty for processing information, applying knowledge, and evaluating or expressing preferences, whether consciously or unconsciously. As such, it has no content at all that is distinct from the environment in which it develops and is maintained and used. To many, therefore, the possibility of genetic influences on cognition is foreign, even frightening. How can something as ephemeral and dependent on the environment as the momentary aesthetic appreciation of a bird's song or the knowledge that one can spell a particular word be genetically influenced? The idea challenges our notions of ourselves as agents expressing free will and our values of human equality. Yet any measure of cognition from intelligence to memory to content of thought to problem-solving strategy will show heritability or evidence of genetic influence.

We can say very similar things about motivation. Motivation is a scientific term for the driving forces through which we achieve our goals. Again, it is a very broad concept that takes different and very specific meanings to different scientists who make use of it. For none of them does the term carry meaning that is distinct from the environment in which humans and other organisms actualize it. Thus, the possibility of genetic influences on motivation is as foreign and potentially frightening as the possibility of genetic influences on cognition. How can something as ephemeral and dependent on the environment as the impulse to comfort a hurt child or the drive to train to win an Olympic medal be genetically influenced? Yet, similar to cognition, any measure of motivation will show heritability or evidence of genetic influence. To simplify the discussion that follows, I focus on cognition, and often, specific ways of measuring cognition rather than motivation, but the concepts and issues involved are essentially identical.

Despite this, the intuition that genes cannot possibly control the process, content, and quality of thought from moment to moment is completely correct. Genes code for enzymes and the regulation of their formation, and these enzymes in turn build proteins, neurotransmitters, and hormones that organize bodily functions and bodily structures, such as kidneys, bones, eyes, brains, and hearts. Genes do not code for particular forms of knowledge or the acquisition of experiences on which we base our thoughts, such as TV watching or oyster-eating. At the same time, because we are biological organisms and our genes form the building blocks through which all of our biological functions are organized, everything that takes place within our bodies takes place through the expression of our genes. Because our minds are products of our brains, which are parts of our bodies, cognition is just another example of bodily function resulting from gene expression. From this perspective, the view that genes cannot possibly control the process, content, and quality of thought from moment to moment is completely, if trivially, incorrect. Reconciliation of the apparent paradox that cognition is heritable yet genes do not control it and interpretation of the significance of this for understanding cognition is the subject of this chapter.

EVOLUTION OF OUR UNDERSTANDING OF GENETIC INFLUENCES

Like our brains and bodies, our understanding of genetic influences has evolved through a process that sifts a jostling mass of essentially chance movements for those most empirically viable. As with our brains and bodies, the resulting understanding at any point in time, including the present, is not always or even often optimal, and the path through which the sifting of ideas progressed has much to do with any current state of understanding. Because of this, it is helpful to review the development of what is commonly called the Modern Evolutionary Synthesis, after Julian Huxley's (1942) book title. The ideas that contributed to the Synthesis were developed over the period from about 1936 to 1947, and reconciled highly specialized and apparently contradictory observations from genetics, cytology, botany, ecology, paleontology, systematics, and morphology. They form the basis of the current scientific understanding of evolution and genetics.

Gregor Mendel is considered the father of modern genetics because of his famous experiments in cultivating peas that led to the articulation of his two laws of inheritance. In his groundbreaking paper (Mendel, 1866) he stated that each individual has two "factors" for each trait, one from each parent. His first Law of Segregation states that when reproductive gametes are formed, each gamete receives only 1 of each of these factors. His second Law of Independent Assortment states that the factors of the various traits sort independently of each other during gamete formation, so that recombination of traits in offspring is essentially random. Although originally presented at a conference in 1865, Mendel's work was ignored until the turn of the twentieth century, when it was rediscovered and quickly replicated. In the meantime, the idea of evolution introduced in Darwin's *Origin of Species* (1859) had taken hold, and biologists had been exploring the implications of natural selection, the theoretical process whereby heritable traits that increase the probability of survival to reproduction become more common over successive generations of a population. Thus, the robust results of Mendelian genetics in discrete traits such as flower color fell into an intellectual climate that saw them as incompatible with both dominant theoretical ideas and empirical measurements of most morphological traits as varying continuously.

The first step toward reconciling these contradictory ideas was the development of population genetics, or the study of allele frequency distributions and their changes as results of natural selection, genetic drift, mutation, and gene flow. Fisher (1918) showed mathematically how continuous variation could emerge from the independent actions of many discrete genetic loci. Over the course of the next 12 years, he produced a series of papers and then a book (Fisher, 1930) showing that Mendelian genetics was completely consistent with evolution by natural selection. This was supported by a series of papers by J. B. S. Haldane that showed this consistency mathematically in real-world examples in specific species. Wright (1931) extended Fisher's mathematical development to show how complexes of genes transacting and interacting together could push small populations that had become physically isolated away from adaptive peaks and force natural selection to drive them to new adaptive peaks in their new circumstances. This appealed particularly to field naturalists such as Dobzhansky (1951), who showed that real-world populations have more genetic variation than had been assumed in Fisher's early population genetic models, and argued that natural selection maintained genetic diversity through maintaining recessive genes as well as by driving evolutionary change.

The ideas of the Modern Evolutionary Synthesis came together in the late 1940s, before the discovery of DNA. As augmented to recognize the role of DNA, they can be summarized as follows:

1) Heredity occurs through the transmission from one generation to the next of germ-line DNA that is located on chromosomes and organized into discrete units known as genes.
2) Hereditary variation reflects variation in DNA base sequence.
3) The variation in DNA base sequence that explains hereditary variation results from the many random combinations of existing alleles that are generated by the sexual reproductive processes and new variants in DNA (mutations) that occur accidentally and spontaneously.
4) Selection occurs at the level of the individual organism and its phenotype (manifested trait), which may co-evolve with its symbionts and parasites.
5) Heritable variations have small effects and evolution is gradual, with few points at which mutation pressure has been of particular importance. The small changes involved in gradual evolution are important when extended over time and can explain the large changes observed in the paleontological record.

DETECTING AND MEASURING THE PRESENCE OF GENETIC INFLUENCE

Among the key accomplishments of the early population geneticists, were the definition and establishment of methods for quantifying heritability or the proportion of population variance that can be attributed to individual differences in germ-line DNA transmitted from one generation to the next. The formulas are simple to apply and tend to show that all measured traits in plants, nonhuman animals, and humans are substantially heritable. Despite the apparent simplicity of its definition, heritability is a notoriously subtle concept that goes to the heart of the Modern Evolutionary Synthesis, and understanding how is crucial to understanding how genes are involved in cognition. To begin to explain this, it is easy to interpret the second tenet of the Modern Evolutionary Synthesis – that hereditary variation reflects variation in base DNA sequence – as indicating that heritability implies the degree to which a trait is genetically determined or passed from one generation to the next. This is not correct. The genes – half from each parent – rather than the trait are passed from one generation to the next, and they are expressed in the contexts of the other genes present and the environment in which the offspring develops. This means that tall parents tend to have tall children, but the variance in heights of children with tall parents is only slightly less than that of the population as a whole.

Heritability takes two forms that are often distinct yet rarely clearly distinguished. People working with domesticated plants and animals had long been aware and taken advantage of the fact that quantitative characteristics are passed in varying degrees from parents to offspring, but Fisher and the other early population geneticists specified how the varying degrees could be quantified using various combinations of biological relatives who differed in degree of biological relatedness. These "breeding values" or "narrow-sense heritabilities" reflect the proportions of population variance that can be attributed to the combined actions of genes that act independently of each other and thus additively. However, not all genetic influences are additive in this way. Genes recombine during the formation of each parent's gametes, and then the gametes with different genetic heritages combine to form the zygote. This process produces combinations of genes that interact with each other and generate other epistatic effects that can be very important to genetic influences on characteristics in the individual. These nonadditive effects tend to be dispersed during recombination in transmission to the next generation, and thus are not part of narrow-sense heritability, but they may be very important in the manifestation of traits in individuals. "Broad-sense heritabilities" include all sources of genetic variance.

The best ways to estimate heritability make use of situations in which reproduction can be controlled, as in agriculture and laboratory situations; it is not possible to use them in humans. The formulas generally used to estimate heritabilities of human traits rely on differences in extent of similarity of biological relatives of different degrees. The most common comparison is between similarity of monozygotic (MZ) and dizygotic (DZ) twins. MZ twins are derived from a single fertilized egg that splits early in gestation, and thus are effectively genetically identical. DZ twins are derived from two eggs released during a single ovulatory period and fertilized separately, and thus are genetically related in the same way as singleton full siblings. When mating is random, they share on average 50 percent of the genes that differ among human individuals (Guo, 1996). Genetic similarity of MZ twins can thus arise from both additive and nonadditive genetic influences, but genetic similarity of DZ twins will tend to arise only from additive genetic influences, so the distinction between narrow- and broad-sense heritabilities is blurred. A correlation between members of MZ twin pairs on a trait that is twice as large as the DZ correlation is generally interpreted as indicating that similarity is due entirely to additive genetic influences, or narrow-sense heritability. An MZ correlation more than twice as large as the DZ correlation is generally interpreted as indicating the presence of nonadditive genetic influences. However, data simulations show that explicitly nonadditive genetic effects generate correlations between relatives that are indistinguishable from those generated by additive genetic effects (Hill, Goddard, & Visscher, 2008). This makes clear that twin and other correlations between relatives cannot provide reliable indications of the relative importance of additive and nonadditive genetic influences. It is important because it emphasizes a point about the third tenet of the Modern Evolutionary Synthesis. Although variation in DNA base sequence underlies hereditary variation, many different combinations of genes and additive and nonadditive genetic processes can underlie similar levels of quantitative traits in different individuals and pairs of relatives.

By definition, heritability is a ratio of genetic variance to the sum of genetic and environmental variances, calculated under the assumption that genetic and environmental variances are independent of each other. Leaving aside the independence assumption for the moment, the fact that genetic variance is a term in both the numerator and denominator of the ratio means that the magnitude of the ratio is very dependent on the magnitude of environmental variance, and changes in environmental variance can mean large changes in heritability. Environmental variance itself consists of truly environmental influences but also of measurement error. This means, first of all, that the more accurately we can measure a trait, the more heritable it will appear to be. This may go far toward explaining, for example, the high heritability (80–90 percent) of human height. However, dependence of the heritability ratio on the magnitude of environmental variance also means that if the environment is constant (or if environmental differences have no effects on the trait), all observed variance will be the result of genetic differences. Such environmental imperviousness may explain the extremely high heritability (90–95 percent) of fingerprint patterns. At the same time, the dependence of the heritability ratio on the magnitude of environmental variance means that if the environmental variance is very large relative to the genetic variance, heritability will be low even when genetic variance is actually substantial. This is important because it indicates the flip side of the third tenet of the Modern Evolutionary Synthesis. Although variation in DNA base sequence underlies the genetic variation that produces heritability, the same genes (DNA base sequences) and genetic processes can underlie very different levels of quantitative traits in different individuals when their environmental circumstances differ meaningfully.

Heritability is thus population- and time-dependent, because all of the terms on which it depends (additive genetic variance, nonadditive genetic variance, environmental influences of all kinds) are specific to a population at a particular point in time, and because the fourth tenet of the Modern Evolutionary Synthesis firmly locates the operation of natural selection on the individual's manifested trait within its environment. Both kinds of genetic variance depend on how the gene alleles that influence the trait are grouped within the population, their frequencies, the magnitudes of their effects, and the modes of their actions, all of which can differ across populations, and of course environmental variance can also differ. Despite this, heritabilities of similar traits are often very similar across populations, and even across species. This can leave the impression that heritability is robust to population differences. There are two reasons, however, to think this an illusion. First, the heritability of many traits is moderated by environmental circumstances *within* populations. For example, heritability of physical health decreased with level of income and level of perceived control over life (Johnson & Krueger, 2005a, 2005b) in a national U.S. sample. Emphasizing the importance of remembering that heritability is a ratio, this was because genetic variance decreased with increasing income. In contrast, heritability of life satisfaction increased with level of income (Johnson & Krueger, 2006), due to decreased environmental variance with increasing income. The second reason to think that robustness of heritability to population differences is an illusion is that heritability estimates tend to gravitate toward the moderate range of perhaps 30–50 percent for essentially psychometric reasons completely unrelated either to genetic or environmental population circumstances. These reasons include the presence of substantial measurement error in environmental variance and, ironically, efforts to reduce measurement error such as aggregating collections of measurement items and including measurement items that generate a range of response frequencies. Thus, similar heritabilities in different populations can arise for very different combinations of reasons involving both factors intrinsic to the genetic and environmental population circumstances of primary interest and properties of the measurement instruments used to assess the traits.

EVOLUTIONARY PROCESSES AND GENE–ENVIRONMENT INTERACTION AND CORRELATION

In giving the definition of heritability as the ratio of genetic variance to the sum of genetic and environmental variance, I noted but temporarily set aside the underlying assumption that genetic and environmental influences are independent of each other. It is now time to return to it. It occupies an uneasy position in both the Modern Evolutionary Synthesis and the formulas used to estimate heritabilities, and exploring this uneasy position will help to illuminate how genes are involved in cognition. Darwin's theories of evolution and natural selection give a prominent role to environmental circumstances in determining the long-term fate of genetic variation, but Mendel's genetic results, derived as they were essentially from a single pea plot, leave little room for environmental variation because there essentially was none. Given his approach of reconciling Mendel's results with evolutionary theory mathematically and statistically, Fisher (1918, 1930) saw the reconciliation problem as *how much* of total variation could be attributed to genetic sources and how much to environmental sources. This focus on variance was a both a major conceptual departure and a major contribution to population genetics and statistical analysis more generally.

To this day, most statistical analysis focuses on mean differences. This kind of analysis incorporates assessment of variance because it is through comparison of mean differences with variance that we develop a conclusion that mean differences are important. Focus tends to be on the standard deviation as the measure of variance, however, because the standard deviation is stated on the same scale as the mean, which makes it possible to directly assess the relative importance of variation in ratio scales with real zero points. (Of course, in psychology in general and cognitive science in particular we are seldom working with ratio scales with real zero points, so the emphasis in this field is not particularly well placed.) Despite this, the scale of mean and standard deviation is not natural for variability itself, so independent sources of deviation from the mean cannot be summed to obtain total deviation when they are stated as standard deviations. If stated as variances, however, they can be summed, at least presuming they are independent. This was Fisher's reason for focusing on variance rather than standard deviation: it made his conceptual goal of reconciling Mendel's genetics with evolutionary theory tractable using his methodological approach of choice – statistical mathematics – at least as long as genetic and environmental influences could be considered independent. Fisher was aware that nonadditive interactions between genetic and environmental influences interrupted the ability to sum variance components, but he treated this as merely a statistical complication. To him, the statistical methods of analysis of variance that he developed were capable of revealing the presence and importance of such interactions, and statistical treatments to remove their effects were appropriate means of dealing with them if they appeared. Fisher's treatment was mathematically rigorous and his (rather limited) experimental work convinced him that interactions were rare and of little practical importance. Many followed him in effectively disregarding them.

Embryologists and evolutionary biologists, however, took a different view. To them, phenotypic characteristics were the current products of ongoing series of transactions between environmental circumstances and genetic material, and individual differences in those characteristics could be attributed to genetic or environmental influences only if the developmental conditions were specified. Failures of independence of genetic and environmental influences were not only not just occasional and annoying exceptions to a general rule; they were standard operating procedure in the natural world. Interactions between genetic and environmental influences were not merely statistical, either; they reflected variability arising from differential genetic sensitivity to environmental conditions, or environmental control of genetic expression.

This could be expressed through the norms of reaction or the patterns of phenotypic expression of individual genotypes in different environments. Figure 10.1 shows an example in fruit flies, taken from Dobzhansky and Spassky (1944). Development in fruit flies is quite sensitive to temperature. In this example, chromosomal types A and B were extracted from natural populations, and viability when hatched at two different temperatures was compared. Chromosomal heterozygotes were the most viable at both temperatures, but A/A homozygotes were much more sensitive to the warmer temperature than B/B homozygotes. As can be seen by comparing the variations with genotype at the two temperatures (the variations within each line of the graph), increasing the temperature by 9 degrees dramatically increased the genetic variance. In the example, environments were identical except for temperature, so heritability of viability was 100 percent in both cases. The example makes clear, however, that in real-world conditions in which both genotypes and environmental conditions would vary, heritability of viability would be heavily dependent on the population frequencies of the two chromosomes and the specific temperature conditions in which the flies were hatched.

Such interactions are well documented in plants and nonhuman animals, and we are starting to document them in humans, as well. Examples from psychology are greater sensitivity to stressful life events in people carrying the short allele of the serotonin transporter (Uher & McGuffin, 2007), and greater sensitivity to childhood maltreatment in males carrying the low-activity MAOA allele (Kim-Cohen et al., 2006). As might be expected given the complexity of the human environment on which they are dependent, however, these interactions have so far not replicated neatly. Statistically, these kinds of interactions produce statistical effects on variance equivalent to the interactions that Fisher considered of little practical importance, but they reflect a very different way of looking at individual differences than Fisher's. Where

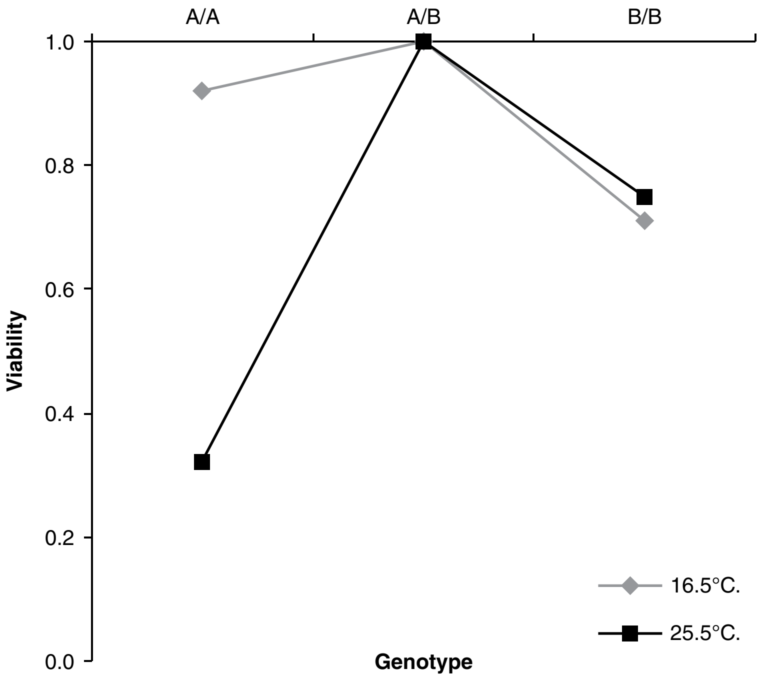

FIGURE 10.1. Norms of reaction in viability in 2 genetic lines of fruit flies in response to differences in temperature. A and B refer to chromosomal types. Adapted from Dobzhansky (1951).

Fisher saw static, independent contributions of genes and environmental influences to differing emerged phenotypes, embryologists and evolutionary biologists such as Lancelot Hogben, Ivan Schmalhausen, and Conrad Hal Waddington saw ongoing variations in developmental processes caused by individual differences in genetic accommodations to environmental circumstances. Where Fisher asked if total variation could be apportioned to genetic and environmental sources, the embryologists asked how specific environmental conditions affected different genotypes to produce individual differences in outcomes, and they developed interventions to test the robustness and magnitudes of the responses they observed. Unlike Fisher, who saw gene-environment interactions as nuisance and distraction, these developmental biologists saw gene-environment interactions as the very heart of the developmental processes in which they were interested (Tabery, 2008).

There was, however, more to it even than this. The embryologists and evolutionary biologists saw this differential sensitivity to environmental circumstances not just as a source of population variance *now*, but as the fundamental mechanism through which evolutionary change has taken place. Moreover, they realized that genetic variation could lie dormant and unexpressed until environmental circumstances triggered its expression (Gibson & Dworkin, 2004; Schmalhausen, 1949). Perhaps most importantly, they also realized that many organisms can choose the environmental circumstances they experience to at least some degree. Plants tend to remain fixed in one place throughout their lifespans; many animals (including, of course, humans) can and do move through space to escape detrimental environmental circumstances and seek more favorable ones. At bottom, the embryologists and evolutionary biologists recognized that genes are involved in the development of individual organisms in exactly the same ways they are involved in evolution.

The existence of dormant genetic variation and the implications of power to choose environmental circumstances are key to understanding this link between evolution and speciation and phenotypic developmental processes. Moreover, dormant genetic variation and power to choose environmental circumstances lead to some of the properties of heritability estimates that we observe in humans. Dormant genetic variance and power to choose environmental circumstances also have consequences that are inextricably bound to each other, and to gene-environment interaction, as well. This is important to understanding the presence of genetic influences on broadly construed traits such as cognition. Dormant genetic variation is primarily regulatory rather than structural and functional (Gerhart & Kirschner, 2007). This is a relatively recent understanding of genetic processes. It means that expression of otherwise dormant genetic variance triggered by environmental circumstances tends to involve changes in levels of production of proteins that are already being produced rather than production of proteins new to the system. In turn, the regulatory, quantitative character of otherwise dormant genetic variation tends to make phenotypic changes quantitative and gradual rather than qualitative in nature, as well. This implies that the emergence of new traits due to environmentally triggered expression of previously dormant genetic variation is simply the most extreme pole of a continuous dimension of gene-environment interaction. At the other pole of this dimension are ephemeral environmentally triggered fluctuations in continuously available gene products.

Similar to other animals, humans of course are constantly experiencing such genetically regulated fluctuations as they move through their environments, and there are individual differences in response to any particular environmental circumstance. There are also individual differences in the environmental circumstances experienced. Moreover, although choice is never complete, humans have choices about many of the environmental circumstances they encounter. People tend to seek environments in which they feel relatively comfortable and avoid those in which they do not, and the environments selected tend to reinforce the traits that led people to seek those environments in the first place (Caspi, Roberts, & Shiner, 2005), thus tightly linking gene-environment correlation with gene-environment interaction at the developmental level. For example, individuals who easily experience sensory overload may seek very constrained environmental situations in which they can focus attention on one kind of stimulus that appeals. They may also experience something akin to panic when forced into situations in which they are presented with large amounts of sensory input, restricting their ability to process that input to generate the synaptic connections that reflect learning. Over time, if ability to choose environmental circumstances is high and/or exposure to hubbub is low, such an individual might develop a calm and controlled personality with a highly specialized body of knowledge. Depending on the subject of the specialized body of knowledge, particular kinds of cognitions would be more likely than others, but a positive emotional outlook might be expected to predominate. In these circumstances, genetic tendencies toward psychopathology of many kinds might be suppressed rather than expressed. An individual with an identical tendency to experience sensory overload but limited ability to choose environmental circumstances and constant exposure to hubbub, however, might over time develop an anxious and explosive personality, difficulty in developing even basic knowledge and educational skills, and a negative, alienated emotional outlook, and genetic expression of tendencies toward psychopathology might flower. In short, the two individuals' habitual patterns of cognition might be very different.

Of course, capacity to tolerate sensory input is far from the only trait on which people make choices about the environmental situations they seek and avoid, and many if not most such choices are not made with any conscious awareness of particular traits or responses at all. Moreover, people have conflicting goals and motivations that may lead them to seek situations that leave them comfortable now but vulnerable to trouble later, or vice versa. For example, people choose to initiate a smoking habit despite knowledge of the long-term health consequences for reasons that have to do with short-term pleasure, setting in motion a series of patterns of social interaction and cognition involving that habit. Others choose to master a skill they find difficult, such as public speaking, because they know it will be necessary in an occupation they desire, again setting in motion patterns of social interaction and cognition that become habitual. The multiplicity of traits on which people may base their conscious and unconscious choices of environmental circumstances and the multiplicity of combinations of traits that people exhibit, degrees of freedom to make environmental choices, and expressed genetic backgrounds on which environmentally triggered genetic expression is placed virtually guarantee that there will be many different patterns of genetic and environmental transactions that lead to the development of any patterns of cognition we care to measure, from mental rotation to rumination to spiritual awareness. Despite the existence of these different developmental pathways, all measurable patterns of cognition will tend to show genetic influences, or heritability. I turn next to showing why.

MEASURING HERITABILITY OF COGNITION IN HUMANS – TWIN AND ADOPTION STUDIES

Recall that heritability is the proportion of variance in a trait that can be attributed to genetic influence, and that it is best measured by evaluating response to selection in situations in which breeding is controlled. Because control of breeding is not possible in humans, we typically take advantage of naturally occurring experiments in which the extent of genetic relatedness of the sample population is known to measure heritabilities in humans. This means making use of samples of twins and adoptive and biological relatives for which the extent of biological relatedness is known with some precision, and applying general formulas that rely on the assumption that genetic and environmental influences are independent. As I have shown, however, this assumption is commonly violated. When it is violated – that is, gene-environment interactions and correlations are present – the heritability formulas generally used generate results that appear interpretable but are biased in systematic ways.

To understand these biases, I need to explain the distinction between shared and nonshared environmental influences. Genetic influences act to make genetically related individuals similar; the individuals have common genetic heritage. Environmental influences, however, could act to make genetically related individuals similar or they could act to make them different. When the environmental influences act to make the individuals similar, they are termed *shared*. When the environmental influences act to make the individuals different, they are termed *nonshared*. Measurement error is thus always included among nonshared environmental influences. Often, people think of environmental circumstances that family members share, such as parental divorce and socioeconomic status in siblings in childhood, as shared, but these environmental influences are shared in the sense the term is used here only to the extent that they act to make the siblings similar. If the siblings respond to such environmental circumstances differently, their influences are nonshared. It is harder to see how different experiences could act to make relatives similar, but the same idea applies: the environmental circumstances could be considered shared environmental influences if they do make the relatives similar. For example, two siblings could develop similar levels of trait perseverance, including ways of thinking about frustration and maintaining motivation, one through participation on a sports team and the other through practicing a musical instrument. In that case, access to opportunities to develop and practice skills might be the shared environmental influence.

When genetic and shared environmental influences are correlated, estimates of genetic and environmental influences that do not explicitly recognize the existence of the correlation understate genetic influences and exaggerate shared environmental influences. When genetic and shared environmental influences interact but the interaction is not recognized, however, the effect is the opposite: genetic influences are exaggerated and shared environmental influences are understated. These distortions in the estimates can be demonstrated mathematically (Purcell, 2002) and could be removed if the appropriate data were available, but this is relatively rare. In contrast, when genetic and nonshared environmental influences are correlated but the correlation is not recognized, genetic influences are exaggerated and nonshared environmental influences are understated. The opposite is the case when genetic and nonshared environmental influences interact: nonshared environmental influences are exaggerated and genetic influences are understated. What does this mean for thinking about genetic influences on cognition?

The greatest volume of data on genetic influences on cognition has been compiled for measures of intelligence. These data show a clear and well-replicated developmental pattern: in young childhood, shared environmental influences account for some 35 percent of variance; genetic influences account for some 30 percent of variance; and nonshared environmental influences, including measurement error, account for the remaining 35 percent or so of variance (Plomin et al., 2007). In samples of children of increasing age, the proportions of variance attributable to genetic influences gradually and steadily increase, and the proportions of variance attributable to shared and nonshared environmental influences steadily decrease. The decrease is much sharper for shared than nonshared environmental influences. In samples of adults, the proportion of variance attributable to genetic influences can be as high as 80 percent. This depends primarily on the reliability of the test, as the proportion of variance attributable to shared environmental influences typically declines to 0 percent. Figure 10.2 shows how this typically works.

With respect to intelligence and many other aspects of cognition, there is no question about the presence of gene-environment correlation. In childhood,

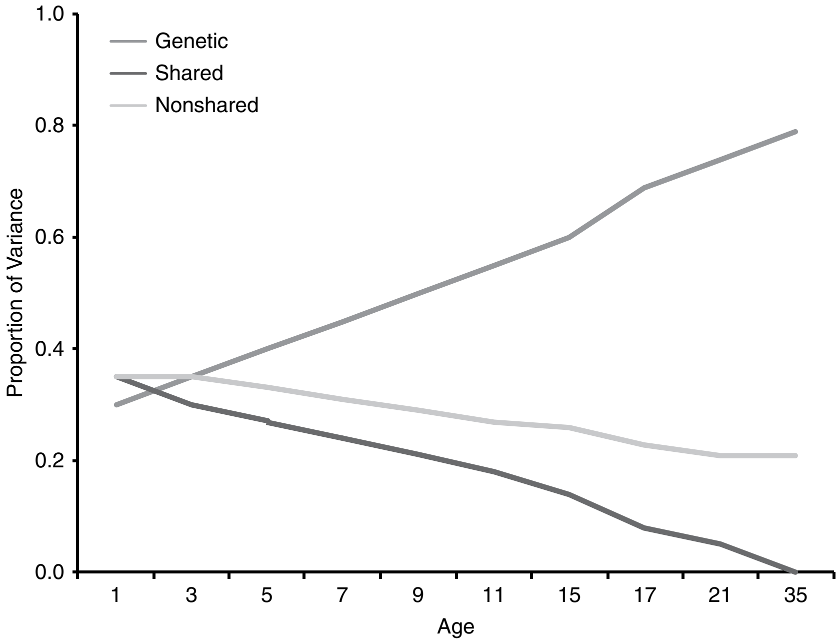

FIGURE 10.2. Typical patterns of changes in genetic and environmental influences on intelligence with age.

the correlation likely centers on the home environment and its extension, the school environment that parents have selected for their children. Brighter parents pass whatever genes are involved in intelligence on to their children, and brighter parents – particularly those with higher socioeconomic status (SES), as that is the way the question has most often been studied – also pass on more optimal childhood environments for the development of intelligence (Hart & Risley, 1995; Heath, 1982). They read more to their children, speak to them more using larger vocabularies, are more likely to talk to them in intellectually stimulating ways, are more likely to expose them to intellectually stimulating activities such as visits to museums and concerts and participation in enrichment classes and science fairs, and are more likely to make active choices about the schools their children attend. These activities probably reflect some combination of parental lifestyle and parenting philosophy applied consistently across siblings, tailoring of parental activities to the individually expressed responsiveness and needs of each child, and parental life circumstances that dictate available parenting resources. For example, parents may read to each of their children in very similar amounts because they believe that reading to children is important, but may find that one child wants to hear the same book over and over and therefore ends up being exposed to relatively few books, and another is always asking for something new and ends up being exposed to many more. Parents may also find it easy to pay for and transport a child to an enrichment course one year and much more difficult another, due purely to their own job or financial circumstances.

Because genes and environments are correlated this way in biological families, we know less than we would like about how much these activities actually matter in the development of intelligence. The best evidence we have comes from studies of children born to parents of one SES and adopted by parents in another. These studies generally show that children born to low SES parents who are adopted into higher SES families tend to have higher IQs than their siblings who remain with their birth parents by perhaps 12–15 IQ points (Capron & Duyme, 1989; van IJzendoorn, Juffer, & Klein Poelhuis, 2005). These studies also tend to show that adoptees born to high SES parents tend to have higher IQs than adoptees born to low SES parents, no matter who raises them, again by perhaps 12 IQ points. These findings are rather soft, due to the relative rarity of studies, small sample sizes, and the absence of randomized assignment to adoptive circumstances, appropriate control samples, clear before and after adoption measurement, and follow up of most adoptive samples into adulthood (van IJzendoorn, Juffer, & Klein Poelhuis, 2005).

Still, together, these adoption findings suggest that high SES environment helps increase IQ, but it matters less to those born to high SES parents than to those born to low SES parents. One way to interpret these findings is that whatever genetic or prenatal or perinatal characteristics are associated with being born to high SES parents are relatively insensitive to the kinds of differences in environments associated with SES, but whatever genetic or prenatal or perinatal characteristics are associated with being born to low SES parents are quite sensitive to those same differences in environments associated with SES. Intelligence is unquestionably a developmental trait that emerges at least partly through the acquisition of cognitive habits and skills and knowledge. We could explain these findings if genes for traits that predispose children to seek experiences that develop intelligence – such as thirst for knowledge, curiosity about how things work, desire to express themselves clearly and accurately, and so on – were more common among children born to high SES parents. If children carrying these genes but growing up in low SES adoptive families had just enough access to books and other learning materials to acquire these developmental experiences themselves, they could acquire higher intelligence than most of their low SES peers through correlation between genetic and nonshared environmental influences. Were these children growing up in their high SES birth environments, some of this correlation would likely instead be between genetic and shared environmental influences. At the same time, if genes for traits that predispose children to adapt to the cognitive behaviors of those around them were more common among children born to low SES parents, then these children might develop higher intelligence when raised in high SES adoptive homes than they would have if they had been raised by their low SES birth parents, and they would do so through correlation between (different) genetic and shared environmental influences as well as interaction between genetic and shared environmental influences.

There is precedent for and some evidence supporting these propositions. Hayes (1962) and Bouchard (1997) have proposed that genes drive the acquisition of experiences through which intelligence develops, and Cronbach and Snow and others (Cronbach & Snow, 1977; Freebody & Tirre, 1985; Shute et al., 1996; Snow, 1982) have gathered considerable evidence that high-ability students tended to benefit more from open-ended educational curricula that encouraged active exploration and experimentation than from structured instruction, but the opposite is the case for lower-ability students. If it were the case that this involved genetic differences that had frequencies that varied with SES, there might be relatively few if any genes for intelligence per se, yet intelligence would show substantial genetic influence or heritability because of the genetic influences on the traits contributing to its development. In a general population of children containing representatives of all genetic backgrounds growing up in all levels of SES, estimates of shared environmental influences would tend to be exaggerated due to the presence of correlation between genetic and shared environmental influences in those children whose intelligence was developing in conformance with the cognitive behaviors of those around them. At the same time, estimates of genetic influences would tend to be exaggerated, too, due to the presence of both interaction between genetic and shared environmental influences in those same children and correlation between genetic and nonshared environmental influences in those children whose intelligence was developing in response to their own intellectual exploratory behaviors. If the genes for intellectual exploratory behaviors were more common among children born to high SES parents, and those for adapting to others' cognitive behaviors more common among children born to low SES parents, we could expect that heritability estimates would be higher (and exaggerated to a greater degree) in high SES groups and estimates of shared environmental influences would be higher (and exaggerated to a greater degree) in low SES groups. Several studies have provided evidence that this is the case (Harden, Turkheimer, & Loehlin, 2007; Rowe, Jacobson, & van den Oord, 1999; Turkheimer et al., 2003). Of course, it is extremely unlikely that genetic influences on the development of any child's intelligence would be either exclusively exploratory or exclusively adaptive.

If we understand performance on intelligence tests to reflect cognitive skills and habits broadly in use at time of testing, this same developmental emphasis on gene-environment correlation and interaction can be used to explain the increases in estimates of genetic influences and decreases in estimates of shared environmental influences on intelligence as samples move from childhood to adulthood. Although gene-environment correlation and interaction likely center on the family environment in childhood, this changes as children grow to adulthood. Once people reach school-leaving age, the day-to-day need to maintain intellectual activity varies widely with occupation and interest, and tends to center on peer group rather than the families in which people were raised. This means a likely shift of current environmental influences from being primarily shared to being primarily nonshared. Thus, in those whose intelligence is adaptive, the correlation between genetic and shared environmental influences in childhood that acted to exaggerate estimates of shared environmental influences would shift to a correlation between genetic and nonshared environmental influences that acts to exaggerate estimates of genetic influences in adulthood. At the same time, the interaction between genetic and shared environmental influences in those same people that acted to exaggerate genetic influences in childhood would shift to an interaction between genetic and nonshared environmental influences that acts to exaggerate estimates of genetic influences in adulthood. The correlation between genetic and nonshared environmental influences in those whose intelligence is exploratory that acted to exaggerate estimates of genetic influence in childhood would continue to operate in adulthood. Taken together, if these genetic and environmental correlative developmental processes were operative, we would expect estimates of shared environmental influences on intelligence to drop dramatically from childhood to adulthood, and estimates of genetic influences to increase, exactly as has been observed. Similar developmental processes could be involved in many other, if not all, aspects of cognition.

GENERATING HERITABILITY THROUGH DEVELOPING ACCURACY OF MEASUREMENT – ABSTRACTION OF COGNITION

Many aspects of cognition are very ephemeral and, as noted at the beginning of this chapter, the idea that there are genetic influences on fleeting cognitive images and idiosyncratic ways of thinking is foreign. The most ephemeral aspects of cognition actually may tend to show little or no genetic influence, for exactly the same reasons that make them difficult psychometrically. However, three familiar psychometric principles used to create precision of measurement of cognition also generate heritability.

The first is aggregation. Individual items are always noisy indicators of the construct of interest. Psychometricians aggregate a sufficient number of items so that the independent sources of error in individual items tend to cancel each other out, thus more clearly revealing the construct of interest they share. Even individual scale items do tend to show heritability (Neale, Rushton, & Fulker, 1986), but due to the principle of aggregation, they tend to be less heritable than scales (Johnson et al., 2008). This applies at the molecular genetic level, as well. Polygenic traits such as cognition tend to show heritability in part because the traits themselves involve the expression of many genetic polymorphisms. The broader the trait construct we consider (and many aspects of cognition such as intelligence, memory, knowledge, problem-solving strategies, and motivational attributions clearly are very broad and involve many aspects of brain function), the more likely manifestation of that trait is to involve a very large number of molecular mechanisms and therefore genes, and thus to display a good solid heritability that is rather stable across populations.

The second process that contributes to both sound psychometric properties and heritability is reliability. Measures of cognition can only be valid if people's responses are consistent over relevant time periods, and this is true of heritability, as well. The third process involved in both is frequency of response. Measurement is most accurate when scales include items that reliably tap the full distribution of the underlying construct, but items at the extremes of the distribution tend to have rather skewed response patterns because almost everyone answers them the same way. As long as there is systematic population variance in response, however, more closely genetically related people will tend to answer them more similarly. Similar to the first process, this also has an analog in molecular genetics. Genetic polymorphisms differ in frequency. Even individual differences completely under genetic control may show little or no heritability if the frequencies of the genes involved are low. The gene involved in Huntington's Disease is an example of this. The deleterious gene involved is so rare that heritability of the disease is effectively 0 in any population sample, yet at this time, presence of the deleterious allele completely determines development of the disease.

CONCLUSIONS: CAN/SHOULD WE EXPECT TO FIND THE GENES FOR COGNITION?

I began this chapter by recounting the development of the Modern Evolutionary Synthesis linking the basic principles of gene action discovered by Gregor Mendel to the evolutionary principles articulated by Charles Darwin. I then showed how this synthesis applies not just to understanding the long-past evolution of the species we see today but to the development processes and manifestation of individual differences in humans today. Along the way, I described how these developmental processes are generally glossed over in making estimates of heritability of cognitive and other psychological traits in humans, leading to systematic biases in those estimates. Some may be quick to seize on this as reason to dismiss the heritability estimates or interpret the presence of bias in the estimates as an indication that there really are no genetic influences on cognitive and other psychological traits. This would be a serious mistake. Genes are involved in cognition as they are involved in all aspects of human behavior. Moreover, their involvement is far more than the tautological expression of the fact that it is through the actions of our genes that all of our biological functions take place. Individual genetic differences drive the experiences we seek and, simultaneously, our sensitivities to the effects of those experiences. This means that at some level our genes drive what we take from those experiences – what we observe, what we learn, how we interpret our experiences, and thus how we build and maintain our cognitive understandings of the world. Our world is constantly changing, so our genetically influenced proclivities do not always drive us to seek constructive experiences, and we never have complete freedom to act as our genes might prompt, anyway. Fortunately as well, when it comes to cognition, our genes rarely get the final word – we have the power to use our wills to direct the ways in which they are expressed.

Throughout this chapter, I have been ignoring an elephant in the room. Huge amounts of energy and resources are presently being devoted to trying to identify the genes involved in human physical and mental diseases and behavioral traits. If there are genetic influences on cognition (and/or motivation), should we be able to find the specific genes involved? The prevailing wisdom has been that high heritability indicates that finding the genes is feasible. So far, though, this is has not been our experience (Maher, 2008, p. 456). To date, we have not been very successful in identifying the genes even for highly heritable, clearly measurable traits such as height (Flint & Mackay, 2009), and we have been spectacularly unsuccessful in identifying genes for normal-range intelligence, arguably the most well-defined measure of cognition. Instead, we have actually been more successful in identifying genes for traits such as Huntington's Disease that are not heritable at all in population samples (Risch & Merikangas, 1996). In the cognitive area, we know of more than 300 genes involved in mental retardation (Inlow & Restifo, 2004), but for the same reason, the conditions involved show little or no heritability in population samples.

Increasingly, geneticists are recognizing that initial indications from model organisms that large proportions of variance in quantitative traits could be accounted for by finite numbers of genes that had finite kinds of effects were illusory, likely due to the oversimplified genetic background produced by working with crosses between inbred strains. Many genes with very small effects on any given trait and genes with effects on many different systems throughout the body appear to be rules rather than exceptions (Flint & Mackay, 2009). Broadly construed traits that have clearly heterogeneous developmental courses such as cognition appear to be especially subject to these complications of gene identification. If this is the case, it is far from clear that identifying the specific genes involved is the best strategy to understand even the genetic involvement in these traits, let alone their observable manifestation. The effects of any genes identified are likely to be extremely small and closely intertwined with those genes affecting other traits. We may make much more rapid progress in understanding traits such as cognition through trying to understand how developmental processes are modified by environmental circumstances when the clearly important genetic background is controlled. This can be accomplished through innovative use of twin and adoption studies (Johnson et al., 2009).

References

Bouchard, T. J. (1997). Experience producing drive theory: How genes drive behavior and shape personality. *Acta Paediatrica*, **86**, 60–64.

Bouchard, T. J., Lykken, D. T., McGue, M., Segal, N. L., & Tellegen, A. (1990). Sources of human psychological differences: The Minnesota Study of Twins Reared Apart. *Science*, **250**, 223–228.

Capron, C., & Duyme, M. (1989). Assessment of the effects of socio-economic status on IQ in a full cross-fostering study. *Nature*, **340**, 552–554.

Caspi, A., Roberts, B. W., & Shiner, R. L. (2005). Personality development: Stability and change. *Annual Review of Psychology*, **56**, 453–484.

Cronbach, L. J., & Snow, R. E. (1977). *Aptitudes and Instructional Methods: A Handbook for Research on Interactions*. New York: Irvington.

Darwin, C. (1859). *On the Origin of Species*. London: John Murray.

Dobzhansky, T. (1951). *Genetics and the Origin of Species, 3rd Edition.* New York: Columbia University Press.

Dobzhansky, T., & Spassky, B. (1944). Genetics of natural populations. XI. Manifestation of genetic variants of drosophila pseudoobscura in different environments. *Genetics*, **20**, 270–290.

Fisher, R. A. (1918). The correlation between relatives on the supposition of Mendelian inheritance. *Transactions of the Royal Society of Edinburgh*, **52**, 399–433.

(1930). *The Genetical Theory of Natural Selection.* Oxford: Clarendon Press.

Flint, J., & Mackay, T. F. (2009). Genetic architecture of quantitative traits in mice, flies, and humans. *Genome Research*, **19**, 723–733.

Freebody, P., & Tirre, W. C. (1985). Achievement outcomes of two reading programs – An instance of aptitude-treatment interaction. *British Journal of Educational Psychology*, **55**, 53–60.

Gerhart, J., & Kirschner, M. (2007). The theory of facilitated variation. *Proceedings of the National Academy of Sciences*, **104**, 8582–8589.

Gibson, G., & Dworkin, I. (2004). Uncovering cryptic genetic variation. *Nature Reviews Genetics*, **5**, 681–690.

Guo, S. W. (1996). Variation in genetic identity among relatives. *Human Heredity*, **46**, 61–70.

Harden, K. P., Turkheimer, E., & Loehlin, J. C. (2007). Genotype by environment interaction in adolescents' cognitive aptitude. *Behavior Genetics*, **37**, 273–283.

Hart, B., & Risley, T. (1995). *Meaningful Differences in the Everyday Experience of Young American Children.* Baltimore: Brookes.

Hay, K. J. (1962). Genes, drives, and intellect. *Psychological Reports*, **10**, 299–342.

Heath, S. B. (1982). What no bedtime story means: Narrative skills at some and school. *Language in Society*, **11**, 49–79.

Hill, W. G., Goddard, M. E., & Visscher, P. M. (2008). Data and theory point to mainly additive genetic variance for complex traits. *PLoS Genetics*, **4**, e1000008.

Huxley, J. S. (1942). *Evolution: The Modern Synthesis.* London: Allen & Unwin.

Inlow, J. K., & Restifo, L. L. (2004). Molecular and comparative genetics of mental retardation. *Genetics*, **166**, 835–881.

Johnson, W., Gangestad, S. W., Segal, N. L., & Bouchard, T. J. (2008). Heritability of fluctuating asymmetry in a human twin sample. *American Journal of Human Biology*, **20**, 651–658.

Johnson, W., & Krueger, R. F. (2005a). Genetic effects on physical health: Lower at higher income levels. *Behavior Genetics*, **35**, 579–590.

(2005b). Higher perceived life control decreases genetic variance in physical health: Evidence from a national twin study. *Journal of Personality and Social Psychology*, **88**, 165–173.

(2006). How money buys happiness: Genetic and environmental processes finances and life satisfaction. *Journal of Personality and Social Psychology*, **90**, 680–691.

Johnson, W., Turkheimer, E., Gottesman, I. I., & Bouchard, T. J. (2009). Beyond heritability: Twin studies in behavioral research. *Current Directions in Psychological Science, in press*.

Kim-Cohen, J., Caspi, A., Taylor, A., Williams, B., Newcombe, R., Craig, I. W., & Moffitt, T. E. (2006). MAOA, maltreatment, and gene-environment interaction predicting children's mental health: New evidence and a meta-analysis. *Molecular Psychiatry*, **11**, 903–913.

Maher, B. (2008). The case of the missing heritability. *Nature*, **456**, 18–21.

Mendel, J. G. (1866). Translated as Experiments in plant hybridization by C. T. Druery & W. Bateson (1901). *Journal of the Royal Horticultural Society*, **26**, 1–32.

Neale, M. C., Rushton, J. P., & Fulker, D. W. (1986). Heritability of item response on the Eysenck Personality Questionnaire. *Personality and Individual Differences*, **7**, 771–779.

Plomin, R., DeFries, J. C., McClearn, G. E., & McGuffin, P. (2007). *Behavioral Genetics, 5th Edition.* New York: Worth Publishers.

Purcell, S. (2002). Variance component models for gene-environment interaction in twin analysis. *Twin Research*, **5**, 554–571.

Risch, N., & Merikangas, K. (1996). The future of genetics of complex human diseases. *Science*, **273**, 1516–1517.

Rowe, D., Jacobson, K., & van den Oord, E. (1999). Genetic and environmental influences on vocabulary IQ: Parental education as a moderator. *Child Development*, **70**, 1151–1162.

Rushton, J. P., Brainerd, C. J., & Pressley, M. (1983). Behavioral development and construct validity: The principle of aggregation. *Psychological Bulletin*, **94**, 18–38.

Schmalhausen, I. I. (1949). *Factors of Evolution: The Theory of Stabilizing Selection.* Philadelphia: The Blakiston Company.

Shute, V. J., Gawlick-Grendell, L. A., Young, R. K., & Burnham, C. A. (1996). An experiential system for learning probability: Stat Lady description and evaluation. *Instructional Science*, **24**, 25–46.

Snow, R. E. (1982). The training of intellectual aptitude. In D. K. Detterman and R. J. Sternberg (Eds.), *How and How Much Can Intelligence Be Increased?* (pp. 1–37). Norwood, NJ: Ablex.

Tabery, J. (2008). R. A. Fisher, Lancelot Hogben, and the origin(s) of genotype-environment interaction. *Journal of the History of Biology*, **41**, 717–761.

Turkheimer, E., Haley, A., Waldron, M., D'Onofrio, B., & Gottesman, I. I. (2003). Socioeconomic status modifies heritability of IQ in young children. *Psychological Science*, **24**, 623–628.

Uher, R., & McGuffin, P. (2007). The moderation by the serotonin transporter gene of environmental adversity in the aetiology of mental illness: Review and methodological analysis. *Molecular psychiatry*, **12**, 1–16.

van IJzendoorn, M. H., Juffer, F., & Klein Poelhuis, C. W. (2005). Adoption and cognitive development: A meta-analytic comparison of adopted and non-adopted children's IQ and school performance. *Psychological Bulletin*, **131**, 301–316.

Wright, S. (1931). Evolution in mendelian populations. *Genetics*, **16**, 97–159.

11

Brain, Behavior, and Cognition

Norbert Jaušovec & Ksenija Jaušovec

"Each of us lives within the universe – the prison – of his own brain. Projecting from it are millions of fragile sensory nerve fibers, in groups uniquely adapted to sample the energetic states of the world around us: heat, light, force and chemical composition. That is all we ever know of it directly; all else is logical inference" (Mountcastle, 1975, p. 131). Within a few million years, the central nervous system has evolved at a spectacular rate and has become predominant in behavior control. It shapes our thoughts, hopes, dreams, and imaginations. The brain – a spongy, one-and-a-half–kilo mass of fatty tissue – is what makes us human. The present chapter will provide only a glimpse of what is known about the relationship between brain functioning and cognition – several facets of this relationship rather than a comprehensive overview.

A FEW BRAIN FACTS

The neocortex comprises most of the forebrain by volume with an area of up to 2,500–3,000 cm^2 and a thickness of only 1.5–3.0 mm (Nunez, 1995). It seems that the neocortex is a device for the most widespread diffusion and mixing of signals (Braitenberg & Schutz, 1991). Therefore, some authors have made the analogy between cortical functioning and the density of social gathering in a mob (Bullock, 1980) or the collective interactions of waves and individual particles in hot plasma systems (Nunez, 1995). A numerical illustration of the extreme interconnectivity of neocortical tissue is the estimate of about a 4-km axon length per cubic millimeter. This interconnectivity in the neocortex is made possible by cortical neurons – pyramidal cells and interneurons. Pyramidal cells account for more than three-fourths of neocortical neurons, and are the primary intracortical cells with excitatory axons; whereas interneurons are mainly inhibitory. Nearly every pyramidal cell sends an excitatory axon into the white matter, and most of these re-enter the cortex at some distant location in the same hemisphere (corticocortical fibers) or opposite hemisphere (commissural fibers). In addition, multiple branches of the axon provide input to regions within a 3 mm radius. The average number of synapses per cortical neuron is about 10^4.

Neocortical neurons are arranged in overlapping modular columns of different sizes (e.g., the minicolumn with a diameter of about 20–50 μm or the macrocolumn with a diameter of 0.5–3 mm). An important modular unit is the corticocortical column, with a 2–3 mm thickness, a diameter of about 0.3 mm, and containing about 10^3–10^4 neurons (Szentagothai, 1979). There are about 10^{10} neocortical neurons, or about 2×10^6 corticocortical columns, and nearly all send connections to other parts of the neocortex. It has been speculated that each module projects to perhaps 10–100 other modules and receives input from the same number (Eccles & Robinson, 1984). Therefore, our neocortex can be viewed as a system involving the interaction of 10^6 corticocortical columns – a reflexive device working on its own input. To illustrate the immense complexity of the neocortex, Nunez (1995) has argued that if the neocortical state can be defined by the distribution of binary states of each unit (on/off), then on the level of the macrocolumn one comes up with the unimaginable number of 10^{3162} states. For comparison, the number of electrons that could be packed into the volume of the known universe is approximately 10^{120}.

NEUROIMAGING TECHNIQUES

A simple method for recording the electrical activity of the brain is electroencephalography (EEG). To record EEG, a small metal disk is attached to the scalp to detect the electrical activity of neurons in the underlying brain area. EEG measurement requires collection of a huge amount of data that are unusable in raw form. Therefore, they are subjected to data-reduction methods. These reduction methods could be roughly classified into two groups: first, methods that are partly or completely based on the magnitude of EEG (e.g., absolute power measures); and second, methods that measure the interrelations of EEG activity between different scalp locations (e.g., coherence measures). Most often, a Fast Fourier Transformation (FFT) is performed on artifact-free chunks of data to derive estimates of absolute power values or relative percentage power values in different frequency bands: $\delta = 1.5 - 3.5$ Hz; $\vartheta = 3.6 - 6.5$ Hz; $\alpha_1 = 6.6 - 8.5$ Hz; $\alpha_2 = 8.6 - 10.5$ Hz; $\alpha_3 = 10.6 - 12.9$ Hz; $\beta_1 = 13.0 - 17.5$ Hz; $\beta_2 = 17.6 - 23.5$ Hz; $\beta_3 = 23.6 - 31.5$ Hz. The decision to select these eight bands is mainly based on recent findings relating some of the bands to different mental processes. In several studies using the event-related desynchronization (ERD) method, Klimesch and his colleagues found that theta synchronization and desynchronization in the lower alpha band were associated with episodic memory tasks and attentional demands of the tasks (Klimesch et al., 1997). On the other hand, semantic memory tasks showed significant alpha desynchronization only in the upper alpha band (Klimesch, Schimke, & Pfurtscheller, 1993). Some studies (Traub et al., 1999; Stein & Petsche, 1995) have further associated neuronal oscillations within the EEG beta and gamma bands (15–80 Hz) with intense mental activity and perception – the so-called binding phenomenon (the selection and binding together of pertinent aspects of a sensory stimulus into a perceived whole). The majority of analyses reported focus on measures in the alpha band (7.5–13 Hz). Evidence indicates that alpha power is inversely related to mental effort (e.g., Nunez, 1995).

According to Petsche (1997), a more suitable indicator of brain functioning than measures based on the magnitude of EEG is coherence, the normalized cross-correlation that provides information about the cooperation between various brain areas. Looking for functional relations between brain regions rather than for localized power measures is useful because of the basic structure of the cortex.

Yet another measure using a recording technique similar to the ongoing EEG are average evoked potentials (AEP), also called event-related potentials (ERP). ERPs consist of a brief change in EEG signal in response to a sensory stimulus. The changes are small and hard to see in the background of EEG activity. Therefore, sensory stimuli are given repeatedly and the brain activity is averaged. Major interest has been devoted to so-called late components in ERPs, namely, those that occur 100 ms after the stimulus onset (Detterman, 1994). Furthermore, the ERP to a stimulus can be segmented into a sequence of transient topographic patterns, also referred to as microstates. Similar to the interpretation of ERP waveform components, microstates are thought to reflect synchronized activity in functionally interconnected neural networks. These networks correspond to different global stages in information processing (Michel et al., 2001 for a review).

Some more recent methods for analyzing the EEG signal are low-resolution brain electromagnetic tomography (LORETA) (Pascual-Marqui, Michel, & Lehmann, 1994) and dynamic causal modeling (DCM) (Friston, 2003). LORETA is a functional imaging method based on electrophysiological and neuroanatomical constraints. For instance, the cortex can be modeled as a collection of volume elements (voxels) in the digitized Talairach atlas. In this case, the LORETA inverse solution (which is consistent with the EEG/MEG measurements) corresponds to the 3D distribution of electric neuronal activity that shows maximum similarity (i.e., maximum synchronization) in terms of orientation and strength between neighboring neuronal populations (represented by adjacent voxels). The cortical surface can be modeled, also, as a collection of surface elements with known orientation. LORETA can accommodate this neuroanatomical constraint and find the inverse solution that maximizes only the synchronization of strength between neighboring neuronal populations.

In DCM, one views the brain as a dynamic network of interacting sources that produces observable responses. The aim is to make inferences about the coupling among brain regions or sources and how that coupling is influenced by experimental factors. DCM uses the notion of *effective connectivity*, defined as the influence one neuronal system exerts over another. DCMs can be phenomenological or biophysical. Biophysical DCMs are constrained by the known physical or biological processes generating the observed signals. In contrast, phenomenological DCMs describe the causal dynamics in a purely formal fashion. DCM is not an exploratory technique; it does not explore all possible models: DCM tests specific models of connectivity and, through model selection, can provide evidence in favor of one model relative to others.

The major benefits of using EEG and ERPs are that the approach is noninvasive, it can be used with alert subjects, and it provides the best temporal resolution between behavior and brain activity. The central problem with EEG, however, is that it "is a composite signal from volume conduction in many different parts of the brain, and it is far from clear what a signal means in terms of how neurons in the relevant networks are behaving" (Sejnovski & Churchland, 1989, p. 332).

Functional magnetic resonance imaging (fMRI) and positron emission tomography (PET) can reveal active brain areas. PET takes advantage of the unique characteristic of positron-emitting radio topes (Metter & Hanson, 1994). During the uptake period given by the half-life of the isotope, the subject works on a task given by the experimenter. Then the subject is placed in a ring of sensors that measure the by-products of the decay of the radioactive isotopes. The idea is that areas of the brain that are active will use more glucose, and hence become more radioactive than less active brain areas. The data are accumulated for the entire brain by sections or slices. MRI produces a picture of any structure showing differences in tissue density. It is based on the principle that hydrogen atoms behave similar to spinning bar magnets in the presence of a magnetic field. When the magnetic field is turned off and a pulse of radiation is beamed across the atoms, they emit detectable radio waves that are characteristic of their density and chemical environment. MRI can be used to assess task related changes in blood oxygenation, which yields an fMRI (Binder & Rao, 1994).

In recent years, fMRI has become the method of choice because it has excellent spatial resolution and subjects are not exposed to radiation. However, a major problem derives from the so-called subtraction technique that is used for determining areas of high activity for a particular task. Numerous t-tests are performed to identify significant differences in the pixels of a pair of images. If the significance levels are not adjusted to compensate for the number of tests performed, errors of statistical inference could occur. Another problem is that fMRI, and especially PET, are rather expensive techniques that restrict the sample size to less than 10 per group, thus rendering questionable the reliability of statistical inferences made. Further, the low temporal resolution of PET and fMRI is inappropriate for investigating brain activity during the solution of simple tasks, when the involved cognitive processes are in the range of milliseconds (Wirth et al., 2007).

Another brain imaging technique is near-infrared spectroscopy (NIRS), an optical technique that can noninvasively measure changes in the state of hemoglobin oxygenation in the human brain. NIRS is based on the principle that near-infrared light is absorbed by oxygenated (oxyHb) and deoxygenated hemoglobin (deoxyHb) but not so much by other tissues. When a certain brain region becomes activated, oxyHb increases due to the dilation of the blood vessels and the acceleration of cerebral blood velocity. Simultaneously, deoxyHb decreases because the increase in cerebral blood volume is larger than that of the oxygen consumption in the activated region. Although the spatial resolution of NIRS is inferior to those of other functional neuroimaging methodologies such as PET and fMRI, NIRS has a high time resolution of less than 0.01 s, and subjects can be scanned under natural conditions. The recent trend in neuroimaging consists in combining methods with high temporal resolution such as EEG or MEG and those having high spatial resolution such as fMRI.

ABILITY

The goal of understanding the relationship between brain activity and ability is fairly old. Almost two centuries ago, Gall (1825) claimed that gross anatomical features of the brain are related to personality traits, such as wit, causality, self-esteem, and many others. These phrenological inquiries gradually gave way to eloquent studies of brain-ability relationships. Since Pavlov (1949), brain function is understood to consist of distributed interactions between cortical regions united to perform a common cognitive task. This approach provides the conceptual framework that is the basis for most modern neuroimaging studies of intelligence, problem solving, and reasoning (Jung & Haier, 2007).

Intelligence

Intelligence represents the individual's overall level of intellectual ability. It serves as a general concept that includes several groups of mental abilities. One of the most influential divisions of intelligence splits it into verbal, performance, and social intelligence (Thorndike, 1920). In recent years, the term "social intelligence" has been replaced largely by *emotional intelligence* – the ability to recognize emotion, reason with emotion and emotion-related information, and process emotional information as part of general problem solving (Mayer, Caruso, & Salovey, 2000). Neurophysiological research has been mainly interested in the verbal and performance components of intelligence (Haier & Benbow, 1995; Jaušovec, 1996; Lutzenberger et al., 1992; Neubauer, Freudenthaler, & Pfurtscheller, 1995) and only recently has paid some attention to emotional intelligence (Jaušovec & Jaušovec, 2004a, 2005; Jaušovec, Jaušovec, & Gerlič, 2001). Most of these studies demonstrated a negative correlation between brain activity under cognitive load and intelligence. These findings were explained by means of the efficiency theory. Efficiency may derive from the non-use of many brain areas irrelevant for good task performance as well as from the more focused use of specific task-relevant areas in highly intelligent individuals. It has even been suggested that individuals with high and low intelligence preferentially activate different neural circuits even when no reasoning or problem solving were required (Haier, White, & Alkire, 2003). Some studies showed a specific topographic pattern of differences related to the level of intelligence. High-ability subjects made relatively greater use of parietal regions, whereas low-ability subjects relied more exclusively on frontal regions (Gevins & Smith, 2000; Jaušovec & Jaušovec, 2004a). More generally, these results suggest that higher-ability subjects tend to better identify strategies needed for the solution of the task at hand. It was further reported that individuals with high intelligence displayed more brain activity in the early stages of task performance; those with average intelligence showed a reverse pattern. This temporal distribution of brain activity suggests that cognitive processes are faster in highly intelligent individuals than in those with average intelligence (Jaušovec & Jaušovec, 2004b).

A second line of research focuses on structural correlates of human intelligence, attempting to answer the question: "Where in the brain is intelligence located?" This body of research has recently been synthesized by Jung and

Haier (2007) in the form of their so-called parieto-frontal integration (P-FIT) model of intelligence. In reviewing 37 neuroimaging studies, referring mostly to structural correlates of intelligence, they tried to answer the question of how the anatomical aspects of gray matter and white matter relate topographically to intelligence. In greater detail, the P-FIT model can be summarized as follows:

- Humans gather and process cognitively salient information predominantly through auditory and/or visual means; therefore, particular brain regions within the temporal and occipital lobes are critical for early processing of sensory information.
- This basic sensory/perceptual processing is then fed forward to the parietal cortex, wherein structural symbolism, abstraction, and elaboration emerge.
- The parietal cortex interacts with frontal regions that serve to test various solutions to a given problem. Once the best solution is reached, the anterior cingulate is engaged to constrain response selection as well as inhibit other competing responses.
- This process is dependent upon the fidelity of underlying white matter necessary to facilitate rapid and error-free transmission of data from posterior to frontal brain regions.

Emotional Intelligence

Only recently has neurophysiological research paid some attention to emotional intelligence. In our lab, we have conducted several studies investigating mainly individual differences in brain functioning related to the level of emotional intelligence.

In our first two studies (Jaušovec et al., 2001; Jaušovec & Jaušovec, 2005), we compared high and average to below-average emotionally intelligent students when they were solving items from an emotional intelligence test. In this task, the respondents had to mentally determine how much each feeling (happiness, sadness, fear, surprise, etc.) is expressed by the presented face or picture. In both studies, respondents in the alpha band displayed brain activity patterns that were in line with the neural efficiency theory. Similar findings were also reported by Freudenthaler, Fink, and Neubauer (2006). On the other hand, the pattern of ERD/ERS in the induced gamma band (Jaušovec & Jaušovec, 2005) was contrary to what would be predicted by the neural efficiency theory: the subjects high in emotional intelligence displayed induced gamma band ERS; those of average emotional intelligence displayed induced gamma band ERD. The difference increased from stimulus onset until 4000 ms. A possible explanation for the findings could be that the individuals high in emotional intelligence identified emotions in faces by relying more on figural and less on semantic information provided by the displayed pictures. This would account for the increased ERS in the induced gamma band and the decreased ERD in the induced upper alpha band manifested by the group high in emotional intelligence. It could be hypothesized that the group average in emotional intelligence would apply a reverse strategy – being more semantically and less figurally oriented.

Creativity

Researchers investigating the relationship between creativity and brain function have been most attracted by hemisphericity. From a theoretical point of view, this is a reasonable inference. Several authors have recognized the importance of conceiving two or more opposites for the creative process. Rothenberg (1983) used the term "Janusian process" to denote the simultaneous conceptualization of opposite or antithetical ideas; Koestler (1967) proposed the term "bisociation," which describes the creative process as an act of combining unrelated structures, separate ideas, facts, and frames of perception within a single brain. Therefore, two hemispheres representing two distinct modes of cognitive processing seemed the ideal neurological explanation of creativity. Still another characteristic in the creative process – the phases of incubation and illumination, where attention to the problem is defocused and later followed by the spontaneous appearance of solutions to problems – gave rise to speculations that creativity is related to the nonspeaking right hemisphere.

Two concepts relating creativity to hemisphericity were proposed. According to the first, creativity was regarded mainly as a right-hemispheric process (Gowan, 1979); according to the second, as an alternation between left- and right-hemisphere modes of processing (Bogen & Bogen, 1969; Torrance, 1982). Moderate research support exists for the relationship between hemisphericity and creativity. Martindale and colleagues (1984) found that the relationship between creativity and right-hemispheric activation is not a general one. A difference between more and less creative respondents was observed during creative production, but not during basal recordings or during a reading task.

Recently, the idea of a right-hemisphere advantage in highly gifted individuals has gained new theoretical support. Giftedness is seen as a kind of left-hemisphere pathology. This speculation is supported by several research findings and opinions. Gazzaniga (1985) explained individual differences in intelligence by means of the negative environmental influence on our brain. Cranberg and Albert (1988) argued that there are three characteristics shared by gifted chess players such as Fischer and Capablanca, composers such as Mozart and Rossini, and mathematicians such as Gauss. First, all of them had profound, original insights as preadolescents; second, all three domains – chess, music, and mathematics – are dominated by males; and third all three domains involve highly nonverbal capacities. The hormonal theory of Geschwind (Geschwind & Galaburda, 1987) could account for some of the characteristics displayed by gifted individuals. According to this theory, the presence of intrauterine testosterone produced by the developing male fetus slows the development of the left hemisphere, which leads to compensatory enhanced development of the right hemisphere. In females, no such compensatory process is necessary. In a series of experiments, Benbow (1986, 1988) established a link between extreme intellectual precocity and left-handedness, immune disorders, and myopia, each of which may be considered a by-product of advantaged right-hemispheric development. In an EEG study, these findings could be only partly replicated (O'Boyle, Alexander, & Benbow, 1991). At baseline, the left hemisphere of the mathematically gifted group was more active, and not the right, as predicted. During mental activity on a nonverbal task, a significant reduction of alpha power over the right hemisphere was found in the mathematically gifted group; no such alpha suppression was found in the group of average individuals. On the verbal task, no significant difference in alpha suppression between the two groups of individuals was found. Similar findings were reported by O'Boyle, Benbow, and Alexander (1995) and Jaušovec (1997).

Valuable insights about possible brain correlates of creative thinking have been revealed by recent EEG studies that contrasted brain activity patterns during convergent versus divergent modes of thinking. Mölle et al. (1999) reported higher EEG complexity during the performance of more free-associative types of tasks, which could be the result of a larger number of independently oscillating neural assemblies during this type of thinking. Similarly, Jaušovec and Jaušovec (2000) as well as Razoumnikova (2000) reported findings that also indicate that convergent and divergent thinking are accompanied by different activity patterns in the EEG. Taken together, neuroscientific studies on creativity have shown that EEG activity in the alpha frequency band was particularly sensitive to creativity-related task demands (e.g., Bechtereva et al., 2004; Fink et al., 2007; Jaušovec & Jaušovec, 2000; Jung-Beeman et al., 2004; Razoumnikova, 2007). In general, a higher level of alpha synchronization was observed in individuals high in creativity as compared to less creative individuals. A similar pattern of neuroelectric activity was observed during the production of more original ideas, which corresponds to the subjective experience of insight or "a-ha."

LEARNING

The best currently accepted idea about how information is stored in the nervous system is based on the concept of the cell assembly, and what is now called the Hebb synapse (Hebb, 1949). The Hebb synapse is a model synapse with a rule that simultaneous presynaptic and postsynaptic activity increases synaptic efficacy. The cell assembly is a sort of irregular three-dimensional net of units connected to each other in a closed loop that reactivates itself repeatedly. This recurrent connectivity and reverbatory activity keeps the cell assembly active, allowing a newly formed assembly to retain information. Therefore, cell assemblies are acquired, dependent on learning and developmental experience. They are stored in a distributive way in the cerebral cortex, and are built from neural building-blocks processes, described in Hebb's neurophysiological postulate. Hebb synapses generate cell assemblies. At a superordinate level, in line with Hebb's hierarchical scheme, cell assemblies can be linked together associatively to form phase sequences. These constitute the neural bases for higher-order percepts and concepts – the brain's realization of thoughts. Changes in the synapses resulting from the simultaneous (or near-simultaneous) activation of the neurons that form them is generally thought to be the basis for all changes in behavior due to experiences, including those that involve learning. Hebb's (1949) notion of the cell assembly was based on evidence suggesting that memory is a time-dependent process, so that it can be influenced in different stages. Priming refers to the facilitative effect of performing one task on the subsequent performance of the same or similar tasks; whereas consolidation refers to the post-training period during which the hypothesized process of synaptic change occurs and transforms from a labile state into a more permanent one. There is also evidence that certain post-training treatments can modulate memory storage in a way that enhances retention.

A recent study in our lab investigated the impact of Mozart's music on brain activity in the process of learning – priming and memory consolidation (Jaušovec, Jaušovec, and Gerlič, 2006). It was shown that music had a beneficial influence on both learning stages; however, physiological differences in EEG patterns were observed only in groups that had been exposed to Mozart's music prior to and after learning. The displayed pattern of brain activity was lower alpha and gamma-approximated entropy, which is a measure of low deterministic chaos, more alpha and gamma-band-event related to synchronization. The respondents who listened to Mozart's music prior to and after learning manifested a pattern of brain activity similar to that reported in studies investigating neurophysiological differences in brain activity related to verbal and performance components of intelligence. A similar finding was reported by Haier and colleagues (1992). A PET study revealed a decrease in glucose metabolic rate in a group of respondents after learning the computer game Tetris.

The concept of plasticity – both neural and cognitive – lies at the heart of learning across the lifespan. Plasticity of the nervous system denotes developmental changes in synaptic density and pruning, and plays the key role in cell loss and the growth and myelination of white matter. It allows for learning and environmental adaptation, and is greatest in childhood (Craik, 2006). One of many interesting points is the fact that synaptic density peaks in the frontal cortex at the age of four years. Notably, Tulving (2005) suggested that true episodic memory and self-awareness do not develop until that same age. However, there is also evidence that there is some plasticity and fine-tuning that continue across the lifespan. Maguire et al. (2000) found that in London taxi drivers, the posterior region of the hippocampus is much larger than in the rest of population, whereas the front region is much smaller. One important role of the hippocampus is to facilitate spatial memory in the form of navigation. There is also preliminary evidence that extensive practice of intellectual skills is associated with higher performance on some cognitive tasks. For example, Bialystok et al. (2004) showed that lifelong bilinguals display an advantage over monolinguals on simple tasks requiring inhibitory control. Such differences could point to anatomical change in a healthy adult brain due to learning.

PERSONALITY

Hans Eysenck and Jeffrey Gray have been among the foremost exponents of the hypothesis that personality traits provide a window on individual differences in brain functioning. Eysenck (Eysenck & Eysenck, 1985) identified two key components of his conceptual nervous system: reticulo-cortical and reticulo-limbic circuits. The reticulo-cortical circuit controls the cortical arousal generated by incoming stimuli, whereas the reticulo-limbic circuit controls response to emotional stimuli. Extraversion-introversion (E) relates to arousability of the reticulo-cortical circuit, so that introverts are typically more aroused than extraverts. However, methodological analyses of extraversion studies (Gale, 1973) have illuminated two basic problems for testing this theory. The first problem is that people actively seek a moderate level of arousal; therefore, the relationship between extraversion and arousal may also reflect individual differences in strategies for seeking or avoiding stimulation. Second, according to Eysenck (1994), increasing stimulation provokes increasing central nervous system reactivity until an optimal point is reached, beyond which inhibition and decreasing reactivity set in. Hence, introverts may have an arousal level higher, lower, or equal to that of extraverts, due to complex interactions of personality type and environmental manipulation.

Neuroticism (N) was explained in terms of activation thresholds in the sympathetic nervous system or visceral brain (the limbic system). Individuals with higher scores in neuroticism had greater activation levels and lower thresholds within subcortical structures (Eysenck, 1990)

There exist several reviews of the relationship between raw EEG measures and E (Gale, 1983; O'Gorman, 1984; Zuckerman et al., 1991; Eysenck, 1994; Matthews & Gilliland, 1999). According to Gale, several studies supported the hypothesis that introverts are higher in cortical arousal than extraverts. However, a similar number of studies found no differences, and three studies found results that contradicted the theory. Gale argued that moderate arousal-inducing environments were the most amenable to testing the predictions of Eysenck's theory. Low arousal-inducing environments resulted in paradoxical arousal, especially in extraverts; high arousal-inducing environments (e.g., task-performance demands) resulted in possible over-arousal, again especially in extraverts. Several recent studies (Fink, Schrausser, & Neubauer, 2002; Fink & Neubauer, 2004) lend some support to Gale's theory. On the other hand, Matthews and Gilliland (1999) and Zuckerman et al. (1991) have been less enthusiastic about the level of support that previous EEG studies provided for the cortical arousal hypothesis of extraversion. Yet, Zuckerman et al. (1991) pointed out that studies using female subjects or equal numbers of both genders seem more often to support Eysenck's theory than those relying on male subjects.

There have been a few more recent studies that are noteworthy in this context. Matthews and Amelang (1993) reported significant correlations between personality and EEG measures that were low in magnitude (i.e., not exceeding 0.20) but on the whole matched expectations. Smith et al. (1995) reported that introverts were generally found to produce lower levels of alpha activity reflecting higher levels of arousal, showing a hemisphere by gender interaction effect. Schmidtke and Heller (2004) found that neuroticism was associated with greater relative right posterior activity, whereas predicted effects for neuroticism with frontal regions and extraversion with brain activity were not significant. Gale et al. (2001) found that extraverts were less cortically aroused than introverts, and that neuroticism was associated with larger left versus right hemisphere differences in alpha-wave activity related to mood. Tran, Craig, and McIsaac (2001) showed extraverted persons to be at least three times more likely to have larger peak amplitudes in frontal alpha-wave activity. However, they found no association between extraversion and alpha activity in posterior regions, and no alpha-wave activity differences were found between those with high and low anxiety levels.

Gray's personality theory began as a modification of Eysenck's theory, but is now usually seen as an alternative theory (Gray, 1991). Gray has proposed two major neurological systems: the behavioral inhibition system (BIS) and the behavioral activation system (BAS). The BIS is sensitive to signals of punishment and frustrating non-reward promoting avoidance behavior, whereas the BAS is sensitive to signals of reward and matches approach behavior. These two brain systems underlie the personality dimensions of anxiety (neurotic introversion) and impulsiveness (neurotic extraversion). Research by Knyazev (Knyazev, Slobodskaya, & Wilson, 2002; Knyazev et al., 2003) revealed that BAS was positively related to delta and negatively to alpha power measures, whereas the BIS showed an opposite pattern of correlations. These findings suggest higher arousal in subjects high on BIS and neuroticism, and lower arousal in subjects high on BAS and extraversion.

From a psychometric perspective, there has been a growing acceptance of a five-factor model of personality (FFM), incorporating two of Eysenck's dimensions, E and N, together with Openness to Experience (O), Agreeableness (A), and Conscientiousness (C). Despite the growing acceptance of the FFM of personality, there have been very few studies that examined the biological basis of O, A, and C. In a preliminary study, Stough (Stough et al., 2001) showed that individuals with higher scores in O tend to have a greater amount of theta production. Because theta activity decreases with age, the interpretation of the authors was that respondents high on O may have retained a somewhat childlike wonderment and open-mindedness about their world, coupled with a willingness to explore alternative views about issues. In a recent large-scale study, Tran and colleagues (Tran et al., 2006) found only mild significant correlations in the delta and theta band with E and C, and few associations between personality and faster frequency bands.

GENDER DIFFERENCES

Gender-based differences in performance have been reported for complex and simple cognitive tasks. Probably one of the first written accounts for female superiority in verbal ability is found in an ancient Sanskrit book, suggesting that nine shares of talk were given to women and one to men (Nyborg, 1994). However, more recent systematic analyses suggest that females surpass males in some but not necessarily all domains of verbal ability (Halpern, 2004). Specifically, women seem to have an advantage in episodic memory tasks where verbal processing is required or can be used as well as in verbal fluency (Maitland et al., 2004). Further, it was found that females surpass males in tests of emotional intelligence (Mayer et al., 2000; Mayer, Salovey, & Caruso, 2002). It is also proposed that in selective attention tasks, female subjects' processing entails more detailed elaboration of information content than that of males (Myers-Levy & Maheswaran, 1991), and that female subjects are more efficient in recognizing faces and facial expressions (Hampson, van Anders, & Mullin, 2005). Female superiority in perceptual speed – namely, the ability to rapidly absorb the details of a visual stimulus – has been recognized since the 1940s (e.g., Kimura, 1999). On the other hand, men typically demonstrate a distinct advantage in a broad range of visual tasks, including visual-spatial orientation. A meta-analysis of studies published prior to 1973 found an average difference of about one-half of a standard deviation in favor of males on tests of visuospatial ability (Hyde, 1981). Factor analytic studies showed that spatial ability is not a unitary process, and can be divided into three categories: spatial perception, mental rotation, and spatial visualization (Linn & Peterson, 1985). Most pronounced gender differences of nearly one standard deviation have been reported mainly for mental rotation tasks (Mackintosh & Bennett, 2005).

Differences in brain activity between the genders have been observed when respondents were solving complex and simple cognitive tasks. Some recent EEG studies relating intelligence with brain activity under cognitive load showed that when males are engaged in solving numerical and figural tasks, they are more likely to produce cortical activation patterns that are in line with the neural efficiency hypothesis (e.g., less activation in brighter individuals), whereas in females, for the same tasks no significant differences were reported (Neubauer, Fink, & Schrausser, 2002; Neubauer et al., 2005). Similar gender-related differences as those reported for intelligence could also be observed in regard to creative problem solving (Fink & Neubauer, 2006) and emotional intelligence (Jaušovec & Jaušovec, 2008). Perhaps the most important finding of these studies was that the inverse intelligence-activation relationship (i.e., neural efficiency) appears to be moderated by task content and the individuals' gender. Males and females displayed the expected inverse IQ–activation relationship in precisely that domain in which they usually perform better: females in the verbal and emotional-intelligence domain and males in the visuospatial-ability domain.

Further empirical evidence favoring gender differences in physiological parameters of cortical activation in the course of solving more complex tasks also comes from PET, fMRI, and functional near-infrared spectroscopy (fNIRS). It was found that for figural tasks, males show significantly stronger parietal activation and females show significantly greater frontal activation (Weiss et al., 2003). A similar greater left-frontal brain activation in females than in men was observed in relation to verbal-intelligence scores (Pfleiderer et al., 2004). Nyberg, Habib, and Herlitz (2000) found gender differences in brain activation during memory retrieval; Haier and Benbow (1995) reported a positive relationship in glucose metabolic rate in temporal-lobe regions and mathematical reasoning ability only in men. A similar finding was also reported by Mansour, Haier, and Buchsbaum (1996). In a recent NIRS study (Kameyama et al., 2004), higher O2Hb during a verbal fluency task was observed for males as compared to females.

Gender-related differences employing the ERP methodology were investigated mainly for the P1-N1 complex and the P3 component. Numerous studies indicate that the P1-N1 complex reflects sensory and early attention processes (Luck & Girelli, 1999). There is some evidence that the P1 amplitude is associated with the suppression of irrelevant information, and the N1 with the processing of the attended relevant information. Thus, it was suggested that the P1 reflects inhibitory and the N1 excitatory processes (Klimesch et al., 2004, for review). The P3 represents the last phase in the identification of a relevant stimulus caused by its significance or the requirements of the task. As stressed by Kok (2001), the P3 amplitude is a reflection of the degree of matching between the presented stimulus and the internal representation of the stimulus relevant for the task.

Several studies demonstrated mixed gender-related effects on visually- and auditory-evoked potentials. Some found lower amplitudes in males or shorter latencies in females for early ERP components (Ehlers et al., 2001); others found both increased amplitude and decreased latency for the early components of the female ERP (Chu, 1987) or no gender-related differences in the early ERP latencies and amplitudes (Wirth et al., 2007; Roalf, Lowery, & Turetsky, 2006); and still others reported increased amplitudes in men (Vaquero et al., 2004) or increased amplitudes in women (Gootjes, 2007). Using both visual and auditory oddball tasks, Hoffman and Polich (1999) found that females have a larger P3 component than males. Findings pointing in the same direction were reported for semantic tasks (Wirth et al., 2007); for Kanji characters (Shen, 2005); for visual stimuli (Steffensen, 2008) and olfactory stimuli (Olofsson & Nardin, 2004). However, some studies contradict these findings by showing that there is no significant difference between male and female auditory P3 (Polich, 1986) or visual and auditory P3 (Shelton, Hartmann, & Allen, 2002). Still others reported that males have larger P3 amplitudes for spatial-attention tasks (Vaquero et al., 2004). A possible explanation for the diversity of the obtained results could be a methodological one (e.g., differences in tasks, type of responses required, time windows used, etc.). However, to our mind, the main shortcoming of the reported studies is that they did not control for possible differences in ability that might have biased the results. Research has shown that peak latencies as well as amplitudes correlate with IQ (e.g., Jaušovec & Jaušovec, 2000).

Recently, gender-related differences were reported also for the gamma response of the brain (Karakaş et al., 2006, Jaušovec & Jaušovec, 2009). There are two basic types of event-related gamma responses: late and early. The late gamma occurs in the 130–400 ms poststimulus time window, has an induced character, and is of special relevance in pattern perception or higher-order recognition processes (Karakaş & Başar, 1998). The early gamma response occurs within 150 ms poststimulus and is time locked to the stimulus. It is related to sensory processing and is basically a phenomenon of the sensory register (Karakaş et al., 2001). To our knowledge, there are only two studies that have investigated the gamma response in relation to gender. Karakaş and colleagues (2006) found no significant gender-related difference in the amplitude of the evoked-gamma response for an auditory oddball task. On the other hand, Jaušovec and Jaušovec (2009) found significant gender-related differences, which were only observed in the amplitudes of the early evoked-gamma response and the P3 component. Women displayed higher amplitudes than men. A second finding was that these differences were more pronounced for the visual than for the auditory stimuli. The NIRS data showed that males displayed a higher percentage of StO_2 in their frontal brain areas than females; and males also showed a higher increase in percent of StO_2 during task performance as compared with the resting condition. Taken all together, the results suggest that the females' visual event-categorization process is more efficient than males'.

SOME CONCLUDING REMARKS

Research into the brain-cognition relationship is characterized by mountains of data and weak theories. The theories are of rather low generality and explain only specific relationships. For instance, the efficiency theory explains only the brain-ability relationship; further, the explanation is adequate only when problem-solving tasks as opposed to memory tasks are involved. In addition, it has a gender-by-task bias. The fact that intelligence tests represent from a psychometric perspective the most reliable measures of human psychological characteristics renders biological explanations of other psychological characteristics, such as personality, even less promising.

Chapters in a book such as ours usually end with an optimistic prognosis, pointing to some promising imaging or modeling techniques that will enable a real breakthrough in understanding in the near future. In our opinion, it is more likely that we will just continue collecting data in rather specific domains of the brain-cognition-behavior relations. At first glance this may seem disappointing, but given the complex structure of human cognition and behavior, on the one hand, and the immense complexity of the neural system, on the other hand, it remains, probably, the only feasible endeavor.

References

Bechtereva, N. P., Korotkov, A. D., Pakhomov, S. V., Roudas, M. S., Starchenko, M. G., & Medvedev, S. V. (2004). PET study of brain maintenance of verbal creative activity. *International Journal of Psychophysiology*, **53**, 11–20.

Benbow, C. P. (1986). Physiological correlates of extreme intellectual precocity. *Neuropsychologia*, **24**, 719–725.

(1988). Sex differences in mathematical reasoning ability in intellectually talented preadolescents: Their nature, effects, and possible causes. *Behaviour and Brain Science*, **11**, 169–232.

Bialystok, E., Craik, F. I. M., Klein, R., & Viswanathan, M. (2004). Bilingualism, aging, and cognitive control: evidence from the Simon task. *Psychology & Aging*, **19**, 290–303.

Binder, R. J., & Rao, S. M. (1994). Human barin mapping with functional magnetic resonance imaging. In A. Kertesz (Ed.), *Localization and neuroimaging in neuropsychology* (pp.185–212). San Diego: Academic Press.

Bogen, J., & Bogen, G. (1969). The other side of the brain: III. The corpus callosum and creativity. *Bulletin of the Los Angeles Neurological Society*, **34**, 191–220.

Braitenberg, V., & Schutz, A. (1991). *Anatomy of the cortex. Statistics and geometry.* New York: Springer-Verlag.

Bullock, T. H. (1980). Reassessment of neural connectivity and its specification. In H. M. Pinsker and W. D. Willis (Ed.), *Information processing in the nervous system* (pp. 119–220). New York: Raven Press.

Chu, N. S. (1987). Pattern-reversal visual evoked potentials: Latency changes with gender and age. *Clinical Electroencephalography*, **18**, 159–162.

Craik, F. I. M. (2006). Brain–behavior relations across the lifespan: A commentary. *Neuroscience and Biobehavioral Reviews*, **30**, 885–892.

Cranberg, L. D., & Albert, M. L. (1988). The chess mind. In L. K. Obler & D. Fein (Ed.), *The exceptional brain* (pp. 156–190). New York: The Guilford Press.

Detterman, D. K. (1994). Intelligence and the brain. In P. A. Vernon (Ed.), *The neuropsychology of individual differences* (pp. 35–57). London: Academic Press INC.

Eccles, J. & Robinson, D. N. (1984). *The wonder of being human: Our brain and our mind.* New York: The Free Press.

Ehlers, C. L., Wall, T. L., Garcia-Andrade, C., & Phillips, E. (2001). Auditory P3 findings in mission Indian youth. *Journal of Studies on Alcohol & Drugs*, **62**, 562–570.

Eysenck, H. J. (1990). Biological dimensions of personality. In L. A. Pervin (Ed.), *Handbook of personality: theory and research* (pp. 244–270). New York: Guilford Press.

(1994). Personality: Biological foundations. In P. A. Vernon (Ed.), *The neuropsychology of individual differences.* London: Academic Press.

Eysenck, H. J., & Eysenck, M. W. (1985). *Personality and individual differences.* New York: Plenum.

Fink, A., Benedek, M., Staudt, B., & Neubauer, A. C. (2007). Creativity meets neuroscience: Experimental tasks for the neuroscientific study of creative thinking. *Methods*, **42**, 67–75.

Fink, A., & Neubauer, A. C. (2004). Extraversion and cortical activation: Effects of task complexity. *Personality & Individual Differences*, **36**, 333–347.

Fink A., & Neubauer, A. C. (2006). EEG alpha oscillations during the performance of verbal creativity tasks: Differential effects of sex and verbal intelligence. *International Journal of Psychophysiology*, **62**, 46–53.

Fink, A., Schrausser, D. G., & Neubauer, A. C. (2002). The moderating influence of extraversion on the relationship between IQ and cortical activation. *Personality & Individual Differences*, **33**, 311–326.

Freudenthaler, H. H., Fink, A., & Neubauer, A. C. (2006). Emotional abilities and cortical activation during emotional information processing. *Personality and Individual Differences*, **41**, 685–695.

Friston, K. (2003). Learning and inference in the brain. *Neural Netw.* **16**, 1325–1352.

Gale, A. (1973). The psychophysiology of individual differences: studies of extraversion and the EEG. In P. Kline (Ed.), *New approaches in psychological measurement* (pp. 211–256). London: Wiley.

(1983). Electroencephalographic studies of extraversion-introversion: A case study in the psychophysiology of individual differences. *Personality & Individual Differences*, **4**, 371–380.

Gale, A., Edwards, J. A., Morris, P., Moore, R., & Forrester, D. (2001). Extraversion–introversion, neuroticism-stability, and EEG indicators of positive and negative empathic mood. *Personality & Individual Differences* **30**, 449–461.

Gall, F. J. (1825). *Sur les fonctions du cerveau et sur celles de chacune de ses parties.* [*On the Functions of the Brain and Each of Its Parts*] Paris: Bailliere.

Gazzaniga, M. S. (1985). *The social brain.* New York: Basic Books, Inc., Publishers.

Geschwind, N. A., & Galaburda, A. M. (1987). *Cerebral lateralization.* Cambridge, MA: MIT Press.

Gevins, A., & Smith, M. E. (2000). Neurophysiological measures of working memory and individual differences in cognitive ability and cognitive style. *Cerebral Cortex*, **10**, 830–839.

Gootjes, L., Bruggeling, E. C., Magneé, T., & Van Strien, J. W. (2007). Sex differences in the latency of the late event-related potential mental rotation effect. *Neuroreport*, **19**, 349–353.

Gowan, J. C. (1979). The production of creativity through right hemisphere imagery. *Journal of Creative Behavior*, **13**, 39–51.

Gray, J. A. (1991). Neural systems, emotion and personality. In J. Madden IV (Ed.), *Neurobiology of learning, emotion and affect* (pp. 273–306). New York: Raven Press.

Haier, R. J., & Benbow, C. P. (1995). Sex differences and lateralization in temporal lobe glucose metabolism during mathematical reasoning. *Developmental Neuropsychology*, **4**, 405–414.

Haier, R. J., Siegel, B., Tang, C., Abel, L., & Buchsbaum, M. S. (1992). Intelligence and changes in regional cerebral glucose mezabolic rate following learning. *Intelligence*, **16**, 415–426.

Haier, R. J., White, N. S., & Alkire, M. T. (2003). Individual differences in general intelligence correlate with brain function during nonreasoning tasks. *Intelligence*, **31**, 429–441.

Halpern, D. F. (2004). A cognitive-process taxonomy for sex differences in cognitive abilities. *Current Directions in Psychological Science*, **13**, 135–139.

Hampson, E., van Anders, S. M., & Mullin, L. I. (2005). A female advantage in the recognition of emotional facial expressions: test of an evolutionary hypothesis. *Evolution & Human Behavior*, **27**, 401–416.

Hebb, D. O. (1949). *Organization of behavior*. New York: John Wiley.

Hoffman, L., & Polich, J. (1999). P300, handedness, and corpus callosal size: Gender, modality, and task. *International Journal of Psychophysiology*, **31**, 163–174.

Hyde, J. S. (1981). How large are cognitive gender differences? *American Psychologist*, **36**, 892–901.

Jaušovec, N. (1996). Differences in EEG alpha activity related to giftedness. *Intelligence*, **23**, 159–173.

(1997). Differences in EEG alpha activity between gifted and non-identified individuals: Insights into problem solving. *Gifted Child Quarterly*, **1**, 26–32.

Jaušovec, N., & Jaušovec, K. (2000). Correlations between ERP parameters and intelligence: a reconsideration. *Biological Psychology*, **50**, 137–154.

(2004a). Intelligence related differences in induced brain activity during the performance of memory tasks. *Personality and Individual Differences*, **36**, 597–612.

(2004b). Differences in induced brain activity during the performance of learning and working-memory tasks related to intelligence. *Brain & Cognition*, **54**, 65–74.

(2005). Differences in induced gamma and upper alpha oscillations in the human brain related to verbal/performance and emotional intelligence. *International Journal of Psychophysiology*, **56**, 223–235.

(2008). Spatial-rotation and recognizing emotions: Gender related differences in brain activity. *Intelligence*, **36**, 383–393.

(2009). Do women see things differently than men do? *NeuroImage*, **45**, 198–207.

Jaušovec, N., Jaušovec, K., & Gerlič, I. (2001). Differences in event related and induced EEG patterns in the theta and alpha frequency bands related to human emotional intelligence. *Neuroscience Letters*, **311**, 93–96.

(2006). The influence of Mozart's music on brain activity in the process of learning. *Clinical Neurophysiology*, **117**, 2703–2714.

Jung, R. E., & Haier, R. J. (2007). The Parieto-Frontal Integration Theory (P-FIT) of intelligence: Converging neuroimaging evidence. *Behavioral and Brain Sciences*, **30**, 135–187.

Jung-Beeman, M., Bowden, E. M., Haberman, J., Frymiare, J. L., Arambel-Liu, S., Greenblatt, R., Reber, P. J., & Kounios, J. (2004). Neural activity when people solve verbal problems with insight. *PLOS Biology*, **2**, 500–510.

Kameyama, M., Fukuda, M., Uehara, T., & Mikuni, M. (2004). Sex and age dependencies of cerebral blood volume changes during cognitive activation: a multi-channel near-infrared spectroscopy study. *NeuroImage* **22**, 1715–1721.

Karakaş, S., & Başar, E. (1998). Early gamma response is sensory in origin: a conclusion based on cross-comparison of results from multiple experimental paradigms. *International Journal of Psychophysiology*, **31**, 13–31.

Karakaş, S., Başar, E., Özesmi, Ç., Kafadar, H., & Erzengin, Ö. U. (2001). Gamma response of the brain: a multifunctional oscillation that represents bottom-up with top-down processing. *International Journal of Psychophysiology*, **39**, 137–150.

Karakaş, S., Tüfekçi, İ., Bekçi, B., Çakmak, E. D., Doğutepe, E., Erzengin, Ö. U., Özkan, A., & Arikan, O. (2006). Early time-locked gamma response and gender specificity. *International Journal of Psychophysiology*, **60**, 225–239.

Kimura, D. (1999). *Sex and cognition*. Cambridge, MA: The MIT Press.

Klimesch, W., Doppelmayr, M., Schimke, H., & Ripper, B. (1997). Theta synchronization and alpha desynchronization in a memory task. *Psychophysiology*, **34**, 169–176.

Klimesch, W., Schabus, M., Doppelmayr, M., Gruber, W., & Sauseng, P. (2004). Evoked oscillations and early components of event-related potentials: an analysis. *International Journal of Bifurcation & Chaos*, **14**, 705–718.

Klimesch, W., Schimke, H., & Pfurtscheller, G. (1993). Alpha frequency, cognitive load and memory performance. *Brain Topography*, **5**, 1–11.

Knyazev, G. G., Slobodskaya, H. R., Safronova, M. V., Sorokin, O. V., Goodman, R., & Wilson, G. D. (2003). Personality, psychopathology and brain oscillations. *Personality & Individual Differences*, **35**, 1331–1349.

Knyazev, G. G., Slobodskaya, H. R., & Wilson, G. D. (2002). Psychophysiological correlates of behavioural inhibition and activation. *Personality & Individual Differences*, **33**, 647–660.

Koestler, A. (1967). *The ghost in the machine.* New York: Macmillan.

Kok, A. (2001). On the utility of P3 amplitude as a measure of processing capacity. *Psychophysiology*, **38**, 567–577.

Linn, M. C., & Peterson, A. C. (1985). Emergence and characterization of sex differences in spatial ability: A meta-analysis. *Child Development*, **56**, 1479–1498.

Luck, S. J., & Girelli, M. (1999). Electrophysiological approaches to the study of selective attention in the human brain. In R. Parasuraman (Ed.), *The Attentive Brain* (pp. 71–94). Cambridge, MA: MIT Press.

Lutzenberger, W., Birbaumer, N., Flor, H., Rockstroh, B., & Elbert, T. (1992). Dimensional analysis of the human EEG and intelligence. *Neuroscience Letters*, **143**, 10–14.

Mackintosh, N. J., & Bennett, E. S. (2005). What do Raven's matrices measure? An analysis in terms of sex differences. *Intelligence*, **33**, 663–664.

Maguire, E. A., Gadian, D. G., Johnsrude, I. S., Good, C. D., Ashburner, J., Frackowiak, R. S. J., & Frith, C. D. (2000). Navigation-related structural change in the hippocampi of taxi drivers. *Proceedings of the National Academy of Sciences USA*, **97**, 4398–4403.

Maitland, S. B., Herlitz, A., Nyberg, L., Backman, L., & Nilsson, L.G. (2004). Selective sex differences in declarative memory. *Memory & Cognition*, **32**, 1160–1169.

Mansour, C. S., Haier, R. J., & Buchsbaum, M. S. (1996). Gender comparison of cerebral glucose metabolic rate in healthy adults during a cognitive task. *Personality and Individual Differences*, **20**, 183–191.

Martindale, C., Hines, D., Mitchell, L., & Covello, E. (1984). EEG alpha asymmetry and creativity. *Personality & Individual Differences*, **5**, 77–86.

Matthews, G., & Amelang, M. (1993). Extraversion, arousal theory and performance: a study of individual differences in the EEG. *Personality & Individual Differences*, **14**, 347–363.

Matthews, G., & Gilliland, K. (1999). The personality theories of H. J. Eysenck and J. A. Gray: a comparative review. *Personality & Individual Differences*, **26**, 583–626.

Mayer, J. D., Caruso, D. R., & Salovey, P. (2000). Emotional intelligence meets traditional standards for an intelligence. *Intelligence*, **27**, 267–298.

Mayer, J. D., Salovey, P., & Caruso, D. R. (2002). *Mayer-Salovey-Caruso emotional intelligence test (MSCEIT).* Toronto: MHS.

Metter, E. J., & Hanson, W. R. (1994). Use of positron emition tomography to study aphasia. In Kertesz (Ed.), *Localization and neuroimaging in neuropsychology* (pp.123–149). San Diego: Academic Press.

Michel, C. M., Thut, G., Morand, S., Khateb, A., Pegna, A. J., Grave, P., Gonzalez, S., Seeck, M., & Landis, T. (2001). Electric source imaging of human brain functions. *Brain Research Brain Research Review*, **36**, 108–118.

Mölle, M., Marshall, L., Wolf, B., Fehm, H., & Born, J. (1999). EEG complexity and performance measures of creative thinking. *Psychophysiology*, **36**, 95–104.

Mountcastle, V. B., (1975). The view from within: Pathways to the study of perception. *Johns Hopkins Medical Journal*, **136**, 109–131.

Myers-Levy, J., & Maheswaran, D. (1991). Exploring differences in males and females processing strategies. *Journal of Consumer Research*, **18**, 63–70.

Neubauer, A. C., Fink, A., & Schrausser, D. G. (2002). Intelligence and neural efficiency: The influence of task content and sex on the brain – IQ relationship. *Intelligence*, **30**, 515–536.

Neubauer, A. C., Grabner, R. H., Fink, A., & Neuper, C. (2005). Intelligence and neural efficiency: further evidence of the influence of task content and sex on the brain–IQ relationship. *Cognition & Brain Research*, **25**, 217–225.

Neubauer, V., Freudenthaler, H. H., & Pfurtscheller, G. (1995). Intelligence and spatiotemporal patterns of event-related desynchronization. *Intelligence*, **3**, 249–266.

Nunez, P. L. (1995). Mind, brain, and electroencephalography. In P. L. Nunez (Ed.), *Neocortical dynamics and human EEG rhythms* (pp. 133–194). New York: Oxford University Press.

Nyberg, L., Habib, R., & Herlitz, A. (2000). Brain activation during episodic memory retrieval: sex differences. *Acta Psychologica*, **105**, 181–194.

Nyborg, H. (1994). The neuropsychology of sex-related differences in brain and specific abilities: Hormones, developmental dynamics and new paradigm. In P. A. Vernon (Ed.), *The neuropsychology of individual differences* (pp. 59–113). London: Academic Press.

O'Boyle, M. W., Alexander, J. E., & Benbow, C. P. (1991). Enhanced right hemisphere activation in the mathematically precocious: A preliminary EEG investigation. *Brain & Cognition*, **17**, 138–153.

O'Boyle, M. W., Benbow, C. P., & Alexander, J. E. (1995). Sex differences, hemispheric laterality, and associated brain activity in the intellectually gifted. *Developmental Neuropsychology*, **4**, 415–443.

O'Gorman, J. G. (1984). Extraversion and the EEG: I. An evaluation of Gale's hypothesis. *Biological Psychology*, **19**, 95–112.

Olofsson, J. K., & Nordin, S. (2004). Gender Differences in Chemosensory Perception and Event-related Potentials. *Chemical Senses*, **29**, 629–637.

Pascual-Marqui, R. D., Michel, C. M., Lehmann, D. (1994). Low resolution electromagnetic tomography: a new method for localizing electrical activity in the brain. *International Journal of Psychophysiology*, **18**, 49–65.

Pavlov, I. P. (1949). *Complete collected works*. Moscow, Izd.

Petsche, H. (1997). EEG coherence and mental activity. In F. Angeleri, S. Butler, S. Giaquinto, & J. Majakowski (Eds.), *Analysis of the electrical activity of the brain* (pp. 141–168). Chichester, UK: John Wiley & Sons Ltd.

Pfleiderer, B., Ohrmann, A. P., Suslow, B.T., Wolgast, B.M., Gerlach, B. A. L., Heindela, C. W., & Michael, N. (2004). N-acetylaspartate levels of left frontal cortex are associated with verbal intelligence in women but not in men: a proton magnetic resonance spectroscopy study. *Neuroscience*, **123**, 1053–1058.

Polich, J. (1986). Normal variation of P300 from auditory stimuli. *Electroencephalography & Clinical Neurophysiology*, **65**, 236–240.

Razoumnikova, O. M. (2000). Functional organization of different brain areas during convergent and divergent thinking: an EEG investigation. *Cognitive Brain Research*, **10**, 11–18.

(2007). Creativity related cortex activity in the remote associates task. *Brain Research Bulletin*, **73**, 96–102.

Roalf, D., Lowery, N., & Turetsky, B. I. (2006). Behavioral and physiological findings of gender differences in global-local visual processing. *Brain & Cognition*, **60**, 32–42.

Rothenberg, A. (1983). Psychopatology and creative cognition. *Archives of General Psychiatry*, **40**, 937–942.

Schmidtke, J. I., & Heller, W. (2004). Personality, affect and EEG: predicting patterns of regional brain activity related to extraversion and neuroticism. *Personality & Individual Differences*, **36**, 717–732.

Sejnovski, T. J., & Churchland, P. S. (1989). Brain and cognition. In M. I. Posner (Ed.), *Foundations of cognitive science* (pp. 301–358). Cambridge, MA: MIT Press.

Shelton, P. P., Hartmann, A. M., & Allen, J. (2002). Seasonal photoperiod, gender, and P300. *Bioogical Psychology*, **60**, 151–171.

Shen, X. (2005). Sex differences in perceptual processing: performance on the color-kanji stroop task of visual stimuli. *International Journal of Neuroscience*, **115**, 1631–1641.

Smith, B. D., Kline, R., Lindgren, K., Ferro, M., Smith, D. A., & Nespor, A. (1995). The lateralized processing of affect in emotion-ally labile extraverts and introverts: central and autonomic effects. *Biological Psychology*, **39**, 143–157.

Steffensen, Scott C., Ohran, A. J., Shipp, D. N., Hales, K., Stobbs, S. H., & Fleming, D. E. (2008). Gender-selective effects of the P300 and N400 components of the visual evoked potential. *Visual Research*, **48**, 917–925.

Stein, A., & Petsche, H. (1995). EEG synchronization seems to reflect functional properties of the underlying cortical networks in the human brain. *European Journal of Neuroscience*, **8**, 32–37.

Stough, C., Donaldson, C., Scarlata, B., & Ciorciari, J. (2001). Psychophysiological correlates of the NEO PI-R Openness, Agreeableness and Conscientiousness: preliminary results. *International Journal of Psychophysiology*, **41**, 87–91.

Szentagothai, J. (1979). Local neuron circuits of the neocortex. In F. O. Schmitt & F. G. Worden (Eds.), *The neurosciences 4th study program* (pp. 399–415). Cambridge, MA: MIT Press.

Thorndike, E. L. (1920). Intelligence and its use. *Harper's Magazine*, **140**, 227–235.

Torrance, E. P. (1982). Hemisphericity and creative functioning. *Journal of Research & Development in Education*, **3**, 29–37.

Tran, Y., Craig, A., Boord, P., Connell, K., Cooper, N., & Gordon, E. (2006). Personality traits and its associations with resting regional brain activity. *International Journal of Psychophysiology*, **60**, 215–224.

Tran, Y., Craig, A., & McIsaac, P. (2001). Extraversion–introversion and 8–13 Hz waves in frontal cortical regions. *Personality & Individual Differences*, **30**, 205–215.

Traub, R. D., Whittington, M. A., Buhl, E. H., Jefferys, J. G. R., & Faulkner, H. J. (1999).On the mechanisms of the $\gamma \rightarrow \beta$ frequency shift in neuronal oscillations induced in rat hippocampal slices by tetanic stimulation. *Journal of Neuroscience*, **19**, 1088–1105.

Tulving, E. (2005). Episodic memory and autonoesis: uniquely human? In H. S. Terrace & J. Metcalfe (Eds.), *The Missing link in cognition: Origins of self-reflective consciousness* (pp. 3–56). New York: Oxford University Press.

Vaquero, E., Cardoso, M. J., Vázquez, M., & Gómez, C. M., (2004). Gender differences in event-related potentials during visual-spatial attention. *International Journal of Neuroscience*, **114**, 541–557.

Weiss, E., Siedentopf, C. M., Hofer, A., Deisenhammer, E. A., Hoptman, M. J., Kremser, C., Golaszewski, S., Felber, S., & Fleischhacker, W. W. (2003). Sex differences in brain activation pattern during a visuospatial cognitive task: a functional magnetic resonance imaging study in healthy volunteers. *Neuroscience Letters*, **344**, 169–172.

Wirth, M., Horn, H., Koenig, K., Stein, M., Federspiel, A., Meier, B., Michel, C. M., & Strik, W. (2007). Sex differences in semantic processing: event-related brain potentials distinguish between lower and higher order semantic analysis during word reading. *Cerebral Cortex*, **17**, 1987–1997.

Zuckerman, M., Kuhlman, D. M., Joireman, J., Teta, P., & Kraft, M. (1993). A comparison of three structural models for personality: the big three, the big five, and the alternative five. *Journal of Personality & Social Psychology*, **4**, 757–768.

12

Physical Health and Cognition

Shulamith Kreitler, Kineret Weissler, & Frida Barak

INTRODUCTION

This chapter deals with the impact of physical health on cognition. There are several lines of research and thinking that support the conception that physical health may be an important factor affecting cognition. One line of research is represented by the body of studies showing that good health in adulthood manifested in longer life expectancy (Deary et al., 2004; Hart et al., 2003; Kuh et al., 2003; Osler et al., 2003), low prevalence of cardio-vascular disease (Batty et al., 2005), and low incidence of serious illness, at least in the 30–39 year age group (Martin et al., 2004), is associated with good mental ability (intelligence) during childhood. Martin et al. (2004) calculated that a lower level of serious disease by a third is correlated with a 15 points higher IQ. Further correlational studies show that straightforward indicators of health in early childhood, such as birth weight and height growth, are related positively to cognitive function in childhood, adolescence, and early adulthood as well as to educational attainment (Richards et al., 2001, 2002). The impact of physical state on cognition is however not limited to childhood. Cognitive ability at 18–20 years is also related to coronary health in middle age (Hemmingsson et al., 2007). Notably, early cognitive function is a major predictor of cognitive function and its rate of change in midlife and beyond as well as of educational and occupational attainment (McCall, 1979). One explanation for these effects is that a variety of hormones target brain areas responsible for cognition at the same time they are playing a critical role in determining body size and physical health. The effect remains valid even if the explanation that hinges on the intermediation of socioeconomic factors proves to be correct (Gottfredson & Deary, 2001).

Another relevant line of research refers to the beneficial effects of aerobic health and exercise on cognition. For example, when previously sedentary adults 60–75 years old were randomly assigned to either aerobic (walking) or anaerobic (stretching and toning) exercise for a period of six months, those who received aerobic training manifested substantial improvements in performance on tasks requiring executive control – such as planning, scheduling, inhibition, and working memory – compared with anaerobically trained subjects (Kramer et al., 1999). There are many further examples: physical exercise at 36 years is associated with a slower decline in memory between 43 and 53 years (Richards, Hardy, & Wadsworth, 2003); and moderate physical activity for 12 months improved the cognitive performance of elderly participants on the Digit Symbol Substitution Test (DSST), Rey Auditory Verbal Learning Test (RAVLT), modified Stroop test, and Modified Mini-Mental State Examination (Williamson et al., 2009). A review by Ploughman (2008) concludes that in clinical studies, exercise increases brain volume in areas implicated in executive processing, improves cognition in children with cerebral palsy, and enhances phonemic skill in school children with reading difficulty.

A third line of research focuses on the influence that fulfilling basic physical needs has on cognitive functioning. Major among these is adequate nutrition and sleep. Thus, concerning nutrition, a recent review emphasized the beneficial effects of bioflavonoids on memory (Spencer, Vauzour, & Rendeiro, 2009). Further, it was found that an overall index of diet quality was correlated positively with overall cognitive performance. Observations over a follow-up period of 11 years showed that consuming a diverse diet that includes a variety of recommended foods may help to attenuate age-related cognitive decline among the elderly (Wengreen et al., 2009). A large body of evidence shows that sleep, too, plays an important role in learning, memory encoding, and cognition. Insufficient quantity or quality of sleep leads not only to short-term neurocognitive dysfunction but also to permanent changes to the central nervous system (Malhotra & Desai, 2010).

The three types of examples introduced indicate that good or improved physical state has beneficial effects on cognition. Evidence of this kind enhances the importance of studying the effects of impaired physical health on cognition. Indeed, it is surprising that physical health and cognition have remained largely dissociated. If a study in cognition is reported in a journal, it is expected of the investigators to mention impaired mental health, such as schizophrenia of all or some of the participating subjects. However, it is still not the habit to report how many of the participants suffer from elevated blood pressure, gastrointestinal disorders, or diabetes, or for that matter which medication they use on a habitual basis.

There may be several reasons for that. One could mention lack of information about specific effects or general medical knowledge in researchers of cognition. Other reasons could be unclarity of the medical findings (for example, in regard to the impact of vitamins B6 or B12 on cognition, see Vollset & Ueland, 2005) or unclarity of the kind of effects that need to be considered (e.g., diseases or medication). Finally, perhaps the reason for leaving out the physical effects is just the difficulty of embedding cognition in the framework of the body. It is notable that even the recently fashionable approach to cognition – embodied cognition – which emphasizes the central role of the body in shaping cognition (Clark, 1998) deals with the effects of actions and environment on thinking but does not reserve a special location for the effects of physical health on cognition. The objective of this chapter is to review evidence concerning the effects of physical health on cognition so as to suggest reasonable guidelines for considering physical health in the study of cognition.

GUIDELINES AND DOMAINS OF IMPACT

The range of possible and proved effects of physical health on cognition is very broad. Because a review of this type can at best be only selective, it should be preceded by a set of guidelines defining the selection and major domains of relevance to the theme. The first guideline is the need to distinguish between the impact of diseases and the psychological effects of diseases. The latter include emotional reactions – such as stress, anxiety, or depression evoked by the disease and the related treatments – as well as coping mechanisms applied in regard to the disease – such as denial or hopelessness and even behavioral and lifestyle changes brought about by the disease. Each of these kinds of reactions could affect cognition (Kreitler, 2005). Effects on cognition of these kinds could be considered as distal or indirect effects of diseases on cognition. The distinction between the diseases and their psychological distal effects is important because the latter are subject to individual differences and can also be treated and changed. As the mechanisms through which diseases and the psychological effects impact cognition are different, it is likely that the cognitive effects of these two factors are also different.

A second important guideline requires distinguishing between the impact of the diseases and the medical treatments applied because of the diseases. Thus, the effects of cancer and of the applied treatments such as chemotherapy need to be dealt with separately. The reason is that the effects of the disease and the treatment are very different. Moreover, not all those who have the disease may be undergoing the treatment. Additionally, the treatments for the particular disease may undergo changes, as is, for example, evident in regard to the treatments for cancer where biological treatments with different side effects start displacing the older more toxic chemotherapeutic agents.

Concerning medical treatments, it should be emphasized that sometimes they are administered as prevention with no evident symptoms of a disease (e.g., use of aspirin).

A third important distinction should be drawn between acute and chronic diseases. There is no doubt that acute states of disease such as acute pain or infection affect cognition (Kreitler & Niv, 2007). However, it is unlikely that cognitive tasks would be administered to individuals in acute states of disease without considering their state or reporting it. Hence, it is evident that the major emphasis of this chapter would be on the effects of chronic diseases.

A fourth distinction should be drawn between diseases that affect the brain directly or preponderantly and other diseases. Evidently, some diseases are first and foremost diseases that implicate the brain. These include brain tumors; Huntington disease (which involves atrophy of certain forebrain structures including the entire cerebral cortex, and even more notably, the caudate nucleus and putamen); Alzheimer's disease (which involves atrophy of the cerebral cortex and some other forebrain regions in the frontal and temporal lobes, whereby the insula and medial part of the temporal lobe tend to demonstrate the highest number of neuritic plaques); stroke; dementia; Parkinson's disease; and epilepsy. In the case of diseases of this class, the cognitive impairment forms part of the symptoms and signs of the disease. Thus, recent memory loss, difficulties using or comprehending language, time, and place disorientation, distractibility, poor judgment, and difficulties with abstract thinking are considered symptoms of dementia (Merck Manuals).

Many other diseases have traditionally not been considered as diseases of the brain, such as hepatitis C or chronic kidney disease. In the case of some of the diseases in this class, recent scientific developments have detected their effects on the brain. One example is diabetes, which was found to affect blood flow and oxygen supply to the brain with the possible result of memory loss (Motta et al., 1996). Because the cognitive effects of brain diseases are well-known, the present chapter will be devoted mainly to chronic diseases whose primary location is the body rather than the brain. Finally, in view of the abundance of diseases and evidence about cognitive effects, the present chapter can be expected only to present examples sampled from the large reservoir of studies.

COGNITIVE EFFECTS OF VARIOUS DISEASES

Cardiovascular Disorders

Widespread cognitive deficits have been reported in individuals with cardiac disease (Barclay et al., 1988; Moser et al., 1999). A review of studies from 1996 to 2006 showed that in a pooled sample of 2,937 heart-failure patients compared with 14,848 control subjects, there was significant evidence for deficits in global cognitive performance, memory scores, and psychomotor speed in the patients (the odds ratio for cognitive impairment was 1:62 among subjects with heart failure) (Vogels et al., 2006).

A body of studies showed that coronary heart disease is associated with a worse performance in mental processes such as reasoning, vocabulary, and verbal fluency and that the longer ago the heart disease had been diagnosed the worse the person's cognitive performance (Singh-Manoux et al., 2008). In population studies, coronary heart disease (CHD) has been associated with worse performance on both mental-status tests (Breteler et al., 1994; Elwood et al., 2002) and measures of specific cognitive functions (Singh-Manoux, Britton, & Marmot, 2003). Cognitively intact individuals with vascular diseases were found to have verbal memory deficits (Rafnsson et al., 2007). Individuals with peripheral arterial disease were found to have generalized cognitive deficits (Phillips, Mate-Kole, & Kirby, 1993; Phillips, & Mate-Kole, 1997) as well as poorer performance on domain-specific cognitive measures (Breteler et al., 1994; Elwood et al., 2002). Individuals with atrial fibrillation were found to have a general cognitive impairment of only slight magnitude (Puccio et al., 2009). Individuals who have undergone cardiac failure or arrest scored significantly lower than controls on 14 of 19 cognitive tests, and 46 percent of the heart-failure patients were rated as having mild to severe cognitive impairment compared to 16 percent of mild impairment in controls. The degree of cognitive impairment was closely related to the number of myocardial infarctions experienced (Sauvé et al., 2009). Individuals with cardiovascular disease who were treated with drugs and stents showed increasing deficits on tests of verbal memory, visual memory, visuoconstruction, language, motor speed, psychomotor speed, attention, and executive function when compared to heart-healthy people who had no known risk factors for coronary artery disease (Selnes et al., 2009).

The impact on cognition of risk factors or correlates of cardiovascular disorders has also been studied. Thus, homocysteine was consistently and strongly associated with worse neurobehavioral test performance in a variety of domains, especially in the domains of simple motor and psychomotor speed, eye-hand coordination/manual dexterity, and verbal memory and learning (Schafer et al., 2005). The findings concerning total cholesterol are less consistent. Some studies found that high total cholesterol in midlife was associated with poorer late-life episodic memory and category fluency (Solomon et al., 2009); other studies found that lower cholesterol levels, either natural or statin induced, were related to lower verbal memory, attention/

concentration, abstract reasoning, and a composite score measuring multiple cognitive domains (e.g., Elias et al., 2005).

Also, elevated blood pressure exerts effects on cognition (Elias et al., 1993; Waldstein, & Katzel, 2001). A review of 96 papers showed that as compared with the common cardiovascular risk factors, hypertension had the strongest deleterious effect on cognition (Hendrie et al., 2006). In older adults (above 60), those with high blood pressure tended to perform more poorly on cognitive tasks, especially those involving inductive reasoning, and thus the ability to work flexibly with unfamiliar information and find solutions (Gamaldo, Weatherbee, & Allaire, 2008). The impact of elevated blood pressure on cognition is related mainly to diastolic blood pressure (Tsivgoulis et al., 2009) and is particularly salient in middle-aged individuals (40–59 years) (Madden et al., 2003).

Diabetes

It has long been observed that diabetes mellitus is associated with an increased rate of cognitive decline (Allen, Frier, & Strachan, 2004), which was attributed to chronic hypoglycemia, vascular disease, cumulative effect of hypoglycemic events, and possible direct effects of insulin on the brain (Biessels et al., 2002) as well as insulin dysregulation (Craft & Watson, 2004). The broad range of cognitive functions that have been studied in individuals with type 2 diabetes include memory, psychomotor speed, visuospatial functions, frontal executive functions, processing speed, verbal fluency, attention, and complex motor functions. A comprehensive review of literature on the association between impaired glucose tolerance, type 2 diabetes, and cognitive function showed that the most consistently reported measures were impairment in verbal memory and processing speed, with preservation of functions in other areas including visuospatial function, attention, semantic memory, and language (Awad, Gagnon, & Messier, 2004). The preservation of memory and learning functions occurred mainly in subjects younger than 65 years of age, in contrast to older subjects where impairments in those domains were largely because of interaction between diabetes-related changes and the normal ageing changes in the brain (Ryan & Geckle, 2000). Younger subjects with type 2 diabetes mellitus consistently showed impairment in psychomotor efficiency, similar to subjects with type 1 diabetes. Impairments in working memory, frontal executive functions, learning, and complex psychomotor abilities have also been found to be associated with a higher level of HbA1c (Munshi et al., 2006). Further, it was shown that poor glucose control and a rise in average blood sugar are strongly associated with poorer functioning abilities, especially poorer memory function (Cukierman-Yaffe et al., 2009).

Gastrointestinal Disorders

Helicobacter pylori is a bacterium that can inhabit various areas of the stomach and duodenum and causes a chronic low-level inflammation of the stomach lining that is strongly linked to the development of duodenal and gastric ulcers. It was found that the prevalence of this bacterium is higher in individuals who exhibit symptoms of mild cognitive impairment than in those who do not (Kountras et al., 2007). In individuals diagnosed with celiac disease, cognitive impairment was found in the form of amnesia, acalculia, confusion, and a score on the Short Test of Mental Status indicating moderate impairment (Hu et al., 2006). Findings of a different order were reported for individuals diagnosed with irritable bowel syndrome. They were found to exhibit global hypersensitivity to a broad range of stimuli (Lawal et al., 2006), manifested for example in a word-association task in which they recognized words representing symptoms and affects, both positive and negative, more quickly than others (Posserud et al., 2009).

Hematological Disorders

Anemia is a common hematological symptom, prevalent in a broad range of physical disorders. There is a lot of evidence that anemia is related to cognitive impairment. For example, elderly individuals (above 65) with anemia score low (<7) on the Abbreviated Mental Test (Zamboni et al., 2006) or the Mini Mental State Examination even with mild anemia (Argyriadou et al., 2001). Cancer patients undergoing treatments depressing hemoglobin levels were found to have serious cognitive deficits (Jacobsen et al., 2004).

Nephrology and Dialysis

A review of older studies of intellectual functioning in uremia and maintenance hemodialysis for renal failure shows that the most frequently reported deficits in neuropsychological functions have been in general intelligence, memory, and attentional processes. Studies have consistently found lowered performance IQ scores compared to verbal IQ scores in renal-failure patients prior to dialysis onset, with significant improvement in short-term memory and attentional functions after onset of maintenance dialysis (Osberg et al., 1982). The reported deficits were attributed to neurochemical mechanisms of the brain, which may be impaired in the abnormal chemical environment imposed by renal failure (Ginn, 1975).

More recently, analysis of data from older adults in the Rush Memory and Aging Project (mean age 81) showed that poor kidney function, assessed at the beginning of the study, was linked with a more rapid rate of decline over the next several years in episodic, semantic, and working memory, but not in visuospatial ability or perceptual speed (Buchman, 2009). In younger individuals, findings indicated that individuals with kidney transplant or chronic kidney disease demonstrated significantly worse verbal learning and memory as well as lowered response inhibition and other executive functioning skills in comparison to controls. Further, those with chronic kidney disease also performed significantly worse on a set-shifting task (Gelb et al., 2008).

Respiratory Disorders

There are various disorders manifested in respiratory difficulties, including apnea, asthma, and chronic lung diseases. Cognitive dysfunction has been repeatedly reported in individuals suffering from obstructive sleep apnea, characterized by repeated episodes of upper airway obstruction and lowered blood oxygen levels during sleep (see review in Beebe et al., 2003). For example, it was found that both snoring and breathing stoppage were associated with low scores in tests requiring visual attention skills, the Trail Making Test, and the Digit Symbol Substitution Test. These relationships were significant only when either snoring or breathing stoppage was associated with daytime sleepiness (Dealberto et al., 1996).

Allergic rhinitis, which also affects breathing, was found to be related to difficulties in cognition and learning (Borres, 2009). Pollen-allergic young people, tested on computer simulation of different learning situations, manifested lower concentration ability than healthy controls (Vuurman et al., 1993). Patients allergic to ragweed were shown to have impaired cognitive learning during the pollen season and some also had memory impairment. Individuals with allergic rhinitis symptoms take a longer time to make decisions and have a slower psychomotor rate than healthy control subjects (Marshall, O'Hara, & Steinberg, 2000). Students with allergic rhinitis tend to get lower grades in school (Borres et al., 2007; Walker et al., 2007).

When individuals with chronic obstructive pulmonary disease (COPD) were compared with healthy controls, they were consistently found to be impaired in verbal memory (Huppert, 1982; Incalzi et al., 1993; Stuss et al., 1997), and to a lesser degree also in aspects of attention and working memory (Berry et al., 1989; Della Sala et al., 1992). Further, studies showed that there may be a pattern of cognitive dysfunction specific to COPD: the incidence of cognitive dysfunction is higher in but hypoxaemia; hypoxaemia, hypercapnia, smoking, and comorbidities (such as vascular disease) are unlikely to account for all of the cognitive dysfunction seen in COPD; and the observed cognitive dysfunction were unrelated to mood, fatigue, or health (Dodd, Getov, & Jones, 2010). Individuals with asthma or COPD were found to have significantly lower oxygen saturation compared to the healthy controls, and performed significantly poorer on tests of delayed word recall and serial subtractions but not on other tasks of immediate word recall, word fluency, and digit-symbol substitution (Moss et al., 2005).

Hormonal Disorders

There is a large body of studies reporting cognitive correlates of hormonal disorders of various kinds. The thyroid gland is associated with several hormones. Cognitive changes have frequently been detected in patients with hypothyroidism, including defects ranging from minimal to severe in general intelligence, psychomotor speed, visual-spatial skills, and memory (Burmeister et al., 2001; Denicoff et al., 1990; Dugbartey, 1998). Several recent studies have suggested that hypothyroid-related memory defects are attributable to specific retrieval deficits rather than to an attentional deficit (Dugbartey, 1998; Miller et al., 2007). Motor skills, language, inhibitory efficiency, and sustained attention appear to be less affected by hypothyroidism (Burmeister et al., 2001; Dugbartey, 1998). Thus, the memory deficit characteristic of hypothyroidism seems to be distinct from that associated with major depression, which affects broad executive difficulties (Miller et al., 2007). Individuals with subclinical hypothyroidism performed poorer than normal controls on neuropsychological tests including the Wechsler Adult Intelligence Scale, the Wechsler Memory scale, and verbal fluency (Baldini et al., 1997). In subclinical hypothyroidism, most detected cognitive deficits are minimal in severity and appear mainly in regard to working memory (Bauer et al., 2008; del Ser Quijano et al., 2000).

Cushing disease is one of the pituitary disorders. Individuals with Cushing disease were found to score significantly lower than controls on four of five verbal IQ subtests, but only on one nonverbal performance IQ subtest (block design). Their verbal, but not visual, learning and delayed recall at 30 minutes were significantly decreased. Despite the lower score on verbal delayed recall, the retention index (percentage), which compares the amount of initially learned material to that recalled after the delay, was not significantly decreased. The cognitive performance was not associated with depression, but a higher degree of cortisol elevation was associated with poorer performance on several subtests of learning, delayed recall, and visual-spatial ability (Starkman et al., 2001).

Cortisol is a hormone that fulfills an important role in the context of the hypothalamic-pituitary-adrenal axis in promoting and maintaining arousal.

Its impact on cognition, however, is unclear (de Kloet, Oitzl, & Joels, 1999). A body of studies has demonstrated a relationship between cortisol levels and memory impairment (de Bruin et al., 2002). In a population-based study of adults 50–70 years old, higher levels of pretest and mean cortisol were found to be associated with worse performance in language, processing speed, eye-hand coordination, executive functioning, verbal memory and learning, and visual memory (Lee et al., 2007). On the other hand, there is also evidence about the facilitatory effects of cortisol on cognitive activities where working memory and attention are required (Annett et al., 2005; Koob & Britton, 1990). It has been concluded that inhibiting effects of cortisol initially influence neuropsychological processes such as learning in a positive manner (Luine et al., 1996), although prolonged cortisol secretion can adversely affect attention, memory, and learning processes (Lupien, Gillin, & Hauger, 1999; Newcomer et al., 1994; Wolkowitz et al., 1990).

A growing literature shows that gonadal hormones influence cognition, although these hormone-induced changes are fairly small. Positive effects have been demonstrated in regard to specific kinds of memory, especially spatial and learning visual memory (Luine, 2008). Efficacious effects on verbal and working memory by both estrogen and testosterone were demonstrated in young women who had undergone surgical menopause (i.e., ovarian removal). Furthermore, the Baltimore Longitudinal Study of Aging provided evidence of better maintenance of many aspects of cognition in normal aging women on hormone replacement therapy (Sherwin & Henry, 2008).

Cancer

There is a lot of research concerning the impact of cancer on cognition, but the overwhelming part of it refers to the effects of chemotherapy on cognitive functioning (see following section) and a smaller part to the impact of cancer types that directly involve the central nervous system (CNS) (Meyers & Perry, 2008). Yet, the few studies of individuals prior to undergoing cancer treatments show that the disease as such also affects cognitive functioning. For example, in a study of individuals about to undergo hematopoietic stem-cell transplantation (HSCT), 26 percent were classified as impaired before as well as after HSCT. Neuropsychological test results did not vary systematically according to medical variables such as extent of pretreatment, graft-versus-host-disease (GvHD), and kind of conditioning protocol (Schultz-Kindermann et al., 2007). A comparison of mean neuropsychological test scores of individuals with invasive and noninvasive breast cancer prior to treatment showed that those with Stage 1–3 cancer scored significantly lower than healthy controls on the Reaction Time domain and were significantly more likely to be classified as having lower than expected overall cognitive performance (22 percent) as compared to Stage 0 patients (0 percent) and healthy controls (4 percent) (Ahles et al., 2008).

Neurological Diseases

Neurological diseases are a controversial section in the present context because it is likely that they include central nervous system (CNS) involvement. Yet, we cite a few examples because CNS pathology may not be the sole factor contributing to the observed cognitive deficits. Thus, in lyme disease, cognitive impairment was found in attention span, memory retrieval, reading comprehension, concentration, organizing and planning, and identifying imagery (Edlow, 2003). In multiple sclerosis, cognitive disfunction occurs in about 50 percent of the individuals (Rao et al., 1991). The consistently reported neuropsychological profile includes deficits concerning learning and working memory as well as reduced attentional and executive abilities, whereas linguistical competence and global intellectual capacity remain relatively intact (Brassington & Marsch, 1998; Rao et al., 1991; Rao, 1995). In adults with new-onset epilepsy, cognitive deficits were detected with regard to delayed recall in verbal memory, selective attention, and psychomotor performance (Rösche, Uhlmann, & Fröscher, 2010).

Chronic Pain

The effects of pain on cognitive functioning have been studied quite extensively, mainly because these effects are likely, first, to exacerbate the patients' suffering and reduce their already compromised quality of life (Niv & Kreitler, 2001); secondly, to restrict the patients' ability to communicate their pain symptoms (Kreitler & Kreitler, 2007); and third, to limit the application of cognitively based treatments of pain that are highly common. In addition, it is expected that information about the cognitive impact of pain could shed light on brain mechanisms that mediate both pain and cognition, thereby pointing the way toward new treatment strategies of pain.

The summary of the findings is based on studies dealing directly with the effects of chronic pain on cognitive processes (for all references, see Kreitler & Niv, 2007). We focused on studies from about 1990 onward (n = 42), which reported significant findings based on comparing at least one measure of a cognitive function, assessed by means of a valid and reliable test, in chronic-pain patients (with no cancer pain and who did not undergo traumatic brain injury and had no neurological disorders) and controls (who had no chronic or acute pain or psychiatric disorder). The chronic-pain patients suffered mostly from musculoskeletal pain at mixed sites, including whiplash-injury patients.

Cognitive complaints reported by chronic-pain patients (at least one by 54 percent of the responders) in one study included forgetfulness (23.4 percent), minor accidents (23.1 percent), difficulty finishing tasks (20.5 percent), and difficulty with attention (18.7 percent). In another study, complaints included memory flaws referring to films and books (61 percent), forgetfulness (44 percent), handling of everyday things (38 percent), and flaws about conversations (38 percent). These and similar surveys indicate that the majority of the cognitive problems is focused on memory and attention. Memory and attention deficits figure prominently also in objective findings about cognitive impairments related to chronic pain. Thus, 88.2 percent of 34 relevant publications reported lower performance by chronic-pain patients on a varied set of memory functions, including verbal and nonverbal memory, immediate and delayed memory, long-term and short-term memory, and memory span. On the whole, it seems justified to conclude that the most affected aspects of memory are those that lean heavily on verbal materials, delayed memory, and require new learning and the use of information previously acquired in the framework of the task. There are indications that memory for figural materials, visual memory, spatial memory, and incidental memory tend on the whole to be less affected by chronic pain.

Attention deficits of chronic-pain patients were reported in 69.2 percent of 13 relevant publications, which however did not include the common measures in the field – namely, the Stroop and the attention and concentration indices based on the Wechsler Memory Scale (WMS-R). Verbal deficits of chronic-pain patients were found in 88.9 percent of the 9 relevant studies, including tests of vocabulary and word or category fluency.

Deficits of chronic-pain patients in varied measures of speed, ranging from verbal tasks through information processing speed to psychomotor speed, were reported in 82.3 percent of 17 relevant studies. Notably, in all three applications of one speed test – the Number Connection Test –chronic-pain patients did not differ from healthy controls.

Chronic-pain patients were found in most studies (72.7 percent of 11 studies) to have lower mental flexibility based mostly on requirements of switching from one task or set of instructions to another. Further, lower performance was found for chronic-pain patients in each of the following, tested mostly by five or less studies: reasoning, construction ability, calculation, the tests of block design and similarities, visual-motor coordination, abstract thinking, problem solving, and decision making in an emotional risk-involving task. Lower performance for chronic-pain patients was found also on the following three basic measures of overall cognitive functioning: the Mini-Mental State Examination, the Neurobehavioral Cognitive Status Examination, and the Wechsler Adult Intelligence Scale (WAIS).

Further evidence about the effects of chronic pain on cognitive difficulties is based on studies examining the correlation between the degree of cognitive deficit and pain intensity. Pain intensity was correlated positively with the number of subjective complaints about cognitive functioning (two studies), and with the degree of objectively assessed cognitive impairment in regard to mental flexibility (six studies), memory (one study), visual-motor coordination (one study), speed (two studies), emotional risk-bound decision making (one study), and overall scores on the Repeatable Battery for Assessment of Neurological Status (one study). However, no correlations were found between pain intensity and attention and concentration (one study), memory (two studies), word fluency (one study), and speed (one study).

In addition, there is evidence that reduction in pain intensity is followed by some improvement in auditory vigilance, and in subjective evaluations of cognitive functioning but not in objective assessments of cognition. Brain research has provided some indications about the processes involved in the negative effects of pain on cognition. It was shown that pain modulated activity in a positive sense in the brain areas involved directly in the cognitive task as well as in other areas of the prefrontal cortex, and in a negative sense in the perigenual cingulate cortex, insula, and medial thalamus. Another study showed that pain-related brain activation in three cortical regions – primary (S1) and secondary (S2) somatosensory cortices and anterior insula – was attenuated by cognitive engagement induced by a cognitively demanding task (viz. Stroop). Further, the evidence provided by human brain-imaging studies that brain regions critical for emotional decision making are also involved in chronic pain led to the interesting discovery that pain affects detrimentally precisely tasks of this kind.

In sum, the majority of chronic-pain patients complain of cognitive difficulties, mainly in regard to memory and attention. Studies performed in this domain show that cognitive deficits actually show up mainly in the domains of memory, attention, speed, verbal ability, and mental flexibility. The evidence concerning more complex cognitive functions is scarce, so that it is still an open question whether chronic pain does not affect these, too.

There may be various explanations for the negative effects of pain on cognitive performance. One approach attributes the cognitive deficits at least partly to the patients' depression and emotional distress (Hart, Wade, & Martelli, 2003). Some investigators argue for the attention-overload explanation. If pain is considered as an attention-consuming stimulus and attention as a unitary and limited resource, it may be expected that too few attentional reserves may remain for cognitive functioning in chronic-pain patients (Eccleston & Crombez, 1999; Grisart, Van der Linden, & Masculier, 2002). Another possible explanation may be decreased motivation and interest of chronic-pain patients to do anything whatsoever, due to their persistent pain and constant worrying. Further likely explanations are the effects of fatigue caused by sleep disorders, and the consumption of analgesics as well as the previously noted impact of pain-induced brain activation in the areas involved in cognitive functioning.

A review of the effects of pain on cognition requires referring to fibromyalgia, which is a special syndrome that includes chronic and widespread pain and sensitivity to pressure. Individuals with fibromyalgia frequently complain of cognitive problems or "fibrofog." The existence of these symptoms has been confirmed by the results of objective tests of metamemory, working memory, semantic memory, everyday attention, task switching, and selective attention. These tests showed that fibromyalgia patients have impairments in working, episodic, and semantic memory, especially when tasks are complex and their attention is divided (Glass, 2008).

Dermatological Diseases

The relations between skin disorders and cognition have not been studied extensively. In a study on psoriasis, it was shown that individuals with psoriasis had an automatic attentional bias to specific classes of information relative to controls. On a computer-based attentional interference task (the modified Stroop task), they manifested a significant interference for disease-specific, self-referent, and others' behavior stimuli relative to controls. Recall bias was limited to disease-specific stimuli only (Fortune et al., 2003). In a sample of non-elderly persons without a psychiatric disorder evaluated with the Repeatable Battery for the Assessment of Neuropsychological Status (RBANS) and the Wisconsin Card Sorting Test, serological evidence of Herpes Simplex Virus type 1 (HSV-1) was significantly associated with a lower RBANS total score independent of demographic factors and the catechol-o-methyl transferase (COMT) Val158Met genotype, as well as a severe impairment in the domain of delayed memory. The Val/Val genotype of the COMT Val158Met polymorphism was also significantly associated with the RBANS total score and a moderate decrease in the domain of attention. Infections with HSV-1 and the COMT Val158Val genotype are risk factors for cognitive deficits in non-elderly persons without a psychiatric disorder (Dickerson et al., 2008).

Sensory Disabilities

Major sensory disabilities that may affect cognition include hearing, vision, olfaction, and tactility. The relations between sensory disabilities and cognition are difficult to disentangle. The senses are an important, indeed essential means of developing and functioning cognitively in a world shaped by and for individuals with all senses intact. For an outside observer, it may seem feasible to overcome the likely difficulties in the cognitive domain by diverse compensatory means. The question is if that actually takes place.

For example, research has demonstrated cognitive differences between deaf and hearing students at all levels, including visual perception, memory, and problem solving, even in mathematics (Dye, Hauser, & Bavelier, 2008; Hauser, Lukomski, & Hillman, 2008; Kelly, 2008). Memory impairment was found to be associated with sound processing disorder and hearing loss (Gates et al., 2008; Wingfield, Tun, & McCoy, 2005). These findings should not be surprising in view of the important role of verbalization and language understanding in cognition. At the same time, there is a lot of evidence showing that deaf and hearing students share many similarities in cognition. It is necessary to consider the possibility that even small differences in learning abilities and knowledge have significant cumulative effects over time (Marschark & Hauser, 2008).

In blindness, the major issue is the difficulties or deficits in regard to contacts with the environment. Orientation in space and the structure of space provide two examples of difficulties that may affect a variety of cognitive functions (Spencer et al., 1992). However, in addition, other functions such as verbal fluency have also been found to be affected (Wakefield, Homewood, & Taylor, 2006).

A study on age-related macular degeneration (AMD) showed that individuals who had more severe AMD had poorer average scores on cognitive tests, regardless of factors such as age, sex, race, education, smoking, diabetes, use of cholesterol-lowering medications, and high blood pressure. Average scores also decreased as vision decreased (Clemons et al., 2006). A study of more than 2,000 older adults (69–97 years) revealed an association between early-stage AMD and cognitive impairment, as assessed by the Digit Symbol Substitution Test (a test of attention and processing speed). There was no association with performance on the Modified Mini-Mental State Examination (used to assess dementia) (Baker et al., 2009).

The olfactory sense is not often considered when studying cognition. Yet, it is of interest to note that difficulty identifying odors predicts over five years the development of mild cognitive impairment in elderly people who have normal cognitive function at baseline. The finding is not changed by controlling for age, sex, education, and semantic memory (Wilson et al., 2007).

The involvement of haptic deficits in cognition was demonstrated by studying groups with different degrees of dementia. The results show that haptic tasks are sensitive to early perceptive-cognitive and functional deficits in patients with minimal cognitive impairment (Grunwald et al., 2002).

Even sensory difficulties that do not represent deficits may affect cognition adversely. For example, individuals with chronic, moderate tinnitus do more poorly on demanding working memory and attention tests than those without tinnitus. However, they do not do more poorly on less complex tasks involving involuntary automatic responses (Rossiter, Stevens, & Walker, 2006).

Special Bodily States

In this section, we will discuss the effects on cognition of the following special bodily states: pregnancy, menstruation, loss of sleep, and being overweight. These states have been selected because they are primarily physical states, occur frequently, and are not usually identified as physical disorders. In view of these criteria of selection the following states have been excluded from the present discussion: stress, which could be mainly psychological; and underweight and nutritional deficiencies, which could be manifestations of psychopathology.

Recent years have witnessed a growing interest in cognitive effects of the state of pregnancy, which is characterized by dramatic hormonal fluctuations. Subjective reports of cognitive difficulties during pregnancy include forgetfulness, disorientation, confusion, and reading difficulties, unrelated to mood fluctuations, age, and medical symptoms (Poser, Kassirer, & Peyser, 1986). Objective testing showed difficulty in verbal learning, verbal memory, immediate and delayed recall, discriminating relevant from irrelevant responses, and tasks requiring speed of cognitive processing and conceptual tracking, unrelated to hormonal levels of E_2, T, and DHEA during pregnancy (Buckwalter et al., 2001; Keenan et al., 1998; Sharp et al., 1993). The major effects seem to be related to memory, especially those types of memory that rely on executive function resources (Henry & Rendell, 2007). Some cognitive deficits also persist after pregnancy, which is in accord with the long-term hormonal effects of pregnancy (Buckwalter et al., 1999, 2001). Improvements in word-list learning and reaction time have been observed only 6 or 12 months after pregnancy (Eidelman, Hoffman, & Katz, 1993; Silber et al., 1990).

Menstruation is another natural physical state whose effects on cognition were explored. Both reaction time and error rate in a mental rotation task were negatively impacted in menstruation and ovulation phases in women (Kozaki & Yasukouchi, 2009). There is further evidence that menstruation negatively impacts performance requiring spatial memory (Postma et al. 1999). Further, in the proximity of the estrogen, peak performance in automatized tasks is facilitated and performance of perceptual-restructuring tasks is impaired, compared with performance in the postovulatory phase when progesterone is thought to counteract the action of estrogen (Broverman et al., 1981). Several studies showed that verbal fluency, manual dexterity, and speeded articulation were performed by women better and visuospatial tasks worse when estrogen and progesterone levels were high than when they were low (Kimura & Hampson, 1994). A slight deficit in memory in women with premenstrual syndrome was found (Keenan et al., 1995).

Sleep plays an important role in learning, memory encoding, executive function, and attention. Insufficient quantity or quality of sleep leads to neurocognitive dysfunction in the short-term and possibly also in the long-term (Durmer & Dinges, 2005). Sleep loss, whether because of poor sleep quality, restricted sleep opportunities, or prolonged sleep deprivation, has been linked with cognitive slowing, increased attention lapses, memory impairment, decreased vigilance, and reduced capacity for sustained attention (Himashree, Banerjee, & Selvamiinhy, 2002). Sleep deprivation negatively affects most notably decision making, flexibility, task switching, evaluating complex situations, and tracking dynamically changing states (Harrison & Home, 2000).

There is growing evidence of a possible association between being overweight and poor cognitive function. Increased body weight is independently associated with decreased visuospatial organization and general mental ability already among school-age children (Li et al., 2008). In adults, body mass index was found to be inversely related to performance on all cognitive tests (Elias et al., 2003; Gunstad et al., 2010; Jeong et al., 2005; Karnehed et al., 2006; Sørensen & Sonne-Holm, 1985). Body mass index was independently associated both with cognitive function (word-list learning and Digit–Symbol Substitution Test) and changes in word-list learning in healthy, nondemented, middle-aged men and women (Cournot et al., 2006). In one study, after controlling for confounding variables such as age, gender, IQ, and years of education, only impaired executive function significantly differentiated overweight or obese subjects from those with normal weight (Gunstad et al., 2008). Long-term mechanisms for this association include consequences of hyperglycemia, dyslipidemia, or other factors comprising metabolic syndrome X as well as physiologic brain changes caused by being overweight, such as subclinical inflammatory changes, vascular changes, or dysmyelinization of white matter (Volkow et al., 2009).

Medical Treatments

Medical treatments may also have side effects that impact cognitive functioning. The examples that will be provided refer to surgery, chemotherapy, and various drugs. The evidence about cognitive dysfunction following surgery with general anesthesia has been accumulating steadily since the late nineties, so that it came to earn the name of a distinct syndrome – post-operative cognitive dysfunction. It involves difficulties in memory, learning, and concentration that may last for months following surgery.

In one study, it was found in 25.8 percent after one week and in 9.9 percent after three months. The syndrome was not canceled by controlling for factors such as age, duration of anesthesia, respiratory complications, and infectious complications (Moller et al., 1998). In another study, memory and cognitive function were tested in 1,000 adult patients of different ages prior to elective noncardiac surgery, at the time of hospital discharge, and three months after surgery. Cognitive dysfunction was detected at the time of discharge from the hospital in 36.6 percent of young adults, 30.4 percent of the middle-aged, and 41.4 percent of the elderly. Three months later, the syndrome persisted, but more in the elderly (12.7 percent) than the younger patients (6 percent) (Price, Garvan, & Monk, 2008). The assumed etiology includes residual concentrations of general anesthetics, a long-lasting effect of general anaesthetics on cholinergic or glutaminergic neurotransmission, and possibly psychological factors related to illness and environment during hospitalization (Bruce et al., 2008).

The incidence of cognitive dysfunction following cardiac surgery has attracted a lot of attention. It has been found to be 30–80 percent after one week and still common (10–40 percent) after several months and later (Shaw et al., 1987). Language, concentration, and motor control are most consistently reported to be affected. Memory, attention, and executive function are more variably affected (Bruce et al., 2008).

The occurrence of cognitive deficits related to treatments of cancer is one of the most widely studied and discussed issues in regard to medicine and psychological health. Major cognitive deficits have been detected following chemotherapy and biological treatments (Wefel, Collins, & Kayl, 2008), hormonal treatments (Schilder, Schagen, & van Dam, 2008), and radiation therapy (Shaw, & Robbins, 2008). Best known are the effects of chemotherapy (also known as chemo-brain or chemo fog), that occur in about 10–40 percent of the patients, and may last even for more than 10 years. The functions most often affected involve visual and semantic memory, attention and motor coordination, and may be manifested in difficulties in regard to decision making, multitasking, comprehending read material, following the thread of a conversation, and retrieving words. The causes for the deficiencies are still unclear and are attributed to toxic drugs that affect brain tissues (Vardy et al., 2010).

In view of the mass of medical drugs and their potential effects on cognition, only a few examples will be mentioned. Thus, in regard to antihypertensive medication it was shown that they are likely to increase the inefficiency of the brain's work during memory tasks (Astle et al., 2007), and that chronic use of drugs with anticholinergic properties is associated with impairment in verbal memory and the ability to perform daily-living tasks. The effect was independent of age, education, morbidities, and severity of hypertension, and increased with amount of drug ingested (Han, Agostini, & Allore, 2008).

The cognitive effects of the use of statins are one of the most controversial issues in the medical arena at present. Accordingly, the best one can do in view of this situation is to quote support for all different claims: first, that the use of statins does not affect cognition at all (Trompet et al., 2010); secondly, that the use of statins is cognitively beneficial and reduces the extent and rate of cognitive decline (Cramer et al., 2008); and thirdly, that the use of statins is associated with deleterious effects on cognition (Elias et al., 2005). The most unexpected and disturbing results are the later, which show a significant positive linear association between total cholesterol and measures of verbal fluency, attention/concentration, abstract reasoning, and a composite score measuring multiple cognitive domains. Individuals with so-called desirable cholesterol levels (<200 mg/dL) performed more poorly than those with borderline-high levels (200–239 mg/dL) or high levels (>240 mg/dL) on cognitive tasks that place high demands on abstract reasoning, attention/concentration, word fluency, and executive functioning.

Antihistamins are mentioned here because as an antiallergy treatment, they are one of the most often-used drugs by individuals of all ages. It was shown that subjects who were treated with the agent diphenhydramine had significant performance deficits on tests of divided attention, working memory, vigilance, and speed (Kay, 2009).

Psychological Reactions to Diseases and Treatments

Common reactions to physical disorders and the associated treatments include fear, anxiety, worry, preoccupation with the disease, depression, and denial. These and similar reactions have been shown to affect cognitive functioning in diverse domains (Kreitler, 2005). For example, anxiety tends to affect mainly executive functions and visual memory (Castaneda et al., 2008). Denial negatively affects executive function, verbal memory, visual inference, and mental speed (Rinn et al., 2002). Worry was found to impair cognitive processing, which is manifested in difficulties of categorization and decision making (Metzger et al., 2006). According to a recent review (Gotlib & Joormann, 2010), depression is characterized by increased elaboration of negative information, difficulties disengaging from negative material, and deficits in cognitive control when processing negative information. Individuals with current depression but no previous depression tend to have worse cognitive performance in all domains than healthy controls, especially in the visuospatial/constructional and attention domains and the total score (Baune et al., 2010). This latter group may resemble individuals reacting with depression to physical disorders.

SOME CONCLUSIONS

The material presented in this chapter demonstrates the extent of the impact of physical disorders on cognitive functioning. Almost all of the major physical disorders have been mentioned. The omission of some does not indicate that they do not affect cognition but rather that they have not been studied or had to be deleted from our necessarily short review. There is no doubt that the studies suffer from a fair number of shortcomings. Some of the major ones are inadequate considerations of relevant confounding factors such as age, comorbidity, phase of disease, and use of medication; the use of limited or inadequate control groups; and inadequate or incomplete selection of variables or tasks for testing cognitive functioning. As a result, it is impossible at present to compare the extent and severity of cognitive effects in the various diseases. Neither is it possible to conclude that the assessed cognitive variables are the major ones or those that are most affected in that particular disease.

Yet, despite all the evident shortcomings, the amount, diversity, and nature of the findings render it barely possible to avoid the conclusion that cognitive functioning is affected by physical disorders and the physical state of the individual. As such, this conclusion should not come as a surprise. It has long been known that the mental state of the individual affects cognitive functioning. Accordingly, regular samples in cognitive psychology that were not designed to study psychopathological cognition did not include individuals suffering from depression, paranoia, or schizophrenia, to mention just a few examples. Yet, no consideration has been paid up to now to the effects of physical disorders on cognitive functioning, despite the fact that physical disorders are much more prevalent and possibly exert even more pervasive effects on cognition than mental disorders.

However, it is precisely the prevalence and pervasiveness of the effects of physical disorders on cognition that render it so difficult to discuss the implications of these findings in regard to the study of cognition. Should all individuals with any physical disorder be excluded from studies in cognition? Or should it become practice that any individual who participates in a study of cognition is to be asked to list in detail all one's physical disorders in the present or the past?

It is evident that recommendations along these lines are impractical and unreasonable. Moreover, they would not be very helpful in promoting the study of cognition because at present too little is known about the mechanisms and processes involved in enabling the impact of physical states on cognition. A great amount of research is still needed in order to specify which physical diseases affect which cognitive functions negatively and perhaps even positively and why.

The field is in dire need of models of a theoretical nature, grounded in biopsychological data, that would specify the kind of mechanisms likely to be involved in the mediation of the effects of diseases on cognition. These mechanism would include states and processes in the brain, in different body parts and bodily systems (hormonal, hematological) as well as psychological processes contributing directly or indirectly to the likelihood of the occurrence of a disease and affecting its course and impact on the individual's quality of life and overall functioning. The outlined models may well constitute the next phase of studies in health psychology. Before the evidence flows in, however, it seems reasonable to recommend that major physical diseases of the individual participating in a study on cognition be at least listed for further reference and future attempts to deepen the exploration and analysis of the findings.

References

Ahles, T. A., Saykin, A. J., McDonald, B. C., Furstenberg, C. T., Cole, B. F., Hanscom, B. S., Mulrooney, T. J., Schwartz, G. N., & Kaufman, P. A. (2008). Cognitive function in breast cancer patients prior to adjuvant treatment. *Breast Cancer Research & Treatments*, **110**, 143–152.

Allen, K. V., Frier, B. M., & Strachan, M. W. (2004). The relationship between type 2 diabetes and cognitive dysfunction: Longitudinal studies and their methodological limitations. *European Journal of Pharmacology*, **490**, 169–175.

Annett, R. D., Stansbury, L. K., Kelly, H. W., & Strunk, R. C. (2005). Association of hypothalamic-pituitaryadrenal axis function with neuropsychological performance in children with mild/moderate asthma. *Child Neuropsychology*, **11**, 333–348.

Argyriadou, S., Vlachonikolis, I., Melisopoulou, H., Katachanakis, K., & Lionis, C. (2001). In what extent anemia coexists with cognitive impairment in elderly: a cross-sectional study in Greece. *BMC Family Practice*, **2**, 5–10.

Astle, K., Muldoon, M., Christie, I., Price, J., & Meltzer, C. (2007). Memory tasks require more coordinated brain blood flow for people with high blood pressure. *American Heart Association meeting report*, Presentation P105.

Awad, N., Gagnon, M., & Messier, C. (2004). The relationship between impaired glucose tolerance, type 2 diabetes and cognitive function. *Journal of Clinical & Experimental Neuropsychology*, **26**, 1044–1080.

Baker, M. L., Wang, J. J., Rogers, S., Klein, R., Kuller, L. H., Larsen, E. K., & Wong, T. Y. (2009). Early age-related macular degeneration, cognitive function, and dementia: The Cardiovascular Health Study. *Archives of Ophthalmology*, **127**, 667–673.

Baldini, I. M., Vita, A., Mauri, M. C., Amodei, V., Carrisi, M., Bravin, S., & Cantalamessa, L. (1997). Psychopathological and cognitive features in subclinical hypothyroidism. *Progress in Neuropsychopharmacology & Biological Psychiatry*, **21**, 925–935.

Barclay, L. L., Weiss, E. M., Mattis, S., Bond, O., & Blass, J. P. (1988). Unrecognized cognitive impairment in cardiac rehabilitation patients. *Journal of the American Geriatric Society*, **36**, 22–28.

Batty, G. D., Mortensen, E. L., Nybo, A. A.-M., & Osler, M. (2005). Childhood intelligence in relation to adult coronary heart disease and stroke risk: evidence from a Danish birth cohort study. *Paediatric & Perinatal Epidemiology*, **19**, 452–459.

Bauer, M., Goetz, T., Glenn, T., & Whybrow, P. C. (2008). The thyroid-brain interaction in thyroid disorders and mood disorders. *Journal of Neuroendocrinology*, **20**, 1101–1114.

Baune, B. T., Miller, R., McAfoose, J., Johnson, M., Quirk, F., & Mitchell, D. (2010). The role of cognitive impairment in general functioning in major depression. *Psychiatry Research*, **176**, 183–189.

Beebe, D. W., Groesz, L., Wells, C., Nichols, A., & McGee, K. (2003). The Neuropsychological effects of obstructive sleep apnea: a meta-analysis of norm-referenced and case-controlled data. *Sleep*, **26**, 298–307.

Berry, D. T., McConnell, J. W., Phillips, B. A., Carswell, C. M., Lamb, D. G., & Prine, B. C. (1989). Isocapnic hypoxemia and neuropsychological functioning. *Journal of Experimental & Clinical Neurology*, **11**, 241–251.

Biessels, G. J., van der Heide, L. P., Kamal, A., Bleys, R. L., & Gispen, W. H. (2002). Ageing and diabetes: Implications for brain function. *European Journal of Pharmacology*, **441**, 1–14.

Borres, M. P. (2009). Allergic rhinitis: more than just a stuffy nose. *Acta Paediatrica*, **98**, 1088–1092.

Brassington, J. C., & Marsh, N. V. (1998). Neuropsychological aspects of multiple sclerosis. *Neuropsychology Review*, **8**, 43–77.

Breteler, M. M. B., Claus, J. J., Grobbee, D. E., & Hofman, A. (1994). Cardiovascular disease and distribution of cognitive function in elderly people: the Rotterdam study. *British Medical Journal*, **308**, 1604–1608.

Broverman, D. M., Vogel, W., Klaiber, E. L., Majcher, D., Shea, D., & Paul, V. (1981). Changes in cognitive task performance across the menstrual cycle. *Journal of Comparative and Physiological Psychology*, **95**, 646–654.

Bruce, K., Smith, J. A., Yelland, G., & Robinson, S. (2008). The impact of cardiac surgery on cognition. *Stress & Health*, **24**, 249–266.

Buchman, A. S., Tanne, D., Boyle, P. A., Shah, R. C., Leurgans, S. E., & Bennett, D. A. (2009). Kidney function is associated with the rate of cognitive decline in the elderly. *Neurology*, **73**, 920–927.

Buckwalter, J. G., Stanczyk, F. Z., McCleary, C. A., Bluestein, B. W., Buckwalter, D. K., Rankle, K. P., Chang, L., & Goodwin, T. M. (1999). Pregnancy, the postpartum, and steroid hormones: Effects on cognition and mood. *Psychoneuroendocrinology*, **24**, 69–54.

Buckwalter, J. G., Buckwalter, D. K., Bluestein, B. W., & Stanczyk, F. Z. (2001). Pregnancy and post partum: changes in cognition and mood. *Progress in Brain Research*, **133**, 303–319.

Burmeister, L. A, Ganguli, M., Dodge, H. H., Toczek, T., DeKosky, S. T., & Nebes, R. D. (2001). Hypothyroidism and cognition: preliminary evidence for a specific defect in memory. *Thyroid*, **11**, 1177–1185.

Castaneda, A. E., Tuulio-Henriksson, A., Marttunen, M., Suvisaari, J., Lönnqvist, J. (2008). A review on cognitive impairments in depressive and anxiety disorders with a focus on young adults. *Journal of Affective Disorders*, **106**, 1–27.

Clark, A. (1998). Embodied, situated, and distributed cognition. In W. Bechtel & G. Graham (Eds.), *A companion to cognitive sciences* (pp. 506–517). Malden, MA: Blackwell.

Clemons, T. E., Rankin, M. W., McBee, W. L., (2006). Association between mild age-related eye disease study research group: Cognitive impairment in the age-related eye disease study: AREDS report no. 16. *Archives of Ophthalmology*, **124**, 537–543.

Cournot, M., Marquié, J. C., Ansiau, D., Martinaud, C., Fonds, H., Ferrières, J., & Ruidavets, J. B. (2006). Relation between body mass index and cognitive function in healthy middle-aged men and women. *Neurology*, **67**, 1208–1214.

Craft, S., & Watson, S. G. (2004). Insulin and neurodegenerative disease: Shared and specific mechanisms. *Lancet Neurology*, **3**, 169–178.

Cramer, C., Haan, M. N., Galea, S., Langa, K. M., & Kalbfleisch, J. D. (2008). Use of statins and incidence of dementia and cognitive impairment without dementia in a cohort study. *Neurology*, **71**, 344–350.

Cukierman-Yaffe, T., Gerstein, H. C., Williamson, J. D., Lazar, R. M., Lovato, L., Miller, M. E., Coker, L. H., Murray, A., Sullivan, M. D., Marcovina, S. M., Launer, L. J., for the Action to Control Cardiovascular Risk in Diabetes-Memory in Diabetes (ACCORD-MIND) Investigators (2009). Relationship between baseline glycemic control and cognitive function in individuals with type 2 diabetes and other cardiovascular risk factors: the action to control cardiovascular risk in diabetes-memory in diabetes (ACCORD-MIND) trial. *Diabetes Care*, **32**, 221–226.

de Bruin, V. Am, Vieira, M. C., Rocha, M. N., & Viana, G. S. (2002). Cortisol and dehydroepiandosterone sulfate plasma levels and their relationship to aging, cognitive function, and dementia. *Brain & Cognition*, **50**, 316–323.

Dealberto, M. J., Pajot, N., Courbon, D., & Alpérovitch, A. (1996). Breathing disorders during sleep and cognitive performance in an older community sample: the EVA Study. *Journal of the American Geriatric Society*, **44**, 1287–1294.

Deary, I. J., Whiteman, M. C., Starr, J. M., Whalley, L. J., & Fox, H. C. (2004). The impact of childhood intelligence on later life: Following up the Scottish mental surveys of 1932 and 1947. *Journal of Personality & Social Psychology*, **86**, 30–47.

de Kloet, E. R., Oitzl, M. S., & Joels, M. (1999). Stress and cognition: Are corticosteroids good or bad guys? *Trends in Neuroscience*, **22**, 422–426.

del Ser Quijano, T., Delgado, C., Martı´nez Espinosa, S., & Va´zquez, C. (2000). Cognitive deficiency in mild hypothyroidism. *Neurologia*, **15**, 193–198.

Della Sala, S., Donner, C. F., Sacco, C., & Spinner, H. (1992). Does chronic lung failure lead to cognitive failure? *Archives of Neurology and Psychiatry*, **143**, 343–354.

Denicoff, K. D., Joffe, R. T., Lakshmanan, M. C., Robbins, J., & Rubinow, D. R. (1990). Neuropsychiatric manifestations of altered thyroid state. *American Journal of Psychiatry*, **147**, 94–99.

Dickerson, F., Stallings, C., Sullens, A., Origoni, A., Leister, F., Krivogorsky, B., & Yolken R. (2008). Association between cognitive functioning, exposure to Herpes Simplex virus type 1, and the COMT Val158Met genetic polymorphism in adults without a psychiatric disorder. *Brain, Behavior & Immunity, 22*, **1103**–1107.

Dodd, J. W., Getov, S. V., & Jones, P. W. (2010). Cognitive function in COPD. *European Respiratory Journal*, **35**, 913–922.

Dugbartey, A. T. (1998). Neurocognitive aspects of hypothyroidism. *Archives of Internal Medicine*, **158**, 1413–1418.

Durmer, J. S., & Dinges, D. F. (2005). Neurocognitive consequences of sleep deprivation. *Seminars in Neurology*, **25**, 117–129.

Dye, M. W. G., Hauser, P. C., & Bavelier, D. (2008). Visual attention in deaf children and adults. In M. Marschark & P. C. Hauser (Eds.), *Deaf cognition* (pp. 250–263). New York: Oxford University Press.

Eccleston, C., & Crombez, G. (1999). Pain demands attention: a cognitive-affective model of the interruptive function of pain. *Psychological Bulletin*, **125**, 356–366.

Edlow, J. A. (2003). *Bull's eye: Unraveling the medical mystery of Lyme disease*. New Haven, CT: Yale University Press.

Eidelman, A. I., Hoffman, N. W., & Katz, M. (1993). Cognitive deficits in women after childbirth. *Obstetrics & Gynecology*, **81**, 764–767.

Elias, P. K., Elias, M. F., D'Agostino, R. B., Sullivan, L. M., & Wolf, P. A. (2005). Serum cholesterol and cognitive performance in the Framingham heart study. *Psychosomatic Medicine*, **67**, 24–30.

Elias, M. F., Elias, P. K., Sullivan, L. M., Wolf, P. A., & D'Agostino, R. B. (2003). Lower cognitive function in the presence of obesity and hypertension: the Framingham Heart Study. *International Journal of Obesity & Related Metabolic Disorders*, **27**, 260–268.

Elias, M. F., Wolf, P. A., D'Agostino, R. B., Cobb, J., & White, L. R. (1993). Untreated blood pressure is inversely related to cognitive functioning: The Framingham Study. *American Journal of Epidemiology*, **138**, 353–364.

Elwood, P. C., Pickering, J., Bayer, A., & Gallacher, J. E. (2002). Vascular disease and cognitive function in older men in the Caerphilly cohort. *Age & Ageing*, **31**, 43–48.

Fortune, D. G., Richards, H. L., Corrin, A., Taylor, R. J., Griffiths, C. E. M., & Main, C. J. (2003). Attentional bias for psoriasis-specific and psychosocial threat in patients with psoriasis. *Journal of Behavioral Medicine*, **26**, 211–224.

Gamaldo, A. A., Weatherbee, S. R. & Allaire, J. C. (2008). Exploring the within-person coupling of blood pressure and cognition in elders. *Journal of Gerontology: Psychological Science*, **63**, 386–389.

Gates, G. A., Anderson, M. L., Feeney, M. P., McCurry, S. M., & Larson, E. B. (2008). Central auditory dysfunction in older persons with memory impairment or Alzheimer dementia. *Archives of Otolaryngology – Head & Neck Surgery*, **134**, 771–777.

Gelb, S., Shapiro, R. J., Hill, A., & Thornton, W. L. (2008). Cognitive outcome following kidney transplantation. *Nephrology Dialysis Transplantation*, **23**, 1032–1038.

Ginn, H. E. (1975). Neurobehavioral dysfunction in uremia. *Kidney International Supplement*, **2**, 217–221.

Glass, J. M. (2008). Fibromyalgia and cognition. *Journal of Clinical Psychiatry*, **69** (Suppl. 2), 20–24.

Gotlib, I. H., & Joormann, J. (2010). Cognition and depression: current status and future directions. *Annual Review of Clinical Psychology*, **6**, 285–312.

Gottfredson, L. S., & Deary, I. J. (2001). Intelligence predicts health and longevity, but why? *Current Directions in Psychological Science*, **13**, 1–4.

Grisart, J., Van der Linden, M., & Masquelier, E. (2002). Controlled processes and automaticity in memory functioning in fibromyalgia patients: relation with emotional distress and hypervigilance. *Journal of Clinical & Experimental Neuropsychology: Official Journal of the International Neuropsychological Society*, **24**, 994–1009.

Grunwald, M., Busse, F., Hensel, A., Riedel-Heller, S., Kruggel, F., Arendt, T., Wolf, H., & Gertz, H. J. (2002). Theta-power differences in patients with mild cognitive impairment under rest condition and during haptic tasks. *Alzheimer Disease and Associated Disorders*, **16**, 40–48.

Gunstad, J., Paul, R. H., Cohen, R. A., Tate, D. F., Spitznagel, M. B., & Gordon, E. (2007). Elevated body mass index is associated with executive dysfunction in otherwise healthy adults. *Comprehensive Psychiatry*, **48**, 57–61.

Gunstad, J., Spitznagel, M. B., Paul, R. H., Cohen, R. A., Kohn, M., Luyster, F. S., Clark, R., Williams, L. M., & Gordon, E. (2008). Body mass index and neuropsychological functioning in healthy children and adolescents. *Appetite*, **50**, 246–251.

Gunstad, J., Lhotsky, A., Carrington, R. W., Ferruci, L., & Zonderman, A. B. (2010). Longitudinal examination of obesity and cognitive function: Results from the Baltimore Longitudinal Study of Aging. *Neuroendocrinology*, **34**, 222–229.

Han, L., Agostini, J. V., & Allore, H. G. (2008). Cumulative anticholinergic exposure is associated with poor memory and executive function in older men. *Journal of the American Geriatrics Society*, **56**, 2203–2210.

Harrison, Y., & Home, J. A. (2000). The impact of sleep deprivation on decision making: a review. *Journal of Experimental & Applied Psychology*, **6**, 236–249.

Hart, C. L., Taylor, M. D., Davey Smith, G., Whalley, L. J., Starr, J. M., Hole, D. J., Wilson, V., & Deary, I. J. (2003). Childhood IQ, social class, deprivation, and their relationships with mortality and morbidity risk in later life: Prospective observational study linking the Scottish mental survey 1932 and the midspan studies. *Psychosomatic Medicine*, **65**, 877–883.

Hart, R. P., Wade, J. B., & Martelli, M. F. (2003). Cognitive impairment in patients with chronic pain: the significance of stress. *Current Pain & Headache Reports*, **7**, 116–126.

Hauser, P. C., Lukomski, J., & Hillman, T. (2008). Development of deaf and hard-of-hearing students' executive function. In M. Marschark & P. C. Hauser (Eds.), *Deaf cognition* (pp. 286–308). New York: Oxford University Press.

Hemmingsson, T., von Essen, J., Melin, B., Allebeck, P., & Lundberg, I. (2007). The association between cognitive ability measured at ages 18–20 and coronary heart disease in middle age among men – a prospective study using the Swedish 1969 conscription cohort. *Social Science & Medicine*, **65**, 1410–1419.

Hendrie, H. C., Albert, M. S., Buttersc, M. A., Gaod, S., Knopmane, D. S., Launer, L. J., Yaffeg, K., Cuthbert, B. N., Edwardsi, E., & Wagster, M. V. 2006. The NIH Cognitive and Emotional Health Project: Report of the critical evaluation study committee. *Alzheimer's & Dementia*, **2**, 12–32.

Henry, J. D., & Rendell, P. G. (2007). A review of the impact of pregnancy on memory function. *Journal of Clinical & Experimental Neuropsychology*, **29**, 793–803.

Himashree, G., Banerjee, P. K., & Selvamiinhy, W. (2002). Sleep and performance: recent trends. *Indian Journal of Physiotherapy & Pharmacology*, **46**, 6–24.

Hu, W. T., Murray, J. A., Greenaway, M. C., Parisi, J. E., & Josephs, K. A. (2006). Cognitive impairment and celiac disease. *Archives of Neurology*, **63**, 1440–1446.

Huppert, F. A. (1982). Memory impairment associated with chronic hypoxia. *Thorax*, **37**, 858–860.

Incalzi, R. A., Gemma, A., Marra, C., Muzzolon, R., Capparella, O., & Carbonin, P. (1993). Chronic obstructive pulmonary disease. An original model of cognitive decline. *American Review of Respiratory Disorders*, **148**, 418–424.

Jacobsen, P. B., Garland, L. L., Booth-Jones, M., Donovan, K. A., Thors, C. L., Winters, E., & Grendys, E. (2004). Relationship of hemoglobin levels to fatigue and cognitive functioning among cancer patients receiving chemotherapy. *Journal of Pain & Symptom Management*, **28**, 7–18.

Karnehed, N., Rasmussen, F., Hemmingsson, T., & Tynelius, P. (2006). Obesity and attained education. Cohort study of more than 700 000 Swedish men. *Obesity*, **14**, 421–1428.

Kay, G. (2009). The effects of antihistamines on cognition and performance. *Journal of Allergy and Clinical Immunology*, **105**, 622–627.

Keenan, P. A., Lindamer, L. A., & Jong, S. K. (1995). Menstrual phase-independent retrieval deficit in women with PMS. *Biol Psychiatry*, **38**, 369–377.

Keenan, P. A., Yaldoo, D. T., Stress, M. E., Fuerst, D. R., & Ginsburg, K. A. (1998). Explicit memory in pregnant women. *American journal of Obstetrics & Gynecology*, **179**, 731–737.

Kelly, R. R. (2008). Deaf learners and mathematical problem solving. In M. Marschark & P. C. Hauser (Eds.), *Deaf cognition* (pp. 226–249). New York: Oxford University Press.

Kimura, D., & Hampson, E. (1994). Cognitive pattern in men and women is influenced by fluctuations in sex hormones. *Current Directions in Psychological Science*, **3**, 57–61.

Koob, G. F., & Britton, K. T. (1990). Behavioral effects of corticotropin-releasing factor. In E. B. DeSouza & C. B. Nemeroff (Eds.), *Corticotropin-releasing factor: Basic and Clinical studies of a neuropeptide* (pp. 254–265). Boca Raton, FL: CRC Press.

Kountourasa, J., Tsolakib, M., Bozikib, M., Gavalasa, E., Zavosa, C., Stergiopoulosa, C., Kapetanakisa, N., Chatzopoulosa, D., & Venizelosa, I. (2007). Association between

Helicobacter pylori infection and mild cognitive impairment. *European Journal of Neurology*, **14**, 976–982.

Kozaki, T., & Yasukouchi, A. (2009). Sex differences on components of mental rotation at different menstrual phases. *International Journal of Neuroscience*, **119**, 59–67.

Kramer, A. F., Hahn, S., Cohen, N. J., Banich, M. T., McAuley, E., Harrison, C. R., Chason, J., Vakil, E., Bardell, L., Boileau, R. A., & Colcombe, A. (1999). Aging, fitness and neurocognitive function. *Nature*, **400**, 418–419.

Kreitler, S. (2005). Coping and quality of life in the context of physical diseases. In A. V. Lee (Ed.), *Coping with disease* (pp. 81–120). New York: Nova Biomedical Books.

Kreitler, S., & Kreitler, M. M. (2007). Psychological approaches to treatment of pain: Sensory, affective, cognitive, and behavioral. In S. Kreitler, D. Beltrutti, A. Lamberto, & D. Niv (Eds.), *Handbook of chronic pain* (pp. 299–322). New York: Nova Science.

Kreitler, S., & Niv, D. (2007). The effects of chronic pain on cognitive functioning. *Pain: Clinical Update*, **15**, 1–4.

Kuh, D., Richards, M., Hardy, R., Butterworth, S., & Michael, E. J. (2003). Childhood cognitive ability and deaths up until middle age: a post-war birth cohort study. *International Journal of Epidemiology*, **33**, 408–413.

Lawal, A., Kern, M., Sidhu, H., Hofmann, C., & Shaker, R. (2006). Novel evidence for hypersensitivity of visceral sensory neural circuitry in irritable bowel syndrome patients. *Gastroenterology*, **130**, 26–33.

Lee, B. K., Glass, T. A., McAtee, M. J., Wand, G. S., Bandeen-Roche, K., Bolla, K. I., & Schwartz, B. S. (2007). Associations of salivary cortisol with cognitive function in the Baltimore memory study. *Archives of General Psychiatry*, **64**, 810–818.

Li, Y., Dai, Q., Jackson, J. C., & Zhang, J. (2008). Overweight is associated with decreased cognitive functioning among school-age children and adolescents. *Obesity*, **16**, 1809–1815.

Luine, V. N. (2008). Sex steroids and cognitive function. *Journal of Neuroendocrinology*, **20**, 866–872.

Luine, V., Martinez, C., Villegas, M., Magarinos, A. M., & McEwen, B. S. (1996). Restraint stress reversibly enhances spatial memory performance. *Physiology & Behavior*, **59**, 27–32.

Lupien, S. J., Gillin, C. J., & Hauger, R. L. (1999). Working memory is more sensitive than declarative memory to the acute effects of corticosteroids: A dose-response study in humans. *Behavioral Neuroscience*, **113**, 420–430.

Madden, D. J., Langley, L. K., Thurston, R. C., Whiting, W. L., & Blumenthal, J. A. (2003). Interaction of blood pressure and adult age in memory search and visual search performance. *Aging, Neuropsychology & Cognition*, **10**, 241–254.

Malhotra, R. K., & Desai, A. K. (2010). Healthy brain aging: What has sleep got to do with it? *Geriatric Medicine*, **26**, 45–56.

Marschark, M., & Hauser, P. C. (Eds.), *Deaf cognition* (pp. 226–249). New York: Oxford University Press.

Marshall, P. S., O'Hara, C., & Steinberg, P. (2000). Effects of seasonal allergic rhinitis on selected cognitive abilities. *Annals of Allergy Asthma & Immunology*, **84**, 403–410.

Martin, L. T., Fitzmaurice, G. M., Kindlon, D. J., & Buka, S. L. (2004). Cognitive performance in childhood and early adult illness: a prospective cohort study. *Journal of Epidemiology and Community Health*, **58**, 674–679.

McCall, R. B. (1979). The development of intellectual functioning in infancy and the prediction of later IQ. In J. D. Osofsky (Ed.), *Handbook of infant development* (pp. 707–741). New York: Wiley.

Metzger, R. L., Miller, M. L., Cohen, M., Sofka, M., & Borkovec, T. D. (2006). Worry changes decision making: The effect of negative thoughts on cognitive processing. *Journal of Clinical Psychology*, **46**, 78–88.

Meyers, C. A., & Perry, J. R. (2008). *Cognition and cancer*. New York: Cambridge University Press.

Miller, K. J., Parsons, T. D., Whybrow, P. C., Van Herle, K., Rasgon, N., Van Herle, A., Martinez, D., Silverman, D. H., & Bauer, M. (2007). Verbal memory retrieval deficits associated with untreated hypothyroidism. *Journal of Neuropsychiatry & Clinical Neurosciences*, **19**, 132–136.

Moller, J. T., Cluitmans, P., Rasmussen, L. S., Houx, P., Rasmussen, H., Canet, J., Rabbitt, P., Jolles, J., Larsen, K., Hanning, C. D., Langeron, O., Johnson, T., Lauven, P. M., Kristensen, P. A., Biedler, A., Beem, H. van, Fraidakis, O., Silverstein, J. H., Beneken, J. E. W., Gravenstein, J. S. for the ISPOCD investigators. (1998). Long-term postoperative cognitive dysfunction in the elderly: ISPOCD1 study. *Lancet*, **351**, 857–861.

Moser, D. J., Cohen, R. A., Clark, M. M., Aloia, M. S., Tate, B. A., Stefanik, S., Forman, D. E., & Tilkemeier, P. L. (1999). Neuropsychological functioning among cardiac rehabilitation patients. *Journal of Cardiopulmonary Rehabilitation*, **19**, 91–97.

Moss, M., Franks, M., Briggs, P., Kennedy, D., & Scholey, A. (2005). Compromised arterial oxygen saturation in elderly asthma sufferers results in selective cognitive impairment. *Journal of Clinical & Experimental Neuropsychology*, **27**, 139–150.

Motta, M., Sorace, S., Restuccia, S., Carnazzo, G., Corrao, G., Seminara, G., & Maugeri, D. (1996). Cognitive impairment in the elderly diabetics. *Archives of Gerontology & Geriatrics*, **22** (Suppl. 1), 43–46.

Munshi, M., Grande, L., Hayes, M., Ayres, D., Suhl, E., Capelson, R., Lin, S., Milberg, W., & Weinger, K. (2006). Cognitive dysfunction is associated with poor diabetes control in older adults. *Diabetes Care*, **29**, 1794–1799.

Newcomer, J. W., Craft, S., Hershey, T., Askins, K., & Bardgett, M. E. (1994). Glucocorticoid induced impairment in declarative memory in adult humans. *Journal of Neuroscience*, **14**, 2047–2053.

Niv, D., & Kreitler, S. (2001). Pain and quality of life. *Pain Practice*, **1**, 150–161.

Osberg, J. W., Meares, G. J., McKee, D. C., & Burnett, G. B. (1982). Intellectual functioning in renal failure and chronic dialysis. *Journal of Chronic Diseases*, **35**, 445–457.

Osler, M., Andersen, A. M., Due, P., Lund, R., Damsgaard, M. T., & Holstein, B. E. (2003). Socioeconomic position in early life, birth weight, childhood cognitive function, and adult mortality. A longitudinal study of Danish men born in 1953. *Journal of Epidemiology & Community Health*, **57**, 681–686.

Phillips, N. A., & Mate-Kole, C. C. (1997). Cognitive deficits in peripheral vascular disease. A comparison of mild stroke patients and normal control subjects. *Stroke*, **28**, 777–784.

Phillips, N. A., Mate-Kole, C. C., & Kirby, R. L. (1993). Neuropsychological function in peripheral vascular disease amputee patients. *Archives of Physical Medicine & Rehabilitation*, **74**, 1309–1314.

Ploughman, M. (2008). Exercise is brain food: the effects of physical activity on cognitive function. *Developmental Neurorehabilitation*, **11**, 236–240.

Poser, C. M., Kassirer, M. R., & Peyser, J. M. (1986).Benign encephalopathy of pregnancy. *Acta Neurologica Scandinavica*, **73**, 39–43.

Posserud, I., Svedlund, J., Wallin, J., & Simrén, M. (2009). Hypervigilance in irritable bowel syndrome compared with organic gastrointestinal disease. *Journal of Psychosomatic Research*, **66**, 399–405.

Postma, A., Winkel, J., Tuiten, A., & van Honk, J. (1999). Sex differences and menstrual cycle effects in human spatial memory. *Psychoneuroendocrinology*, **24**, 175–192.

Price, C. C., Garvan, C. W., & Monk, T. G. (2008). Type and severity of cognitive decline in older adults after noncardiac surgery. *Anesthesiology*, **108**, 8–17.

Puccio, D., Novo, G., Baiamonte, V., Nuccio, A., Fazio, G., Corrado, E., Coppola, G., Muratori, I., Vernuccio, L., & Novo, S. (2009). Atrial fibrillation and mild cognitive impairment: what correlation? *Minerva Cardiologica*, **57**, 143–150.

Rafnsson, S. B., Deary, I. J., Smith, F. B., Whiteman, M. C., & Fowkes, F. G. (2007). Cardiovascular diseases and decline in cognitive function in an elderly community population: the Edinburgh Artery Study. *Psychosomatic Medicine*, **69**, 425–434.

Rao S.M. (1995). Neuropsychology of multiple sclerosis. *Current Opinion in Neurology*, **8**, 216–220.

Rao, S. M., Leo, G. J., Bernardin, L., & Unverzagt, F. (1991). Cognitive dysfunction in multiple sclerosis. I. Frequency, patterns, and prediction. *Neurology*, **41**, 685–691.

Richards, M., Hardy, R., Kuh, D., & Wadsworth, M. (2001). Birthweight and cognitive function in the British 1946 birth cohort. *British Medical Journal*, **322**, 199–202.

(2002). Postnatal growth and cognitive function in a national UK birth cohort. *International Journal of Epidemiology*, **31**, 342–348.

Richards, M., Hardy, R., & Wadsworth, M. (2003). Does active leisure protect cognition? Evidence from a national birth cohort. *Social Science and Medicine*, **56**, 785–792.

Rinn, W., Desai, N., Rosenblatt, H., & Gastfried, D. R. (2002). Addiction denial and cognitive dysfunction: A preliminary investigation. *Journal of Neuropsychiatry & Clinical Neurosciences*, **14**, 52–57.

Rösche, J., Uhlmann, C., & Fröscher, W. (2010). Kognitive Defizite und psychiatrische Störungen in Frühstadien epileptischer Erkrankungen [Cognitive deficits and psychiatric disorders in patients with new-onset epilepsy.] *Fortschritte Der Neurologie-Psychiatrie*, **78**, 18–26.

Rossiter, S., Stevens, C., & Walker, G. (2006). Tinnitus and its effect on working memory and attention. *Journal of Speech, Language, and Hearing Research*, **49**, 150–160.

Ryan, M. R., & Geckle, M. (2000). Why is learning and memory dysfunction in Type 2 diabetes limited to older adults? *Diabetes/Metabolism Research & Reviews*, **16**, 308–315.

Sauvé, M. J., Lewis, W. R., Blankenbiller, M., Rickabaugh, B., & Pressler, S. J. (2009). Cognitive impairments in chronic heart failure: A case controlled study. *Journal of Cardiac Failure*, **15**, 1–10.

Schafer, J. H., Glass, T. A., Bolla, K. I., Mintz, M., Jedlicka, A. E., & Schwartz, B. S. (2005). Homocysteine and cognitive function in a population-based study of older adults. *American Geriatric Society*, **53**, 381–388.

Schilder, C., Schagen, S., & van Dam, F. (2008). Effects of hormones and hormonal treatment on cognition. In C. A. Meyers & J. R. Perry (Eds.), *Cognition and cancer* (pp. 115–141). New York: Cambridge University Press.

Schulz-Kindermann, F., Mehnert, A., Scherwath, A., Schirmer, L., Schleimer, B., Zander, A. R., & Koch, U. (2007). Cognitive function in the acute course of allogeneic hematopoietic stem cell transplantation for hematological malignancies. *Bone Marrow Transplantation*, **39**, 789–799.

Selnes, O. A., Grega, M. A., Bailey, M. M., Pham, L. D., Zeger, S. L., Baumgartner, W. A., & McKhann, G. M. (2009). Do management strategies for coronary artery disease influence 6-year cognitive outcomes? *Annals of Thoracic Surgery*, **88**, 445–454.

Sharp, K., Brindle, P. M., Brown, M. W., & Turner, G. M. (1993). Memory loss during pregnancy. *British Journal of Obstetrics & Gynecology*, **100**, 209–215.

Shaw, E. G., & Robbins, M. E. (2008). Biological bases of radiation injury to the brain. In C. A. Meyers & J. R. Perry (Eds.), *Cognition and cancer* (pp. 83–96). New York: Cambridge University Press.

Shaw, P. J., Bates, D., Cartlidge, N. E. F., French, J. M., Heaviside, D., Julian, D. G., & Shaw, D. A. (1987). Long-term intellectual dysfunction following coronary artery bypass graft surgery: a six month follow-up study. *Quarterly Journal of Medicine*, **62**, 259–268.

Sherwin, B. B., & Henry, J. F. (2008). Brain aging modulates the neuroprotective effects of estrogen on selective aspects of cognition in women: a critical review. *Front Neuroendocrinology*, **29**, 88–113.

Silber, M., Almkvist, O., Larsson, B., & Uvnas-Moberg, K. (1990). Temporary peripartal impairment in memory and attention and its possible relation to oxytocin concentration. *Life Science*, **47**, 57–65.

Singh-Manoux, A., Britton, A. R., & Marmot, M. (2003). Vascular disease and cognitive function: evidence from the Whitehall II study. *Journal of the American Geriatric Society*, **51**, 1445–1450.

Singh-Manoux, A., Lajnef, S. S. M., Ferrie, J. E., Nabi, H., Britton, A. R., Marmot, M. G., & Shipley, M. J. (2008). History of coronary heart disease and cognitive performance in midlife: the Whitehall II study. *European Heart Journal*, Advance Access published on July 22, 2008. *doi:10.1093/eurheartj/ehn298*.

Solomon, A., Kåreholt, I., Ngandu, T., Wolozin, B., MacDonald, S., Winblad, B., Nissinen, A. Tuomilehto, J., Soininen, H., & Kivipelto, M. (2009). Serum total cholesterol, statins and cognition in non-demented elderly. *Neurobiology of Aging*, **30**, 1006–1009.

Sørensen, T. I. A., & Sonne-Holm, S. (1985). Intelligence test performance in obesity in relation to educational attainment and parental social class. *Journal of Biosocial Science*, **17**, 379–387.

Spencer, C., Morsley, K., Ungar, S., Pike, E., & Blades, M. (1992). Developing the blind child's cognition of the environment: the role of direct and map-given experience. *Geoforum*, **23**, 191–197.

Spencer, J. P., Vauzour, D., & Rendeiro, C. (2009). Flavonoids and cognition : The molecular mechanisms underlying their behavioral effects. *Archives of Biochemistry & Biophysics*, **492**, 1–9.

Starkman, M. N., Giordani, B., Berent, S., Schork, M. A., & Schteingart, D. E. (2001). Elevated cortisol levels in Cushing's disease are associated with cognitive decrements. *Psychosomatic Medicine*, **63**, 985–993.

Stuss, D. T., Peterkin, I., Guzman, D. A., Guzman, C., & Troyer, A. K. (1997). Chronic obstructive pulmonary disease: Effects of hypoxia on neurological and neuropsychological measures. *Journal of Clinical Experimental Neuropsychology*, **19**, 515–524.

Trompet, S., van Viet, P., de Craen, A. J. et al. (2010). Pravastatin and cognitive function in the elderly. Results of the PROSPER study. *Journal of Neurology*, **257**, 85–90.

Tsivgoulis, G., Alexandrov, A. V., Wadley, V. G., Unverzagt, F. W., Go, R. C. P., Moy, C. S., Kissela, B., & Howard, G. (2009). Association of higher diastolic blood pressure levels with cognitive impairment. *Neurology*, **73**, 589–595.

Vardy, J., Wefel, J. S., Ahles, T., Tannock, I. F., & Schagen, S. B. (2010). Cancer and cancer-therapy related cognitive dysfunction: an international perspective from the Venice cognitive workshop. *Annals of Oncology*, **19**, 623–629.

Vogels, R. L. C., Scheltens, P., Schroeder-Tanka, J. M., & Weinstein, H. C. (2006). Cognitive impairment in heart failure. *European Journal of Heart Failure*, **9**, 440–409.

Volkow, N. D., Wang, G.-J., Telang, F., Fowler, J. S., Goldstein, R. Z., Alia-Klein, N., Logan, J., Wong, C., Thanos, P. K., Ma, Y., & Pradhan, K. (2009). Inverse association between BMI and prefrontal metabolic activity in healthy adults. *Obesity*, **17**, 60–65.

Vollset, S. E., & Ueland, P. M. (2005). B vitamins and cognitive function: do we need more and larger trials? *American Journal of Clinical Nutrition*, **81**, 951–952.

Vuurman, E. F., van Veggel, L. M., Uiterwijk, M. M., Leutner, D., & O'Hanlon, J. F. (1993). Seasonal allergic rhinitis and antihistamine effects on children's learning. *Annals of Allergy*, **71**, 121–126.

Wakefield, C. E., Homewood, J., & Taylor, A. J. (2006). Early blindness may be associated with changes in performance on verbal fluency tasks. *Journal of Visual Impairment and Blindness*, **100**, 306–310.

Waldstein, S. R., & Katzel, L. I. (2001). Hypertension and cognitive functioning. In S. R. Waldstein & M. F. Elias (Eds.*), Neuropsychology of cardiovascular disease* (pp. 15–36). Mahwah, NJ: Lawrence Erlbaum.

Walker, S., Khan-Wasti, S., Fletcher, M., Cullinan, P., Harris, J., & Sheikh, A. (2007). Seasonal allergic rhinitis is associated with a detrimental effect on examination performance in United Kingdom teenagers: case-control study. *Journal of Allergy & Clinical Immunology*, **120**, 381–387.

Wefel, J. F., Collins, R., & Kayl, A. E. (2008). Cognitive dysfunction related to chemotherapy and biological response modifiers. In C. A. Meyers & J. R. Perry (Eds.), *Cognition and cancer* (pp. 97–114). New York: Cambridge University Press.

Wengreen, H. J., Neilson, C., Munger, R., & Corcoran, C. (2009). Diet quality is associated with better cognitive test performance among aging men and women. *Journal of Nutrition*, **139**, 1944–1949.

Whalley, L.J., & Deary, I.J. (2001). Longitudinal cohort study of childhood IQ and survival up to age 76. *British Medical Journal*, **322**, 1–5.

Williamson, J. D., Espeland, M., Kritchevsky, S. B., Newman, A. B., King, A. C., Pahor, M., Guralnik, J. M., Pruitt, L. A., & Miller, M. E. (2009). Changes in cognitive function in a randomized trial of physical activity: Results of the lifestyle interventions and independence for elders pilot study. *Journals of Gerontology. Series A, Biological Sciences & Medical Sciences*, **64**, 688–694.

Wilson, R. S., Schneider, J. A., Arnold, S. E., Tang, Y., Boyle, P. A., & Bennett, D. A. (2007). Olfactory identification and incidence of mild cognitive impairment in older age. *Archives of General Psychiatry*, **64**, 802–808.

Wingfield, A., Tun, P. A., & McCoy, S. L. (2005). Hearing loss in older adulthood: What it is and how it interacts with cognitive performance. *Current Directions in Psychological Science*, **14**, 144–148.

Wolkowitz, O. M., Reus, V. I., Weingartner, H., Thompson, K., Breier, A., Doran, A., Rubinow, D., & Pickar, D. (1990). Cognitive effects of corticosteroids. *American Journal of Psychiatry*, **147**, 1297–1303.

Zamboni, V., Cesari, M., Zuccal, G., Onder, G., Woodman, R. C., Maraldi, C., Ranzini, M., Volpato, S., Pahor, M., Bernabei, R. (2006). Anemia and cognitive performance in hospitalized older patients: results from the GIFA study. *International Journal of Geriatric Psychiatry*, **21**, 529–534.

PART II

DOMAINS OF COGNITION IN CONTEXT

13

Motivation, Goals, Thinking, and Problem Solving

Ken J. Gilhooly & Evridiki Fioratou

INTRODUCTION

Problem solving and motivation are closely intertwined, as is indicated by the classic definition of a problem situation from Duncker (1945, p. 1), "A problem arises when a living organism has a goal but does not know how this goal is to be reached." Before proceeding further, we will briefly discuss some definitional issues and consider the relationships between goals and motives.

Austin and Vancouver (1996, p. 338) proposed that goals be defined as "internal representations of desired states." In a broad sense, a goal reflects a preference for some proposition to be true versus not true (e.g., the goal to have more money tomorrow than today reflects a preference for "having more money tomorrow" to be true rather than false). According to one dictionary definition (Chambers, 1962), "a motive is a consideration that excites to action (from the Latin, *movere*, to move)." Motives and goals are clearly very closely related concepts in that both involve representations of desired states. Austin and Vancouver made the useful suggestion that goals can vary in degree of specificity or abstractness and that more abstract goals, such as Need for Cognition (Caccioppo et al., 1996) or Achievement Need (Atkinson, 1964), are usefully labelled as motives and more specific representations of desired states should be labelled as goals. If a motive is to lead to action, it would seem that it must ultimately lead to the activation of a specific goal representation, which can then play a role in initiating and controlling behaviour. Research on problem solving tends to theorise at the level of goals rather than at the level of very broad motives (which are dealt with largely in personality and motivational psychology).

Goals can be said to vary in terms of structure and content (Austin & Vancouver, 1996). *Content* refers to what desired state is represented by the goal, and can vary essentially infinitely in detail. Austin and Vancouver propose a taxonomy of goal *content*, which yields approximately 30 broad categories of goals such as happiness, understanding, safety, material gain, and so forth. Structurally, goals are generally seen as organised into hierarchies from more general to more specific, where the specific goals serve their "supergoals" above them in the hierarchy and in turn have yet more specific subgoals beneath them in the hierarchy. As we discuss later, a major category of problem-solving processes, known as "problem reduction" processes, generate hierarchies of ever more-specific goals from starting goals in the light of problem contents. Further, Austin and Vancouver pointed out that goals can vary in terms of a number of structural dimensions including specificity (or concreteness) as indicated above, difficulty, temporal range (next few seconds v. years), whether conscious or not, and importance (how strongly desired the goal state is).

Behaviourists in the early years of the twentieth century tended to downplay the notion that goals were useful concepts because goals were regarded as mentalistic concepts that suggested discredited teleological explanations against preferred causal explanations. However, developments in cybernetics (Wiener, 1948) and computer systems in the mid-twentieth century indicated that goals could be incorporated into fully specified deterministic systems that carried out complex information processing (from guiding missiles to playing chess at a high level). These demonstrations were invoked by the pioneers of the information-processing approach who launched the cognitive revolution in psychology in the late 1950s and early 1960s. Key work in developing and promoting computer models and analogies for human problem solving was carried out by Simon and colleagues (e.g., Newell, Shaw, & Simon, 1958) with their Logic Theorist and General Problem Solver programs (Newell & Simon, 1963), both of which instantiated goal processing during problem solving. The general idea of higher-level cognition as goal-driven information processing was further promoted by Miller, Galanter, and Pribram's (1960) very influential monograph, *Plans and the Structure of Behavior*. In this book, the idea of explaining behaviour by means of hierarchically organised goal-driven units known as Test-Operate-Test-Exit (TOTE) units, such that the Operate stage could itself be a TOTE unit and so on, was set out persuasively.

The Test phase was essentially a test to determine whether a particular goal condition had been met. If the goal condition was not met, the associated Operation (which could be composed of yet more TOTE units) would be repeated and the results tested again for compliance with the goal condition. When the goal condition for an active TOTE was met, then control would pass to the next TOTE. In this way, complex hierarchically organised plans could be built up from simple units.

Simon (1967) addressed criticisms, particularly from Neisser (1963), regarding the degree to which such information-processing models could deal with multiple goals, and motivational and emotional aspects of cognition. Simon proposed two central assumptions about the information processing system. It is (a) organised in a serial fashion; and (b) regulated by a "tightly organized hierarchy of goals." Serial organisation means that "only a few things go on at a time". A hierarchical organisation is one in which, "More macroscopic processes are synthesized from sequences of elementary processes" (Simon, 1967, p. 30), and these macroscopic processes can be thought of as akin to programs, which can call other programs so that a large amount of nesting of processes is possible. Simon argued that motivation was the mechanism by which a tightly organised goal hierarchy is created and controlled. Motivation controls attention, the ordering of the goal hierarchy, goal prioritisation, and the criteria for determining when a goal is complete (e.g., satisficing or impatience). Simon further proposed that emotion is an interrupt system that causes the system to switch to highly time-pressing goals (e.g., escape a source of fear that has suddenly arisen).

Simon pointed out that conditions are needed for programs to terminate and return control to the next higher level. Possible mechanisms for terminating are: (a) *aspiration achievement* – the subgoal has been achieved; (b) *satisficing* – the state reached is satisfactory, if not ideal; (c) *impatience* – enough time has been expended; and (d) *discouragement* – the task is too difficult and is to be abandoned.

So far, goals have been discussed in terms of single states to be reached. However, often motives are mixed and multiple goals may be sought simultaneously (e.g., seeking a pleasant, affordable, convenient restaurant for a three-course dinner with wine rather than just eating anything to satisfy the goal of reducing a hunger state). Attention to multiple goals in information-processing models can be achieved through at least two mechanisms: (a) *queuing* of goals by priority ordering; and (b) use of *multifaceted criteria*, in which two goals are combined so that Task A and Task B can be collapsed under the single goal "Complete tasks A and B."

In the remainder of this chapter, we will largely be reviewing work in the cognitivist, information-processing tradition, as outlined above, which has been dominant since the early 1960s. On this view, thinking is an internal symbolic exploration of possible representations of the world and can be tightly directed by a specific pressing active goal or relatively undirected when no current goal is active. *Directed thinking* aimed at problem solving is driven by goals, and hence is clearly motivated. When no goals are currently active, then *undirected thinking* of the type often called daydreaming tends to arise. However, even undirected thinking is normally influenced by motives and current concerns rather than being purely driven by associations (Klinger, 1978). In the main part of this chapter, we will discuss the detailed role of goals in problem solving, goals and motivation in expert and creative thinking, and the roles of intrinsic and extrinsic motivation in problem solving and creative thinking.

GOALS IN PROBLEM-SOLVING PROCESSES

Sometimes pre-learned or instinctive behaviours will be elicited by goal states and no thinking or problem solving is required. Our focus is on situations where there are no pre-learned or instinctive behaviours available to meet a current active goal. Such cases match Duncker's (1945) classic definition of a problem arising when an organism has a goal but does not know how the goal can be reached. In such a case, problem solving is an adaptive reaction and involves a search for a suitable action or sequence of actions. We will now discuss the role of goals in generation of possible actions and in evaluation of possible actions against closeness of consequences to goal state. Our focus will be on well-defined problems in which the starting state of the problem, the goal state, and the possible actions are well specified. Most problem-solving research has concerned this type of problem. Less well-defined problems are common in the real world (e.g., how can one improve one's quality of life?). In such cases, the initial steps typically involve attempting to convert the ill-defined problem into a well defined one and then proceeding from the well-defined version (Kochen & Badre, 1974). In the example just given, a first step would be to decide on how quality of life could be measured (e.g., by income, job satisfaction, health, relationships, and so on) and what restrictions there might be on possible actions (e.g., legal, physically possible, not overly time-consuming, and so on). Thus, the study of search for solutions in well-defined problems is also relevant to the search stage of ill-defined problems that follows the definition stage.

There are two broad approaches to searching for solutions in well-defined problems: (1) *forward search* through possible sequences of actions and (2) *problem reduction,* in which the overall goal is decomposed into ever more-specific subgoals. The classic Hobbits and Orcs task (Thomas, 1974) is typically approached by means of a forward search. In this task, the goal is to transport three hobbits and three orcs from one side of a river to the other using a boat that can hold up to two creatures, without ever allowing hobbits to be outnumbered by orcs on either side of the river. At least one creature must be in the boat for it to cross the river. The number of legal moves at each state of the problem is very limited. Figure 13.1 lays out the possible states and moves in this task. It appears that people generally choose which move to execute at each choice point by assessing which move will lead to a state closest to the goal state. The degree of looking ahead is typically just one step. This type of procedure is sometimes known as *hill-climbing,* by analogy with a method of climbing a hill in a thick fog by testing out one step in each of the four principal directions and taking the step that leads to the highest ground. To apply hill-climbing in well-defined tasks, an evaluation function is applied to possible states in order to index closeness to the goal. A possible evaluation function in the Hobbits and Orcs problem would be to count the number of creatures on the target side and use the resulting score to indicate which move to execute at each step (choose the move that leads to the highest scoring state). A simple application of this type of approach can lead to difficulties with problems that require a *detour,* in that the sequence of states leading to solution do not yield monotonically increasing evaluations. The Hobbits and Orcs problem is a detour problem because there is a state which has four creatures on the target side, but the solution requires moving from that apparently promising state to an apparently less promising state with only two creatures on the target side. As would be predicted, if people are using forward search guided by a simple evaluation function for this task, the state from which a detour is needed for progress causes marked difficulties in terms of latencies and error moves (Thomas, 1974). Many solvers initially go backwards from the detour state and then must retrace their steps. To avoid perpetual looping, some memory for previous moves must be postulated, with extra rules about avoiding previously visited states. This need for memory-guided search is particularly strong in problems that permit a great deal of looping such as Water Jars (Atwood, Masson, & Polson, 1980). More recently, forward search guided by goal-based evaluation functions has been shown to be implicated in the difficulties engendered by a number of classic insight tasks such as the 9-dot problem (Chronicle, MacGregor, & Ormerod, 2004). In such tasks, some redefinition of the problem is typically required, but initial attempts within the normal "obvious" interpretation typically show a hill-climbing pattern, and it is only after repeated failures of the hill-climbing approach that problem redefinition or restructuring is likely to occur.

Forward search guided by a goal-based evaluation function to assess possible intermediate states seems most common when problems are well-defined and few actions are possible at each state. In tasks where there are many possible actions (which is often the case for ill-defined or only partially well-defined tasks) or in which simple evaluation functions are not helpful, a problem-reduction approach is often adopted. In this approach, the overall

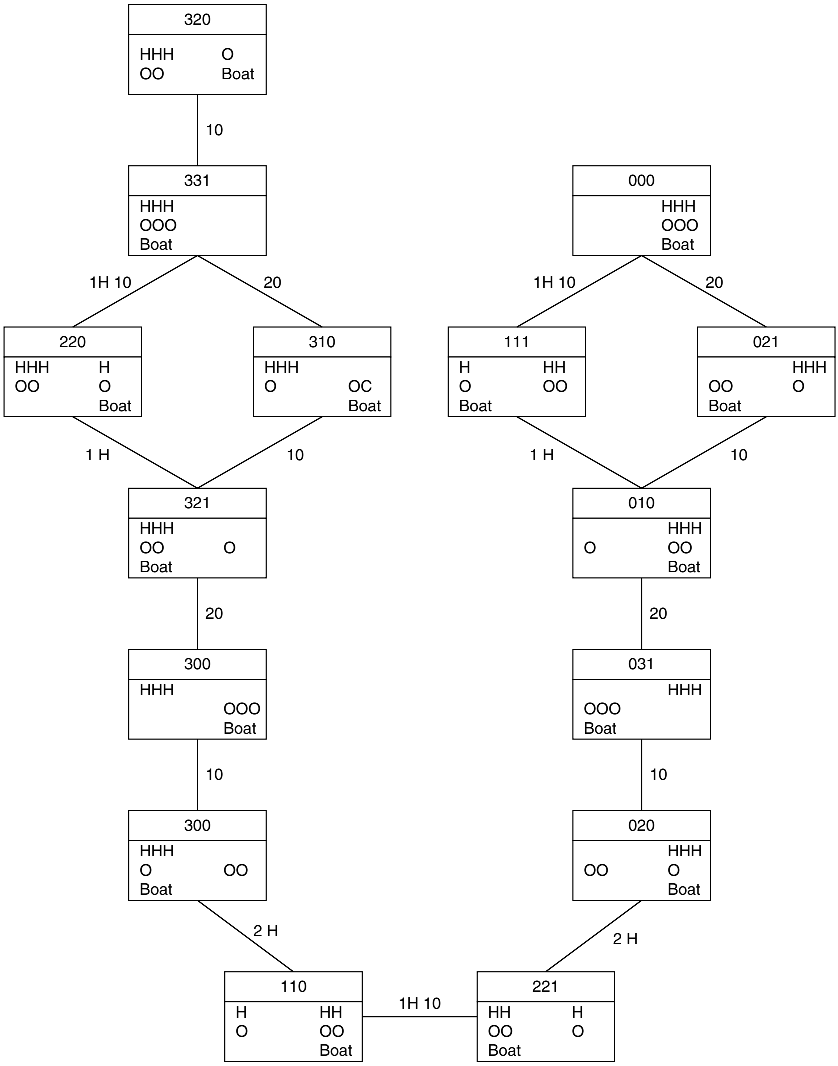

FIGURE 13.1. Problem-space figure for the Hobbits and Orcs problem.
Note: The figure above sets out all the possible moves that can be made and resultant states, given that the boat can only hold two creatures and Hobbits must never be outnumbered by Orcs. The starting state of the problem is the second state down from the top. The solver does not have the layout below, but rather sees only one state at a time and must imagine possible moves and choose amongst such moves. When a move is made the next state is displayed. The number Hs and Os on the left- and right-hand side of each box indicate the number of Hobbits and Orcs on each side of the river at any given time.

goal is progressively specified into subgoals, which in turn are specified further into still lower-level subgoals. In complex tasks, many alternative subgoals will often need exploration before solution. An everyday example of problem reduction is that of making travel plans. The overall goal is to be at a distant place. Means are sought to reduce the distance between where one is and where one wishes to be, such as using a commercial flight. To apply such a means, a new goal (subgoal) is established of meeting the conditions needed to take a flight (be at airport, have valid ticket, etc). These subgoals in turn generate new subgoals, until immediately actionable subgoals are generated (e.g., logon to internet to make booking). The generation of subgoals proceeds by a process of *means-ends* analysis. Goals or ends lead to subgoals (means), which in turn act as ends to generate further subgoals. This approach was instantiated in Newell and Simon's (1963) General Problem Solver program, and is evident in later programs such as Newell's (1992) SOAR.

Duncker's (1945) study of the X-ray task provides a laboratory example of problem reduction in a task with some ill-defined elements (particularly regarding possible actions). Participants are to find a way of using X-radiation to destroy a tumour in the middle of a patient without destroying healthy tissue around the tumour. Thinking-aloud records indicated a strong tendency to use a problem-reduction approach. For example, a participant suggested that the major goal of "treating the tumour by rays without destroying healthy tissue" could be reached by means of the subgoal of "avoiding contact between rays and healthy tissue" and this could perhaps be achieved via a subgoal of "using a cannula" or a subgoal of "reaching tumour through the esophagus". The "avoiding contact" subgoal was unproductive and had to be abandoned for the subgoal of "lowering intensity of rays on their way through the healthy tissue", which led to the solution "use a lens to concentrate a bundle of weak rays on the tumour" (Figure 13.2).

The Tower of Hanoi provides an example of a well-defined problem in which simple evaluation functions are not clearly available or helpful. In this task (see Figure 13.3), one is presented with three vertical rods or pegs on one of which are *n* discs assembled in order of size with the largest at the bottom and the smallest on top. The goal is to move the entire assembly of discs from the starting peg to a target peg, moving one disc at a time and never putting a larger disc on top of a smaller disc. The non-target peg is to be used for temporary storage. With *n* discs, the number of moves required increases rapidly according to the function $2^n - 1$, so the 3-disc version in Figure 13.3 requires 7 moves, a 4-disc version requires 15 moves, a 5-disc version requires 31 moves, a 6-disc version 63 moves, and so on. Although naïve solvers do often begin trying a hill-climbing approach (Anzai & Simon,

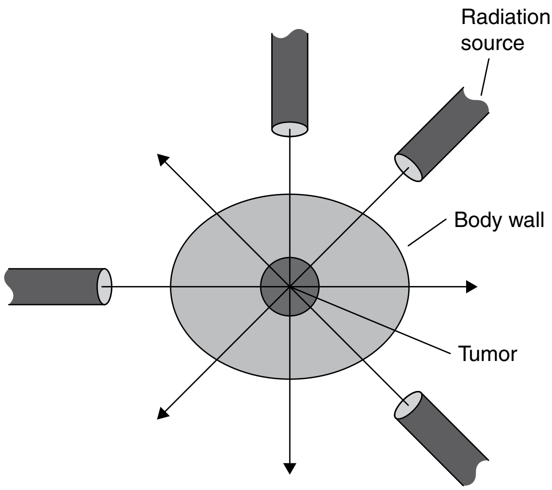

FIGURE 13.2. Solution of Duncker's X-ray problem.

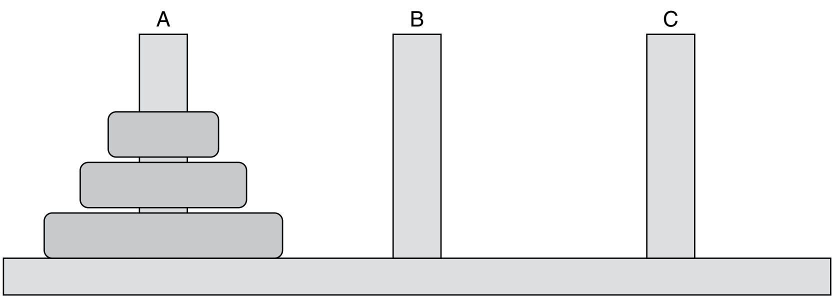

FIGURE 13.3. Three-disc Tower of Hanoi. Move all discs from peg A to peg C, one disc at a time, and never put a larger disc on top of a smaller disc.

1979), this is generally superseded by a problem-reduction approach, probably because until very near the end obvious evaluation functions do not discriminate between good and poor moves. A number of studies (Simon, 1975) have found strong signs of problem reduction as the preferred approach in this task. In the problem-reduction approach, the overall goal of the Tower of Hanoi task is reduced to three major subgoals: first, move the pyramid of *n*-1 discs to the holding peg; second, move the largest disc to the target; third, move the pyramid of *n*-1 discs to the target. The first and last subgoal are themselves Tower of Hanoi tasks that can be reduced again in the same way … and so on. Simon (1975) labelled this type of procedure, in which larger goals are reduced to smaller versions of the same goals, a "problem recursion" strategy. A process-tracing study by Luger (1976), which tracked participants' moves through the Tower of Hanoi problem space, found that participants generally follow goal-directed paths in that successive steps approach a goal or subgoal, and when a subgoal is reached the next steps address a new subgoal.

In summary, goals play a crucial role in the course of problem-directed thinking by guiding the selection of possible actions towards a solution in forward search (e.g., by hill-climbing) or by the development of subgoal structures (in problem reduction) that lead to useful actions relevant to overall goal achievement. In the next section, we consider the longer-term impact of enduring motivations in the development of problem-solving skills in expertise and creativity.

EXPERT SOLVING, CREATIVITY, AND MOTIVATION

So far, we have considered the short-term role of goals in problem-solving episodes, particularly in tasks that require little background knowledge (*knowledge-lean* tasks). Since De Groot's (1965) pioneering studies of chess experts, there has been a growing interest in expert solving of *knowledge-rich* problems. Short-term goals and subgoals that arise within a given episode are important in expert as well as nonexpert problem solving, but accumulated domain knowledge will permit better generation of subgoals and evaluations of intermediate positions. The nature of expert problem solving involves application of a large body of prior knowledge to perceive or structure the problem differently than the beginner. De Groot (1965) developed the paradigm of testing memory for briefly presented random versus meaningful materials and showed, in the chess domain, that experts recalled meaningful patterns much better than novices, but showed no advantage with random patterns. This result indicates superior pattern identification by the experts, permitting larger chunks to be rapidly stored in (long-term) working memory (Ericsson & Kintsch, 1995). Similar results have been found in many different areas of expertise such as the games of GO (Eisenstadt & Kareev, 1977) and Bridge (Charness, 1979), programming (Adelson, 1981), and map-reading (Gilhooly et al., 1988). Experts use their greater background knowledge to structure tasks more effectively and explore possible solutions more efficiently. For example, De Groot (1965) reported chess experts engaged in a similar amount of mental search for good moves as less-skilled players, but with much better final results in terms of the moves chosen.

Experts' thinking is thus shaped by a large body of relevant knowledge that is accumulated over a long period. It is commonly estimated that high-level expertise in chess (grand master level) requires at least 10 years of intensive study and preparation. Similar estimates have been made in other fields such as music and mathematics (Ericsson, 2003). To study and practice in an area intensively for 10 or more years clearly requires high levels of motivation to excel in that area. From interviews with experts (Bloom, 1985), it appears that motivation typically begins with simple enjoyment of an activity undertaken in a playful way, which is found to be intrinsically rewarding. Promising performance then leads to support from parents who encourage and strengthen existing motivation and seek out teachers, coaches, training facilities, and suitable competitions. The time commitment for individuals in developing expertise is indicated by the finding that expert (professional) musicians had spent over 10,000 hours practicing by age 20, which was around 8,000 hours more than amateur musicians by the same age (Ericsson, 2003).

Ericsson (2003) pointed out that developing expertise is in itself a large-scale problem with the goal of ever-improving performance, which is tackled through deliberate practice exercises that themselves comprise subproblems of improving particular aspects of the skill concerned. Sheer experience in itself, without deliberate targeted practice, does not lead to growth in skills beyond plateaus. To progress, budding experts must engage in deliberate practice aimed at extending their current skill levels. In the case of chess, experts have typically spent four to five hours per day analysing games between masters from printed sources (Ericsson, 2003). They set themselves the goal of predicting each move in a recorded game, and if they predict wrongly, they then set the goal of understanding why the master's move was made. This process will help adjust the player's representations of chess positions, for example, by adding in an aspect of a position that was previously not noticed when making evaluations of possible moves. Thus, the general motivation to improve skill level leads to specific goals in deliberate practice such as understanding particular puzzling but masterly moves.

The pinnacle of real-life expert thinking is that involved in creative thinking that leads to major transformations in a given field. Creative thinking is thinking that is both novel and useful. It is helpful to distinguish between novel thoughts that arise from exploration of an established framework or conceptual space and represent *combinational creativity* and novel thoughts that lead to new conceptual spaces (i.e., exemplify *transformational creativity*) (Boden, 2004). New conceptual spaces can be generated by transforming existing spaces. For example, non-Euclidean geometry arose by dropping a particular axiom from Euclidean geometry; atonal music arose by dropping the requirement of tonal music that a piece of music must have a "home key" from which it starts and returns. Biographies of acknowledged creative contributors to the arts and sciences indicate extremely high levels of commitment (motivation) and immersion in the field of work (Boden, 2004). "Normal" expertise in the chosen domain must be developed initially (and we have seen that normal expertise requires c. 10 years of devoted study and deliberate practice) before the potential creative contributor can understand a complex conceptual space (e.g., classical geometry or classical music) and then transform it in a useful way. In Edison's famous saying, creativity is "one per cent inspiration and 99 per cent perspiration" (Rosanoff, 1932).

EXTRINSIC AND INTRINSIC MOTIVATION IN PROBLEM SOLVING AND CREATIVITY

Given that creative work requires exceptional levels of motivation, the question remains about what leads to the very high levels of motivation required for creative thinking. Early psychodynamic theories explained creative activity as a sublimation of libidinal energy into a socially acceptable form (Freud, 1959) or by using the amoral, aggressive, and destructive impulses of the id to suggest creative ideas by means of regression in the service of the ego (Kris, 1952). Other dynamic suggestions involve higher-order needs such as effectance motivation (White, 1959) and need for mastery (Cangelosi & Schaefer, 1992), which could motivate towards creativity. However, more recent approaches have stressed the possible role of intrinsic motivation arising from enjoyment and satisfaction experienced while engaged in the creative activity (Collins & Amabile, 1999). Psychometric (Barron, 1988) and longitudinal studies (Torrance, 1987) indicate that creative individuals are highly absorbed by their work and continue to be so over many years, and it is plausible that intrinsic motivation could maintain such persistence. A specific hypothesis regarding intrinsic enjoyment has been proposed by Csikszentmihalyi (1990) in terms of the "flow" experience that arises when a person is working at tasks in which the challenges match their skill level. In the flow state, there are heightened levels of enjoyment and absorption. By contrast, if the challenges are too easy, boredom will be experienced; if the challenges are too difficult, stress will be experienced. Seeking optimal flow experiences that are rewarding in themselves would lead to ever-increasing skill levels in a virtuous circle.

In contrast to intrinsic motivation, extrinsic motivation such as seeking external approval and rewards is often seen as less important for creative thinking work, and indeed, a general lack of concern with the opinions of others does seem to emerge from biographical and psychometric studies of eminent scientists and artists (Cattell, 1959), suggesting that such individuals are not motivated by a search for others' approval. Intrinsic motivation is often taken to be key and extrinsic motivation regarded as secondary or even deleterious (Csikszentmihalyi, 1990). For example, Amabile (1983, p. 91) proposed that, "The intrinsically motivated state is conducive to creativity, whereas the extrinsically motivated state is detrimental".

Consistent with Amabile's (1983) view, a number of early studies of the effects of external incentives did find that external incentives seemed to reduce intrinsic interest in tasks and reduce novelty and creativity (e.g., Amabile, 1989). Subsequent studies have produced more mixed results. A meta-analysis by Cameron and Pierce (1994) of 96 studies involving experimental groups receiving a reward and control groups that did not indicated that intrinsic motivation (indexed by attitude scores and propensity to engage in the task after the experimental manipulation) was boosted by external verbal rewards and tangible rewards dependent on performance, but reduced by tangible rewards that were not dependent on performance. Eisenberger and Cameron (1996) interpret these results as indicating that the detrimental effects of external incentives occur mainly under very restricted conditions and external rewards are often beneficial. Eisenberger and Cameron's behaviourist approach naturally stresses the positive role of reinforcement, and they argue that reinforcement for effort in difficult tasks leads to a "learned industriousness", in which effort itself has acquired secondary reinforcing value. They report some interesting results indicating that reinforcement of novelty in divergent tasks generalises from one type of divergent task to another (e.g., from a verbal divergent task to a visuospatial divergent task involving production of pictures using circles). They suggest that this result could reflect learned industriousness, which as a general tendency to persistence would benefit divergent production. Consistent with this view, recent work in our laboratory has found that initial responses in the divergent Alternative Uses task tend to be low in executive demands (retrieval of known uses) and later, subjectively novel responses involve use of executively demanding strategies that would require persistence (Gilhooly et al., 2007). A review paper by Camerer and Hogarth (2004) of 74 studies reached a similar conclusion to that of Eisenberger and Cameron – tasks with positive incentive effects were those in which effort is increased by incentives and increased effort improves performance. Wieth and Burns (2006) explored incentive effects with a view to identifying differences between non-insight problems and insight problems. It was hypothesised that non-insight problems would respond positively to incentives, as incentives would lead to increases in persistence with the initial approach, which in turn would speed solutions. On the other hand, insight problems would be hampered by increased persistence with the initial approach. It was found that both types of problem responded positively to the incentives, which suggests that insight and non-insight problems have more in common than is sometimes suggested (Gilhooly & Murphy, 2005).

Overall, the current view is that both intrinsic and extrinsic sources of motivation are important in creative problem solving, but that the effects of extrinsic motivation are more variable and depend on the nature of the incentive or reward and how it is dependent on quality of behaviour. If the external reward is the same no matter what level of performance is reached, this could induce "learned helplessness" (Eisenberger & Cameron, 1996) and impair performance. External reward dependent on results has an informational aspect and is more likely to be helpful. In the light of recent research, Amabile (1996, p. 119) has revised her earlier hypothesis and formulated the Intrinsic Motivation Principle as follows: " Intrinsic motivation is conducive to creativity; controlling extrinsic motivation is detrimental to creativity, but informational or enabling extrinsic motivation can be conducive, particularly if initial levels of intrinsic motivation are high".

CONCLUDING COMMENTS

It is clear that problem solving and motivation are closely intertwined. Without unmet motives and active unsatisfied goals, there would be no problems to solve. General motives lead to more specific goals, and goals play a crucial role in problem-directed thinking by guiding the would-be solver towards promising actions in searching a state-action space or useful developments of subgoals and subsubgoals that in turn lead to suitable actions towards the overall goal or goals.

Expert problem solving is based on extensive domain knowledge, which is built-up slowly over many years (around 10 years being a common estimate across domains) and results from continued motivation to develop the particular skill in question. Deliberate practice and guided training seem crucial to developing expertise in all domains. Clearly, long-term motivation is essential to develop expertise. Having acquired expert knowledge, leading thinkers can then develop their domain further by creative thinking, which is largely motivated by an intrinsic interest and enjoyment of the field.

References

Adelson, B. (1981). Problem solving and the development of abstract categories in programming languages. *Memory and Cognition*, **9**, 422–433.

Amabile, T. M. (1983). *The social psychology of creativity*. New York: Springer-Verlag.

(1989). *Growing up creative*. Buffalo, NY: Creative Education Foundation.
(1996). *Creativity in context: Update to The Social Psychology of Creativity.* Boulder, CO: Westview.

Anzai, Y., & Simon, H. A. (1979). The theory of learning by doing. *Psychological Review*, **86**, 124–140.

Atkinson, J. W. (1964). *An introduction to motivation*. New York: Van Nostrand-Reinhold.

Atwood, M. E., Masson, M. E. J., & Polson, P. G. (1980). Further exploration with a process model for water jug problems. *Memory and Cognition*, **8**, 182–192.

Austin, J. A., & Vancouver, J. B. (1996). Goal constructs in psychology: Structure, process, and content. *Psychological Bulletin*, **120**, 338–375.

Barron, F. (1988). Putting creativity to work. In R. J. Sternberg (Ed.), *The nature of creativity (*pp. 43–75). Cambridge: Cambridge University Press.

Boden, M. (2004). *The creative mind: Myths and mechanisms. 2nd Ed.* London: Weidenfeld & Nicholson.

Bloom, B. S. (1985). Generalizations about talent development. In B. S. Bloom (Ed.), *Developing talent in young people (*pp. 507–549). New York: Ballantine Books.

Cacioppo, J. T., Petty, R. E., Feinstein, J. A., & Jarvis, W. B. G. (1996). Dispositional differences in cognitive motivation: The life and times of individuals varying in need for cognition. *Psychological Bulletin*, **119**, 197–253.

Camerer, C. F., & Hogarth, R. M. (2004). The effects of financial incentives in experiments: A review and capital-labor-production framework. *Journal of Risk and Uncertainty*, **19**, 7–42.

Cameron, J., & Pierce, W. D. (1994). Reinforcement, reward and intrinsic motivation: A meta-analysis. *Review of Educational Research*, **64**, 363–423.

Cangelosi, D., & Schaefer, C. E. (1992). Psychological needs underlying the creative process. *Psychological Reports*, **71**, 321–322.

Cattell, R. N. (1959). The personality and motivation of the researcher from measurements of contemporaries and from biography. In C. W. Taylor (Ed.), *The 1959 University of Utah Research Conference on the Identification of Creative Scientific Talent (*pp. 195–203). Salt Lake City: University of Utah Press.

Chambers Twentieth Century Dictionary, 1962. Edinburgh: W. R. Chambers Ltd.

Charness, N. (1979). Components of skills in bridge. *Canadian Journal of Psychology*, **33**, 1–16.

Chronicle, E. P., MacGregor, J. N., & Ormerod, T. C. (2004). What makes an insight problem? Roles of heuristics, goal conception, and solution recoding in knowledge-lean problems. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, **30**, 14–27.

Collins, M. A., & Amabile, T. M. (1999). Motivation and creativity. In R. J. Sternberg (Ed.), *Handbook of creativity (*pp. 297–312). Cambridge: Cambridge University Press.

Csikszentmihalyi, M. (1990). *Flow: the psychology of optimal experience*. New York: Harper & Row.

De Groot, A. D. (1965). *Thought and choice in chess.* The Hague: Mouton.

Duncker, K. (1945). On problem solving. *Psychological Monographs*, **58**, 1–113.

Eisenberger, R., & Cameron, J. (1996). Detrimental effects of reward: Reality or myth? *American Psychologist*, **51**, 1153–1166.

Eisenstadt, M., & Kareev, Y. (1977). Perception in game playing. In P. N. Johnson-Laird & P. C. Wason (Eds.), *Thinking (*pp. 548–564). Cambridge: Cambridge University Press.

Ericsson, K. A. (2003). The acquisition of expert performance as problem solving: construction and modification of mediating mechanisms through deliberate practice. In J. E. Davidson & R. J. Sternberg (Eds.), *The psychology of problem solving (*pp. 31–83). Cambridge: Cambridge University Press.

Ericsson, K. A., & Kintsch, W. (1995). Long-term working memory. *Psychological Review*, **102**, 211–245.

Freud, S. (1959). Creative writers and day-dreaming. In J. Strachey (Ed.), *The standard edition of the complete psychological works of Sigmund Freud* (Vol.9, pp. 142–156). London: Hogarth Press.

Gilhooly, K. J., Fioratou, E., Anthony, S. A., & Wynn, V. (2007). Divergent thinking: Strategies and executive involvement in generating novel uses for familiar objects. *British Journal of Psychology*, **98**, 611–625.

Gilhooly, K. J., & Murphy, P. (2005). Differentiating insight from non-insight problems. *Thinking and Reasoning*, **11**, 279–302.

Gilhooly, K. J., Wood, M., Kinnear, P. R., & Green, C. (1988). Skill in map reading and memory for maps. *Quarterly Journal of Experimental Psychology*, **40A**, 87–107.

Klinger, E. (1978). Modes of normal conscious flow. In K. S. Pope & J. L. Singer (Eds.), *The stream of consciousness (*pp. 225–258). New York: J. Wiley.

Kochen, M., & Badre, A. N. (1974). Questions and shifts of representation in problem solving. *American Journal of Psychology*, **87**, 369–383.

Kris, E. (1952). *Psychoanalytic explorations in art*. New York: International Universities Press.

Luger, G. F. (1976). The use of the state-space to record the behavioural effects of subproblems and symmetries on the Tower of Hanoi problem. *International Journal of Man-Machine Studies*, **8**, 411–421.

Miller, G. A., Galanter, E. H., & Pribram, K. H. (1960). *Plans and the structure of behavior*. New York: H. Holt.

Neisser, U. (1963). The imitation of man by machine. *Science*, **139**, 193–197.

Newell, A. (1992). Precis of Unified Theories of Cognition. *Behavioral and Brain Sciences*, **15**, 425–492.

Newell, A., Shaw, J. C., & Simon, H. A. (1958). Elements of a theory of human problem solving. *Psychological Review*, **65**, 151–166.

Newell, A., & Simon, H. A. (1963). Computers in psychology. In R. D. Luce, R. R. Bush, & E. Galanter (Eds.), *Handbook of mathematical psychology* (Vol. 1, pp. 361–428). New York: Wiley.

Rosanoff, M. (1932). Edison in his laboratory. *Harpers Monthly*, September, 402–417.

Simon, H. A. (1967). Motivational and emotional controls of cognition. *Psychological Review*, **74**, 29–39.

(1975). The functional equivalence of problem solving skills. *Cognitive Psychology*, 7, 268–288.

Thomas, J. C. Jr. (1974). An analysis of behavior in the hobbits-orcs problem. *Cognitive Psychology*, **6**, 257–269.

Torrance, E. P. (1987). Future career image as a predictor of creative achievement in the 22 year longitudinal study. *Psychological Reports*, **60**, 574.

White, R. (1959). Motivation reconsidered: the concept of competence. *Psychological Review*, **66**, 297–323.

Wiener, N. (1948). *Cybernetics: or Control and Communication in the animal and the machine.* Cambridge, MA: MIT Press.

Wieth, M., & Burns, B. D. (2006). Incentives improve performance on both incremental and insight problem solving. *The Quarterly Journal of Experimental Psychology*, **59**, 1378–1394.

14

Motivation and Heuristic Thinking

Dan Zakay & Dida Fleisig

INTRODUCTION

An advertisement was recently distributed among many Israeli families by the Israeli National Lottery (Mifal Hapais) in which joining a subscription program by purchasing a certain number was offered. According to the offer, the number would participate weekly in the lottery, and the unique aspect of it was its being a personal lucky number, especially chosen for each recipient. Furthermore, it was promised that this personal lucky number would increase the chances of winning. Because the National Lottery is a profitable organization, it seems logical to assume that the advertisement succeeded in recruiting enough members that at least the costs of producing the campaign were paid back.

A rational analysis of that advertisement readily reveals several nonrational biases: (1) The idea that a fixed number increases the chances of winning; (2) there are lucky numbers; and (3) a personal number augments the chances of winning. Yet, there are people who fall into such traps. Furthermore, most probably, some of those who do are aware of the misleading information included in the advertisement. In a study conducted by Klar, Zakay, and Sharvit (2002), it was found that many Israelis adopted unique behavior patterns in order to cope with the threat of terrorist attacks. Many of those patterns (e.g., avoiding going to shopping centers at the same day and hour of the week in which a terrorist attack previously occurred) might be considered as reflecting superstitious behavior. In effect, many of those who adopted such behaviors were aware of the fact that this did not really reduce their chances of being involved in terrorist attacks; still, they could not give up these behaviors, mainly because it gave them some feeling of control over the situation. Those two examples raise questions about why people swallow intuitive nonrational baits, on the one hand, but, on the other hand, can justify such behaviors from a utilitarian perspective of some sort. In the present chapter, an attempt will be made to analyze those questions, but first, the topic of heuristics and the impact of motivation on heuristic thinking will be reviewed.

THINKING, HEURISTICS, AND SURVIVAL

A major problem facing any living organism is that of being able to internally represent the environment in a manner that will enable adaptation and survival. Perception, language, and thinking are the major mental faculties that have evolved for doing that job. Whereas many organisms possess perceptual systems that are equal or even better in terms of sensitivity than those of humans, the main advantage of the latter over other species is grounded in better language and thinking abilities that enable reasoning, problem solving, judgment, and decision making.

A question can be raised concerning the criteria by which the optimality of a representation of the environment can be determined. Should the representation be accurate, or is it enough that it will enable optimal survival and adaptation? Several views concerning that question have been proffered by different schools of thought. Only some of these will be reviewed here.

The rational view. Scholars representing the rational view (e.g., Lee, 1971) argue that thinking processes had to be rational in order to enable the best adaptation to the environment. To be rational is to reason in accordance with principles of reasoning that are based on rules of logic, probability theory, and so forth (Gilovich & Griffin, 2002; Stein, 1996). Accordingly, any deviation from normative rationality should be considered as a cognitive bias leading to suboptimal behavior. Similar to perceptual illusions, cognitive biases were also called "cognitive illusions."

The human being as an "intuitive statistician." As it started to become clear that human thinking does not fully comply with the principles of normative rationality, nor is the matching between human judgments and predictions based on statistics and probability theory perfect, a view of the human being as an "intuitive statistician" emerged (Peterson & Beach, 1967). According to this view, humans do base their judgments on the rules of statistics and probability theory, but due to limited mental capacity that prevents accurate calculations, the products of human judgment are, eventually, less accurate than normative predictions. The deviations, however, reflect calculation errors rather than systematic cognitive biases.

Bounded rationality. Evidence that started to accumulate (e.g., the allais paradox; Allais, 1997) indicated that deviations of human thinking from "normative rationality" are caused by fundamental processes rather than computational limitations. Simon (1957) argued that the normative rationality model was not compatible with the characteristics of the human cognitive system. Acknowledging the limitation of the human mind, Simon introduced the notion of "bounded rationality" to indicate that human reasoning and judgment are based on simple heuristics that people could employ (Gilovich & Griffin, 2002). Simon suggested that bounded rationality results from the tendency to base judgment and decision making on partial knowledge about the world, and from the motivation to "satisfice." In contradistinction to the normative-rational view, which assumes that humans have a basic motivation to maximize utility, "satisficing" indicates the willingness of human beings to invest as minimal a mental effort as possible and thereby accept alternatives that provide that degree of utility that satisfies one's achievement need.

Heuristics and biases view. The bounded rationality view triggered a stream of comprehensive and systematic research, which culminated in the seminal work of Tversky and Kahneman (1974) and Kahneman and Tversky (1984). The major theme of this view is that under certain conditions, mainly conditions of uncertainty, intuitive rather than rational thinking dominates human judgment processes. Intuitive thinking is performed by the employment of certain heuristics. In many cases, the products of the utilization of heuristics are good-enough judgments that enable satisfactory adaptation. However, misapplication of heuristics to inappropriate situations leads to biased judgments (Bazerman, 2006) when compared with respective predictions stemming from normative-rational models. The claim is that similar to perceptual illusions, such cognitive biases might, in several cases, lead to suboptimal behavior.

The heuristics and biases view became a target of criticism, based on the argument that the notion of biases is incorrect, as normative-rational models are not necessarily a justified point of reference for judging the optimality of adaptation and survival. Furthermore, the claim was made that heuristics are efficient and useful thinking tools (e.g., Gigerenzer & Todd, 1999). It is not a main objective of this chapter to discuss and evaluate the opposing views, but some further elaboration of them is required. However, before doing so, we should first delve more deeply into the notion of heuristics.

THE "ANATOMY" OF HEURISTICS

Heuristics can be defined as simplifying and time-saving rules of thumb that people use to make judgments under uncertainty or in face of incomplete and ambiguous information. Heuristics constitute the antithesis of extensive algorithmic processing (Gilovich & Griffin, 2002). One drawback of heuristic thinking is that individuals are frequently unaware that they rely on it, a state which poses an obstacle in regard to amending the suboptimality resulting from it.

Heuristics base their claim to fame on the three general-purpose heuristics identified by Tversky and Kahneman (1974) that underlie many intuitive judgments under uncertainty: availability, representativeness, and anchoring and adjustment. Since then, many more have been identified in the area of judgments under uncertainty, but heuristics can be identified in various thinking domains such as problem solving, planning, choice, metacognitive processes, causality judgment, social judgment, and others. Some examples are briefly presented here.

Problem solving. Several heuristics are associated with the problem-solving process. The anti-looping (Davies, 2000) and the hill-climbing (Chronicle, MacGregor, & Ormerod, 2004) heuristics can serve as examples. Both heuristics are concerned with strategies of problem solving – avoiding previous moves in the anti-looping heuristic or taking whichever next step brings one closest to or least distant from the goal in the hill-climbing process.

Planning. The planning fallacy (Kahneman & Tversky, 1979) exhibits the tendency to estimate optimistically future task-completion times, so that predicted completion times are more optimistic than can be justified by actual completion time.

Choice. The diversification heuristic (Simonson, 1990) is relevant in regard to choice tasks, and is concerned with the degree of diversity in people's choices based on their need for variety. It was found that when asked to make several choices at the same time, people tend to diversify, and they do so not only for a simultaneous choice condition (i.e., choosing three courses in a certain meal) but also for a sequential choice (i.e., choosing at a certain time what to eat in sequential meals). It is clear that this heuristic is sensible under the simultaneous condition, but less so under the sequential one. Ayal and Zakay (2009) showed that people tend to choose the alternative that is perceived to be more diversified, even when this actually reduces their chances of maximizing utility.

Language. Some heuristics were defined even in the domain of language comprehension. For example, instead of focusing on a mutual perspective when communicating, people rely more on an egocentric interpretation, which is fast and cheap in mental resources. Keysar et al. (2000) argued that using such a process, which they called the egocentric heuristic, is successful in reducing ambiguity, although it could lead to systematic errors.

Magical thinking. Some heuristics characterize magical thinking. One is the contagion heuristic, which reflects the belief that when objects make physical contact essences may be permanently transferred between them. The similarity heuristic exhibits the belief that causes resemble their effects, or that appearance equals reality (Rozin & Nemeroff, 2002).

In another domain, that of *aesthetic judgments*, according to the "bigger is better heuristic" (Silvera, Josephs, & Giesler, 2002), the size of an object influences its aesthetic preference.

Causality judgments. One domain, which is of utmost importance for understanding the environment and assigning meaning to it, is that of causality judgments. This process, too, relies on heuristic thinking. The basic heuristic here is that of false causality, which is the tendency to conclude that an event is caused by another event simply because it follows it in space and time. Again, it should be emphasized that causality heuristics probably lead to correct decisions in many cases (Nisbett & Ross, 1980), but under some conditions illusionary causality can be perceived as a veridical one. Gilovich and Griffin (2002) demonstrated how relying on representativeness might induce false causality judgments, and they bring some striking examples for this in the domain of health and medicine. Causality judgments are also important in the domains of interpersonal and social relationships. People have a need for understanding the reason underlying other people's behavior and to predict their future behavior. In doing so, people also use heuristic thinking in the form of stereotyping and attribution (Gilbert, 2002).

Juridical thinking is another domain in which rational thinking is expected but heuristic thinking was found to be widely used. As legal issues are often complex, lacking in coherent information, and limited in time, heuristics are often utilized (Gigerenzer, 2006). Indeed, legal reasoning falls prey to biases, and employs heuristic thinking as much as reasoning in any other domain (Zakay & Fleisig, 2010). For example, judges and juries' decisions are often affected by anchoring (Sunstein, Kahneman, & Schkade, 2007), availability, and optimistic biases (Jolls, Sunstein, & Thaler, 2007).

Metacognition is the last domain in which the involvement of heuristics will be illustrated. Metacognitive processes are used to monitor lower-level cognitive functioning and are responsible for the emergence of feelings, such as feeling of knowing (FOK) or feeling of confidence (FOC) in the correctness of retrieved knowledge. Empirical evidence (e.g., Koriat, 1993) indicates that the reliability of some metacognitive judgments is not high. A major reason for this robust finding is the reliance of metacognitive processes on heuristics. Koriat (1993) argued that FOK judgments are based on the accessibility heuristic, namely, on the ease of retrieval of information, regardless of its correctness. Similarly, judgments of familiarity are influenced by heuristics such as the "warm glow" heuristic (Monin, 2003), according to which liking leads to familiarity; namely, the positive valence of a stimulus increases its perceived familiarity, even in the absence of prior exposure. As for FOC, Zakay and Tuvia (1998) demonstrated that these feelings are partially influenced by the latency heuristic, according to which the faster a piece of information is retrieved from memory the higher the confidence that this information is the one sought for. This heuristic can result in a reliable confidence judgment when knowledge is stored in memory, but can lead to an unreliable sense of confidence when the relevant knowledge does not exist and a fast retrieval is due to other factors, such as those involved in the availability heuristic. Fleisig and Zakay (2005) demonstrated that when judging the ratio of correct answers after completing a forced-choice test, people rely on a heuristic process that reflects their naive theories about the actual number of correct answers they can expect in each category of FOC. The reliance on this heuristic leads in many cases to significant underestimations.

Several heuristics have been reviewed. Deliberately, the most important and well-known judgmental heuristics were not included because the aim was to demonstrate the huge variety of heuristics and the wide range of mental domains in which heuristics play a role. Another aim was to demonstrate, in some cases, how heuristics can lead to optimal outcomes under certain conditions, but erroneous ones when other conditions prevail.

Affect and Heuristics

In recent years, the involvement and importance of affect in cognitive processes has started to be emphasized. Slovic et al. (2007) present the affect heuristic. By "affect" they mean the specific quality of "goodness" or "badness" that arises automatically in association with a certain stimulus. Those automatic affective responses guide judgments and decisions. A similar choice heuristic based on affect was proposed by Schwarz and Clore (1988), who named it "how do I feel about it" heuristic. Frederick (2002) proposed two automated-choice heuristics – choosing by liking; that is, choosing on the basis of the spontaneous affective evaluations elicited by the options and choosing by default (the "status quo"); that is, choosing an option currently possessed or customarily chosen, which is preferred over other options.

Various studies have demonstrated that affect is an important component of human judgment and choice, when the cause of the particular affect is consciously perceived or not (Slovic et al., 2007). Gigerenzer and Todd (1999, p. 31) indicated that "emotions can also function as heuristic principles for guiding and stopping information search."

COGNITIVE AND MOTIVATIONAL HEURISTICS AND BIASES

The distinction between cognitive and motivational biases is common and well documented in the literature. A cognitive bias is assumed to be caused by an erroneous cognitive process in the form of a heuristic that was utilized when it was not appropriate to use it. However, no motivational benefit or gain is thereby obtained; on the contrary, it can be assumed that one would prefer to avoid the bias. For example, a physician who commits a diagnostic error due to the base-rate fallacy would be much happier if that error had not been committed.

A motivational bias, too, might be said to result from the utilization of an inappropriate heuristic, but the one who is utilizing the heuristic obtains some motivational gain – usually an ego-defending one – from the resulting bias. It can be assumed that attaining the motivational gain was the reason for utilizing the heuristic in the first place, and that he/she would not have preferred an "unbiased" outcome. Bazerman (2006) defined the following categories of motivational biases: 1) The motivation to reduce the tension between doing what one wants and doing what one thinks one ought to do; 2) positivity motivation (i.e., to view oneself and the world more positively than reality suggests); 3) egocentrism (i.e., the motivation to interpret information in a favorable way that defends one's ego and boosts his/her self-esteem); and 4) the motivation to avoid regret.

Whereas other classifications of motivational biases are possible, it is clear that there are several basic distinctions between cognitive and motivational biases. As previously noted, the cognitive biases are an "accidental" outcome of inappropriate heuristic processes; the motivational ones are, in a way, intentional. Another distinction is that the cognitive biases always reflect an error vis-à-vis the respective normative model, whereas this is not the case regarding motivational biases. It is true that in some cases motivational biases also reflect clear judgmental errors, but in other cases the error might be in the internal judgment or belief of a person and does not necessarily lead to a behavioral error. For example, the diversification heuristic might lead one to choose an option that seems to him or her to be more diverse than other options, but in reality the utility associated with each one of the alternatives might be the same. Thus, the personal lucky number example presented earlier reflects an error of internal belief, but as a matter of fact, the personal lucky number has the same probability of winning as any other number that could have been chosen. Another example is the illusion of control. It describes people's tendency to believe that they have greater control over outcomes than they actually have (Trope, Gervey, & Liberman, 1997). It was found that perceived vulnerability to risk is heavily influenced by the perceived control over the risk (Zakay, 1984), and that people generally overestimate their level of control over many kinds of risks (Bronwell, 1991) as well as their relative control, compared to their peers (Harris, 1996). Klar, Zakay, and Sharvit (2002) examined whether such illusions of control were extended to the domain of terrorism during a period of intense terrorist threat in Israel. It was found that no illusion of control and comparative control were manifested regarding the risk of being a victim of terrorist attacks. Again, the one who prefers to take a lottery ticket in his/her own hand rather than be handed the card is making an internal mistake of judgment, but is actually not harming one's actual chances of winning. On the other hand, in all of these examples and in contradistinction to the cognitive biases, the motivational heuristics lead to an obvious motivational gain – a higher feeling of control, better self-esteem, and so forth.

The distinction between cognitive and motivational biases suggests that the criticism and debate about the legitimacy of the term "biases" should be treated in the context of motivational and cognitive biases. It seems, however, that making a distinction between cognitive and motivational heuristics without referring to the nature of their outcomes is almost impossible. Both types of heuristics are actually similar in terms of process. The distinction between the two types is sensible only when the motivation to utilize them and the degree of motivational gain associated with their outcomes are considered. Examples of "pure" cognitive heuristics are the "classic" ones such as anchoring and adjustment or availability. "Naive optimism" can serve as an example of a pure motivational heuristic. Naive optimism is responsible for the tendency of people to assign higher probabilities to the occurrence of positive events to themselves and people who are socially close to them than to unknown people who are socially distant (Zakay, 1985). These judgments are biased in cases for which occurrence probabilities are objectively equal to anyone who belongs to a certain population. The motivational gain associated with the outcomes of the naive optimism heuristic can be classified as a possible gain enhancing one's feeling of well-being and self-esteem, which in most cases might help adaptation. However, in some cases, such as in the case of a potential illness, this can delay treatment and might be dangerous for survival. It is of interest to note that naive optimism is activated when there is a motivational threat involved with an unfavorable outcome. However, when such a threat does not exist, for example when one has to judge his/her chances of winning the lottery in comparison with the chances of some unknown person, people tend to judge their own chances as lower.

This might be due to the lack of any meaning that might threaten one's ego or self-esteem if he/she does not win the lottery. The outcome is still biased, but this is a cognitive bias, most probably resulting from utilizing the availability heuristic. Essentially, most people never win such a prize, but they read a lot about unknown people who do win (Zakay, 1985). However, one cannot deny the possibility that the motivation to avoid regret also plays some role in this case. Therefore, it is plausible to think also about "mixed" biases, in which the outcome is caused by an inappropriate cognitive process but also serves some motivational goal.

THE "BIAS" DEBATE

Whereas a "heuristic" is a type of a thinking process, the term "bias" refers to the evaluation of the mental product resulting from the application of a certain heuristic. When this product systematically deviates in a predictable direction from some normatively expected result, this deviation is called a bias. Thus, it is important to note that a heuristic process may result in an unbiased as well as biased outcome. This distinction has not always been clear, and as a result, some scholars who disagree with the term "bias" tend also to criticize the heuristic approach, as if the two were synonyms. In our mind, it is important to distinguish between the two terms. From a phenomenological point of view, it is clear that heuristic thinking exists and is in wide use by humans, as exhibited by the two examples presented in the introduction. Nevertheless, it is justified to question the term "bias" and to ask whether, under certain conditions, the products of heuristic thinking are indeed biased. A different question is whether or not heuristics should be considered as adaptive strategies or as maladaptive, from the very start.

The issue of whether or not the term "bias" is inappropriate has to do mainly with the definition of a correct criterion, a deviation from which should be considered as a bias. Some scholars argue that there is no reason to consider normative theories such as probability theory as a "true" criterion (Cohen, 1979; Kruglansky, 1975). We will not elaborate here on this issue and turn rather to the question of whether or not heuristics are adaptive.

As was said earlier, "It is important to note that a 'heuristic' is both a good thing and a bad thing" (Camerer & Loewenstein, 2002, p. 11), whereby the good thing is its fastness under conditions of limited time or cognitive capabilities and its bad thing is the involved violation of logical principles. It is clear, then, that being fast and able to produce judgment despite difficult real-world situations indicates that heuristics are efficient processes. What about the other side of the coin? As claimed above, the critical issue here is whether or not a judgment must be compatible with normative theories and logic in order to support survival and adaptation or whether the heuristic judgment as is can be considered as adaptive.

The evolutionary view. In recent years, evolutionary psychologists have claimed that adaptationist considerations ought to play a central role in developing psychological hypotheses about behavior. The evolutionary school maintains that the human mind and its cognitive architecture are designed by processes of natural selection to be able to solve adaptive problems (Tooby & Cosmides, 1995). In accordance with these lines of thought, Gigerenzer and Todd (1999) suggested a different criterion against which the outcomes of heuristic judgments should be evaluated. The essence of this criterion, which may be labeled an "evolutionary" one, is that the evaluation should be based on the degree to which decisions and judgments fare adaptively and reasonably in the real world (the correspondence criterion) (Gigerenzer & Todd, 1999). The correspondence criterion is an evolutionary one because it reflects the need of organisms to adapt to environmental challenges, a need which forces them to make "fast and frugal" inferences. Instead of speaking of normative rationality, Gigerenzer and Todd (1999) and their collaborators speak about "ecological rationality," which reflects the extent to which the structure of heuristics and the environment match. The claim is that different environmental domains may require different specific heuristics that take advantage of the particulars of the environmental structure, thus enabling adaptive decisions. Furthermore, those who adopt the evolutionary view argue that when considering ecological rationality, the utilization of heuristics and intuition often result in more useful judgments as compared with analytic judgments, as "there is a point where too much information and too much information processing can hurt" (Gigerenzer & Todd, 1999, p. 21). A similar argument is proffered by Wilson and Schooler (1991), who claim that "thinking too much" can reduce the quality of preferences' formation and decision-making processes.

Samuels, Stich, and Faucher (2004) went even further by indicating that studies show people lack the rational competence to perform a big part of their reasoning tasks; therefore, they exploit various simple heuristics, which do not obey the patterns of normative reasoning. The evolutionary view is reflected in the notion of "the adaptive toolbox" (Gigerenzer & Todd, 1999), which is described as containing fast-and-frugal heuristics, composed of building blocks that guide and stop search leading to ecologically rational judgments and decisions. Some examples of fast-and-frugal heuristics are the heuristics of "take the best," "take the last," and "take the first" (Goldstein et al., 2000).

"Take the best" is a lexicographic procedure that uses a rank ordering of cues to make inferences and predictions. Search is stopped as soon as the first cue that favors one alternative is found. The decision is made on the basis of the cue that stopped search, whereas other cues are ignored. "Take the last" heuristic is applied when dealing with consecutive problems, so that starting from the second problem onward, the cue that stopped search the last time is used as the starting point. The "take the first" heuristic is found when experts have to solve problems and choose the first course of action that comes to mind (Goldstein et al., 2000).

Gigerenzer went even further (Gigerenzer, Hoffrage, & Kleinbolting, 1991) by claiming that cognitive biases are mostly artifacts caused by forcing respondents to create judgments in face of nonrelevant situations that lack ecological validity. The claim was that by presenting respondents with relevant and ecologically valid problems that enable them to use adaptive heuristics that are compatible with the structure of available information, cognitive biases should disappear. Indeed, Gigerenzer demonstrated his claim in regard to several cognitive biases (Gigerenzer & Todd, 1999). In replying to Gigerenzer (and others), Kahneman and Tversky (1996) argue that just as in the case of perceptual processes, under most conditions heuristics can produce adaptive judgments; under certain conditions that might occur in reality, maladaptive outcomes – similar to perceptual illusions – might appear. Indeed, it can be claimed that the conditions under which Gigerenzer and his colleges made cognitive biases disappear cannot be considered as a representative sample of all the conditions under which individuals have to make judgments in real life. For example, in the case of overconfidence, it might be claimed that the conditions under which respondents were found to be well calibrated (Gigerenzer et al., 1991) are simply conditions in which respondents had to make easy choices. Thus, the calibration found can be explained by the hard-easy effect (i.e., going systematically from overconfidence to underconfidence as task difficulty decreases) without the necessity of reliance on evolutionary assumptions. Furthermore, several studies (e.g., Fleisig & Zakay, 2005) showed that even when respondents were asked to answer "ecological questions" constructed according to Gigerenzer's criteria, significant overconfidence was still found in some cases.

It seems that a balanced approach should be adopted to the question of whether or not heuristics are adaptive. Gilovich and Griffin (2002) state that although heuristics do not "obey" rational rules, and despite the fact that they yield quick solutions, they are still sensible estimation procedures, which are by no measure "irrational," and admittedly they draw on highly sophisticated processes (e.g., feature matching, memory retrieval). We agree that this represents one side of the coin, but on the other side, under many real-life conditions the utilization of heuristics might yield maladaptive results, regardless of any comparison to any "normative" criteria. Illustrations for this claim are provided by some metacognitive heuristics involved in the formation of the feeling of knowing (Koriat, 1998) and the latency heuristic (Zakay & Tuvia, 1998) involved in the emergence of the feeling of confidence (see previous section).

The criterion for the reliability of FOK is the existence of relevant knowledge. This does not depend on any normative model, but simply reflects the actual state of knowledge that one can retrieve from memory at a certain point in time. The same holds for FOC, as feelings of overconfidence might lead one to suboptimal behavior, as in the case of answering forced-choice questions in examinations (Zakay & Glicksohn, 1992).

MOTIVATION AND HEURISTICS

Motivation can be defined as the psychological feature that causes organisms to act toward a desired goal (Webster, 1961). This definition includes two interconnected aspects of motivation: the reason for the action and its direction or purpose. Similarly, when speaking about the relationship between motivation and the utilization of heuristics, two aspects should be discussed: 1) What is the general motivation behind the utilization of any heuristic; and 2) are any motivational gains obtained by applying heuristics.

As for the first question, it seems that the evolutionary view discussed earlier provides a reasonable explanation in regard to the basic motivation for utilizing heuristics. This motivation is rooted in the basic need to act in an adaptive way and as fast as possible in face of an unstable and uncertain world. Heuristics are the thinking tools that were evolved in order to cope with such conditions as part of the "survival kit" that humans are equipped with. This fundamental motivation (see Svenson, current book) can be applied to any type of heuristics. However, the second issue concerning motivational gains necessitates a categorization of heuristics into two types: cognitive and motivational, as discussed earlier. The distinction between the two types of heuristics is summarized again. Cognitive heuristics, in contradistinction to motivational heuristics, do not provide any motivational gain. In other words, the one who uses the heuristic does not have any a priori preference, conscious or unconscious, in regard to the value or direction of the outcome of the judgment. An example of a cognitive heuristic is "anchoring and adjustment" (Tversky & Kahneman, 1974). The essence of this heuristic is to be able to make a judgment under uncertainty about a certain property of the world without having any a priori preference for the end-value that will be obtained. "Motivational heuristics" are those that, in addition to enabling fast and energy-saving judgments, are chosen in order to assure a certain outcome in terms of its motivational value and avoid an outcome that threatens the person from a motivational point of view. Thus, in contrast to cognitive heuristics, an accurate outcome that represents the state of the world objectively is not welcome in the case of motivational heuristics. The naive optimism heuristic, which was discussed earlier, may serve as an example.

This analysis leads to the conclusion that fundamental motivation is involved in the utilization of any kind of heuristics. In addition to that, specific motivations are associated with the utilization of motivational heuristics. Thus, it seems that the link between motivation and heuristics is stronger than has been assumed so far.

MOTIVATION AND THE ACTIVATION OF HEURISTICS

An interesting question, not yet discussed, concerns the manner in which heuristic processes are activated. The question might be answered in terms of several approaches. According to Tversky and Kahneman's approach, heuristic processes are activated in the same way as perceptual ones; namely, the heuristic process is an automatic one, determined by the characteristics and requirements of the situation. It is interesting to note that Gigerenzer and Todd (1999) hold a similar approach regarding that point. Yet, a profound examination reveals that the perceptual approach is problematic when motivational heuristics are involved. Because these heuristics require a preliminary analysis that identifies the motivational threat, a distinction between the activation of pure cognitive heuristics and motivational heuristics is needed.

In addition, some approaches view the activation of heuristic processes as activation of regular cognitive processes. Yet, the heuristic model reflects the "cognitive miser" metaphor, according to which a partial cognitive process is utilized due to the lack of sufficient mental resources. A possible reason for this might be the existence of a low level of epistemic motivation regarding a specific required judgment (Kruglansky, 1975).

Other approaches also bind the motivational system with the activation of heuristics. The heuristic-systematic model of persuasion (Chaiken, Liberman, & Eagly, 1989) defines three different underlying types of processing motivations: defense motivation; impression motivation; and accuracy motivation. *Defense motivation* is the desire to hold attitudes and beliefs that are congruent with existing ones, especially those that are critical to the self. *Impression motivation* is the desire to express attitudes that will satisfy interpersonal goals. *Accuracy motivation* is defined as a person's need of an accurate judgment. Kunda's (1990) "case for Motivated Reasoning" suggests two kinds of motivations affecting cognitive processes: the motivation to be accurate that leads to the use of strategies that are considered most appropriate; and the motivation to arrive at particular conclusions that enhances the use of strategies that are considered the most likely to yield those conclusions. The motivations are responsible for the choice of strategies amongst the various cognitive strategies available that will provide the motivation's goal.

The argument that the activation of motivational heuristics necessitates an initial phase of analysis for identifying a motivational threat can be supported by theories of denial. Freud (1956) introduced denial as an unconscious intrapsychic mechanism designed to expel anxiety and negative feelings from the human mind. Following this view, most studies defined denial as the negation of something in word or act (Lazarus, 1983). Denial was perceived as a specific primitive mechanism (one of many) at the lower levels of adaptation. A similar approach is presented by Breznitz (1983).

According to psychoanalytic theories, within the process of denial the threatening information may not access the system, or it may get in and get out before it has been deeply processed. The information may be partially registered (Spence, 1983) or partially processed, but then processing stops and attention is shifted (Dorpat, 1985). Psychoanalytic theories propose that this is an unconscious process. In contrast, avoidance strategies, which offer a cognitive mechanism, do not necessarily require unconscious processes. On the contrary, avoidance cognitive mechanisms such as daydreaming or sleep necessitate functions of control.

Thus, both the psychoanalytic theories and the avoidance strategies require, although implicitly, a dual-stage processing mode, as an initial registration or examination is crucial for identifying target information to be excluded from further processing. It seems that similar processes might explain the first phase that precedes the activation of motivational heuristics.

A different approach was recently introduced in the literature proposing the existence of two different systems, one responsible for analytic rational thinking and the other for intuitive heuristic thinking. Epstein (1994) claims that a person has two cognitive modes of thought: a rational mode and an experiential mode. The experiential mode, similar to Freud's idea of the unconscious, is emotionally driven; the rational mode is analytically and logically oriented. The experiential mode uses direct motivation to attain immediate gratification, and the rational mode uses either direct or indirect motivation to attain either immediate or delayed goals.

Kahneman and Frederick (2002) suggest a dual-system process. System 1 represents rapid and automatic intuitive responses to arising judgmental problems. System 2 monitors System 1's products in a controlled, effortful, slow, and rule-based manner. Due to that monitoring, the initial judgment may be endorsed, corrected, or overridden. In order for the finally expressed judgments to be called intuitive, they have to preserve, unmodified, the initial proposal. Thus, a heuristic process may be automatic (as in System 1) and may be deliberate (in System 2).

The notion of System 2 monitoring and controlling System 1 seems problematic to us, because the basic motivation for activating heuristics actually reflects the need for rapid and resource-saving processes. Activating both systems means, in fact, consuming resources in an economizing system, which generates a kind of internal contradiction.

It seems to us more appropriate to suggest the following process. According to dual-stage models (such as in the process of denial), an initial analysis of the situation always occurs in order to identify the potential existence of motivational threats. When such threats do not exist, the level of epistemic motivation, the need for accuracy, and the situational conditions will either activate System 1 heuristic processes or System 2. In any case, the metacognitive processes, which control and monitor the cognitive processes, are those that control and monitor both systems. In some instances, such as in processes of correction, the initial judgment produced in stage one of the process will be modified in the second stage (Koriat & Levy-Sadot, 1999; Fleisig & Zakay, 2005). However, if a motivational threat in the first stage is recognized, particular ego-defensive and self-esteem guarding motivations cause the activation of specific heuristic processes that also belong to System 1.

An interesting question is whether the metacognitive control system can, in those cases as well, cause a correction in the initial judgment. Muramatsu and Hanoch (2005) indicate how emotions can be embedded into the bounded rationality theory. Yun Dai and Sternberg (2004) propose an approach that integrates motivation, emotion, and cognition. They argue that "an exclusive emphasis on cognition misses some essential components of intellectual functioning and development" (p. xi). The analysis in the present chapter concurs with the aforementioned argument in regard to heuristic thinking, which demonstrates the complex and deep involvement of the motivational system in the activation process of heuristics. This notion requires further research.

References

Allais, M. (1997). An outline of my main contributions to economic science. *American Economic* Review, **87**, 3–12.

Ayal, S., & Zakay, D. (2009). Perceived diversification heuristic: the case of pseidodiversity. *Journal of Personality and Social Psychology*, **96**, 559–573.

Bazerman, M. H. (2006). *Judgment in managerial decision making*. New York: John Wiley & Sons.

Breznitz, S. (1983). *The denial of stress*. New York: International Universities Press.

Bronwell, K. D. (1991). Personal responsibility and control over our bodies: When expectation exceeds reality. *Health Psychology*, **10**, 303–310.

Camerer, C. F., & Loewenstein, G. (2002). Behavioral economics: Past, present, future. In C. F. Camerer, G. Loewenstein, & M. Rabin (Eds.), *Advances in behavioral economics (*pp. 3–51). Princeton, NJ: Princeton University Press.

Chronicle, E. P., MacGregor, J. N., & Ormerod, T. C. (2004). What makes an insight problem? The roles of heuristics, goal conception, and solution recoding in knowledge-lean problems. *Journal of Experimental Psychology: Learning, Memory and Cognition*, **30**, 14–27.

Chaiken, S., Liberman, A., & Eagly, A. (1989). Heuristic and systematic information processing within and beyond the persuasion context. In J. S. Uleman & J. A. Bargh (Eds.), *Unintended thought* (pp. 212–252). New York: Guilford Press.

Cohen, L. J. (1979). On the psychology of prediction: Whose is the fallacy? *Cognition*, **7**, 385–407.

Davies, S. P. (2000). Memory and planning processes in solutions to well-structured problems. *Quarterly Journal of Experimental Psychology: Human Experimental Psychology*, **53**, 896–927.

Dorpat, T. L. (1985). *Denial and defense in the therapeutic situation*. New York: Aronson.

Epstein, S. (1994). Integration of the cognitive and the psychodynamic unconscious. *American Psychologist*, **49**, 709–724.

Fleisig, D., & Zakay, D. (2005). *The confidence weighting heuristic: an explanation to the overconfidence paradox*. Unpublished manuscript. Tel-Aviv University (Hebrew).

Frederick, S. (2002). Automated choice heuristics. In T. Gilovich, D. Griffin, & D. Kahneman (Eds.), *Heuristics and biases* (pp. 548–558). New York: Cambridge University Press.

Freud, S. (1956). Inhibitions, symptoms and anxiety. In J. Strachey (Ed.), *The standard edition of the complete psychological works of Sigmund Freud* (Volume 20, pp. 75–175). London: Hogarth.

Gigerenzer, G. (2006). Heuristics. In G. Gigerenzer & C. Engel (Eds.), *Heuristics and the law* (pp. 17–37). Boston, MA: The MIT Press.

Gigerenzer, G., Hoffrage, U., & Kleinbolting, H. (1991). Probabilistic mental models: A Brunswikian theory of confidence. *Psychological Review*, **98**, 506–528.

Gigerenzer, G., & Todd, P. M. (1999). Fast and frugal heuristics: The adaptive toolbox. In G. Gigerenzer & P. M. Todd (Eds.), *Simple heuristics that make us smart* (pp.3–34). New York: Oxford University Press.

Gilbert, D. T. (2002). Inferential Correction. In T. Gilovich, D. Griffin, & D. Kahneman (Eds.), *Heuristics and biases*. New York: Cambridge University Press.

Gilovich, T., & Griffin, D. (2002). Introduction – heuristics and biases: Then and now. In T. Gilovich, D. Griffin, & D. Kahneman (Eds.), *Heuristics and biases* (pp. 1–18). New York: Cambridge University Press

Goldstein, D. G., Gigerenzer, G., Hogarth, R. M., Kacelnik, A., Kareev, Y., Klein, G., Martignon, L., Payne, J. W., & Schlag, K. (2000). Why and when do simple heuristics work? In G. Gigerenzer & R. Selten (Eds.), *Bounded rationality: The adaptive toolbox* (pp. 173–190). Cambridge, MA: MIT Press.

Harris, P. (1996). Sufficient ground for optimism? The relationship between perceived controllability and optimistic bias. *Journal of Social and Clinical Psychology*, **15**, 9–52.

Jolls, C., Sunstein, C. R., & Thaler, R. H. (2007). A behavioral approach to law and economics. In C. R. Sunstein (Ed.), *Behavioral law and economics (*pp. 13–58). New York: Cambridge University Press.

Kahneman, D., & Frederick, S. (2002). Representativeness revisited: Attribute substitution in intuitive judgment. In T. Gilovich, D. Griffin, & D. Kahneman (Eds.), *Heuristics and biases* (pp. 49–81). New York: Cambridge University Press.

Kahneman, D., & Tversky, A. (1979). Intuitive prediction: Biases and corrective procedures. *TIMS Studies in Management Science*, **12**, 313–327.

(1984). Choices, values and frames. *American Psychologist*, **39**, 341–350.

(1996). On the reality of cognitive illusions. *Psychological Review*, **103**, 582–591.

Keysar, B., Barr, D. J., Balin, J.A., & Brauner, J. S. (2000). Taking perspective in conversation: The role of mutual knowledge in comprehension. *Psychological Science*, **11**(1), 32–38.

Klar, Y., Zakay, D., & Sharvit, K. (2002). "If I don't get blown up…": Realism in face of terrorism in an Israeli nationwide sample. *Risk Decision and Policy*, **7**, 203–219.

Koriat, A. (1993). How do we know that we know? The accessibility model of feeling of knowing. *Psychological Review*, **100**, 609–639.

(1998). Illusions of knowing: the link between knowledge and metaknowledge. In V. Y. Yzerbyt, G. Lories, & B. Dardenne (Eds.), *Metacognition: Cognitive and social dimensions (*pp. 16–34). London, England: Sage.

Koriat, A., & Levy-Sadot, R. (1999). Processes underlying metacognitive judgments: Information-based and experience-based monitoring of one's own knowledge. In S. Chaiken & Y. Trope (Eds.), *Dual-process theories in social psychology* (pp. 483–502). New York: Guilford Press.

Kruglansky, A. W. (1975). The endogenous-exogenous partition in attribution theory. *Psychological Review*, **82**, 387–406.

Kunda, Z. (1990). The case for motivated reasoning. *Psychological Bulletin*, **108**, 480–498.

Lazarus, R. S. (1983). The costs and benefits of denial. In S. Breznitz (Ed.), *The denial of stress* (pp. 1–30). New York: International Universities Press.

Lee, W. (1971). *Decision theory and human behaviors*. New York: John Wiley & Sons.

Monin, B. (2003). The warm glow heuristic: When liking leads to familiarity. *Journal of Personality and Social Psychology*, **85**, 1035–1048.

Muramatsu, R., & Hanoch, Y. (2005). Emotions as a mechanism for boundedly rational agents: The fast and frugal way. *Journal of Economic Psychology*, **26**, 201–221.

Nisbett, R. E., & Ross, L. D. (1980). *Human inference: Strategies and shortcomings of social judgment*. Englewood Cliffs, NJ: Prentice-Hall.

Peterson, C. R., & Beach, L. R. (1967). Man as an intuitive statistician. *Psychological Bulletin*, **68**, 29–46.

Rozin, P., & Nemeroff, C. (2002). Sympathetic magical thinking: The contagion and similarity heuristics. In T. Gilovich, D. Griffin, & D. Kahneman (Eds.), *Heuristics and biases* (pp. 201–216). New York: Cambridge University Press.

Samuels, R., Stich, S., & Faucher, L. (2004). Reason and rationality. In I. Niiniluoto, M. Sintonen, & J. Wolenski (Eds.), *Handbook of epistemology* (pp. 131–179). Dordrecht, The Netherlands: Kluwer.

Schwarz, N., & Clore, G. L. (1988). How do I feel about it? Informative functions of affective states. In K. Fiedler & J. Forgas (Eds.), *Affect, cognition and social behavior* (pp. 44–62). Toronto: Hogrefe International.

Silvera, D. H., Josephs, R. A., & Giesler, R. B. (2002). Bigger is better: the influence of physical size on aesthetic preference judgments. *Journal of Behavioral Decision Making*, **15**, 189–202.

Simon, H. A. (1957). *Models of man: Social and rational.* New York: Wiley.

Simonson, I. (1990). The effect of purchase quantity and timing on variety-seeking behavior. *Journal of Marketing Research*, **28**, 150–162.

Slovic, P., Finucane, M., Peters, E., & MacGregor, D. G. (2007). The affect heuristic. *European Journal of Operational Research*, **177**, 1333–1352.

Spence, D. P. (1983). The paradox of denial. In S. Breznitz (Ed.), *The denial of stress* (pp. 103–123). New York: International Universities Press.

Stein, E. (1996). *Without good reason*. Oxford: Clarendon Press.

Sunstein, C. R., Kahneman, D., & Schkade, D. (2007). Assessing punitive damages (with notes on cognition and valuation in law). In C. R. Sunstein (Ed.), *Behavioral law and economics* (pp.232–258). New York: Cambridge University Press.

Svenson, O. [Chapter, current book, pp. xxx]

Tooby, J., & Cosmides, L. (1995). 'Foreword' to S. *Baron-Cohen, Mindblindness: An essay on autism and theory of mind*, (Cambridge, MA: MIT Press), pp. xi-xviii.

Trope, Y., Gervey, B., & Liberman, N., (1997). Wishful thinking from a pragmatic hypothesis-testing perspective. In M. S. Myslobodsky (Ed.), *The mythomanias: The nature of deception and self-deception* (pp.105–131). Mahwah, NJ: Lawrence Erlbaum Associates, Publishers.

Tversky, A., & Kahneman, D. (1974). Judgment under uncertainty: Heuristics and biases. *Science*, **185**, 1124–1131.

Webster (1961). *Webster's third new international dictionary of the English language* (Unabridged). Hagen Westfalen: Koenemann.

Wilson, T. D., & Schooler, J. W. (1991). Thinking too much: Introspection can reduce the quality of preferences and decisions. *Journal of Personality and Social Psychology*, **60**, 181–192.

Yun Dai, D., & Sternberg, R. J. (2004). *Motivation, emotion and cognition*. Mah- wah: Lawrence Erlbaum.

Zakay, D. (1984). The influence of perceived event's controllability on its subjective occurrence probability. *Psychological Record*, **34**, 233–240.

(1985). Post-decisional confidence and conflict experienced in a choice process. *Acta Psychologica*, **58**, 75–80.

Zakay, D., & Fleisig, D. (2010). Heuristic thinking in judges' decisions. *Law & Business, VOl. 12, pp. 91–116. Interdisciplinary Center, Herzeliya, Radzyner School of Law.* (Hebrew).

Zakay, D., & Glicksohn, J. (1992). Overconfidence in a multiple-choice test and its relationship to achievement. *The Psychological Record*, **42**, 519–524.

Zakay, D., & Tuvia, R. (1998). Choice latency times as determinants of post-decisional confidence. *Acta Psychologica*, **98**, 103–115.

15

Motivation, Decision Theory, and Human Decision Making

Ola Svenson

INTRODUCTION

Human decision-making researchers investigate people who make choices between two or more alternatives, how the choices are made, and how they deviate from predictions of normative models of rational behavior. Although decisions are made in response to a decision maker's needs reflected in her or his motivation, discussions of motivation are rare in the mainstream decision research literature; needs and motivation seem to be taken for granted without any presentation or discussion of them.

To illustrate, two volumes summarizing the most important research of judgment and decision making at the time (Arkes & Hammond, 1986; Gilovich, Griffin & Kahneman, 2002) do not have a single reference to motivation or even goal in their subject indices. Goldstein and Hogarth's (1997) edited volume includes 2 chapters out of 24 that briefly mention the concept of motivation, and of the remaining 22 chapters only 1 has a reference to goal – the other chapters do not treat either motivation or goal. However, Schneider and Shanteau (2003) edited a volume with a whole chapter on motivation, and several chapters including the concepts of motivation and goal. Textbooks on psychology and decision making follow the main trend, and they typically do not have motivation in their subject indices (e.g., Baron, 2008; Plous, 1993).

To be able to understand the role played by motivation in earlier traditional mainstream behavioral decision-making research, it is necessary to uncover hidden assumptions related to motivation. In process approaches to decision making, the researchers are often more explicit about what motivates the processes than in mainstream decision research.

The author wishes to thank Torun Lindholm, Ellen Peters, and Ilkka Salo for valuable comments on an earlier version of this chapter.

In this chapter, I shall present some concepts related to motivation and of relevance for decision research. The starting point will be the needs of a decision maker. Needs are referred to when a decision maker identifies goal states. A person's value system (norms, etc.) may also be used for identifying goal states. A goal state that is not yet realized leads to motivation to approach that particular goal state (e.g., to start eating if the goal relates to the need of food, get more money if the need is money). In other words, human needs are behind goals, and the goals motivate a decision maker to make a choice, which she or he believes leads to the best fulfillment of her or his goals. Motivation also leads to the identification of subgoals and mental mapping of the alternatives in relation to the goals. The mental mapping includes attractiveness mapping, meaning that each alternative is represented by a number of more or less attractive aspects (e.g., the color, price, age of a car) or cues in support of or against an alternative. Sometimes there is a holistic, sometimes intuitive impression of the attractiveness of an alternative.

Two kinds of needs and motivations can be related to human decision-making research. The first kind includes basic needs and motivations of a decision maker – what she or he needs and wants to achieve, what motivates a decision, and so forth. These needs will be called *fundamental needs* in this chapter (although many of them may be derived needs in other contexts). The second kind of needs relates to decision processes – how they should be carried through to solve conflicts, what final representations of decision alternatives a decision maker needs to make a final decision, and so on. This kind of needs and motives will be called *process and representation needs and motivation*. To illustrate the second kind of needs, Beach asserts there is a general motivation to "expend the least possible amount of time, effort and money while still meeting the demands of the decision task" (Beach, 1990, p. 134). The distinction between procedural justice and outcome (Kwong & Leung, 2002) corresponds to process and fundamental motivation.

If a decision maker is interested in a decision problem, she or he may get involved, which means that she or he is willing to spend energetic resources on the process of solving that decision problem. There are different kinds of involvement depending on what needs and interests are activated. Some kinds of involvement may originate from a need to please others, and other kinds of involvement from a need of money or from process-related needs. When performing laboratory studies of decision making, it is important that the participants become involved in the task to secure valid results.

Johnson and Eagly (1989) discussed involvement in terms of self-relevance, and defined involvement as "the motivational state induced by an association between an activated attitude and some aspect of the self-concept" (Johnson

& Eagly, 1989, p. 293). Janis and Mann (1977) listed some major categories of needs related to personal involvement that can activate goals and motivation. They differentiated between the needs of (1) own utilitarian gains; (2) utilitarian gains for significant others; (3) need of self-approval; and (4) need for social approval. All four types of needs are relevant to some extent in the most important decisions that a person makes.

Svenson (1992) differentiated between four different kinds of decisions. He ordered them on levels. Level 1 contains repeated, quick automatic decisions, habits, and all decisions, which – when they are made – have no direct reference to values, needs, or goals. Most of the decisions in human lives belong to this category, and many of them are not even experienced as decisions. However, these decisions were once related to needs, values, and goals before they became automated. That is, when the first of the repeated decisions were made, they were made on higher levels and related to needs and goals.

Level 2 includes decisions with direct couplings to a dominating need, value, or goal. The decisions on this level are motivated by a wish to approach one particular goal state (e.g., to find the cheapest flight). Here, the decisions may also be quick, as for example, when a positive or emotional reaction with its origin in a need is elicited by one or several alternatives. Decisions on this level may also take longer, and depend on more elaborate processing to approach the goal.

On level 3, one finds decisions activating different needs, with different and conflicting motivational forces as a result. There is not one alternative that is better on all significant attributes. Most decision research has treated this kind of decisions, which invite trade-offs between goals, resulting in decisions depending on the relative strengths of different motivations to reach these goals.

Level 4 decision making includes decisions with alternatives that are actively created by the decision-makers themselves. This is sometimes a possible solution for a decision maker who is presented with a decision problem that does not seem to offer any satisfactory solution at all.

TRADITIONAL DECISION THEORY

Traditional behavioral decision theory was introduced by authors such as Edwards (1954). He used the Expected Value (EV) theory as a foundation when he elaborated the Subjective Expected Utility (SEU) model for describing human decision making. In the former theory, the (long-run) expected value is computed for each alternative. This is done through multiplying the value of each of the alternatives' possible outcomes with its probability of occurrence. The alternative with the greatest long-run expected value should be preferred even if there was only one decision to be made.

Equation (15.1) describes the expected value (EV) of one alternative with two possible outcomes with probabilities p1 and ($1-p_1$). The values of the outcomes are denoted V1 and V2:

$$EV = p_1 \cdot V1 + (1-p_1) \cdot V2 \tag{15.1}$$

This equation, originating from economic statistical theory, was translated into a theory for human decision making by inserting U (subjective value or utility) for V and ψ for p. The result was a theory that has dominated human decision research for 50 years. Instead of EV, the subjective expected utility (SEU) was used:

$$SEU = \psi_1 \cdot U1 + \psi 2 \cdot U2 \tag{15.2}$$

SEU theory assumes that a decision maker can and is motivated to order aspects characterizing the alternatives on a continuum of utility. Equation (15.2) shows that a decision maker who makes even one single choice would be motivated to calculate and decide according to a normative rule that was developed to maximize the gain from repeated decisions. Thus, SEU theory assumes that decision makers share the goal of maximizing their own utility only, and that this motivates them to estimate the expected utility for each alternative.

However, people do not follow SEU theory in most situations, and later research has shown, for example, that ψ1 and ψ2 do not necessarily add to 1 and that the relation between value (e.g., money) and utility is not linear and changes from one function to another when it passes from losses to gains (Kahneman & Tversky, 1979). In many situations, decision makers satisfice (select the first alternative that is good enough – satisficing) and do not maximize (Simon, 1955). Although the facts against the SEU theory are overwhelming, the model, empirical data deviating from it, and its relatives have dominated behavioral decision research for half a century.

In multiattribute utility theory (MAUT), an alternative is represented by aspects (e.g., SEK 35,000 a month, 40 km from home) on attributes (e.g., salary, distance to work). The model is an extension of the SEU model to the multidimensional case with independent attributes. This kind of representation of decision alternatives is also used in most process theories.

SEU theory and variations of the fundamental theory model human decision making without any description of the psychological processes leading to a decision. It only takes into account the decision problem and describes the outcome of the decision. Such an approach to behavioral decision theory has been called *structural*. There has been no explicit room for motivation in this context. Instead, one may say that the empirical results have been used to find out about the decision makers' motivation (e.g., to maximize or satisfice) even if motivation was not the focus of the research. When the results from structural decision studies have been reported in terms of interindividual differences, needs and motivation may be inferred hypothetically even if they are not treated as such in the original work. To illustrate, a need of security can be assumed to motivate decision makers who avoid taking risks. Risk avoidance, risk taking, and conservatism have been explained as reflecting personal strategies, and in general no elaborated analyses have been made in terms of motivation. However, Cacioppo and Petty (1982) explain differences in decision making in terms of need for cognition motivating different decision-making strategies. Webster and Kruglanski also address individual differences and explain them in terms of need of cognitive closure (Webster & Kruglanski, 1994).

There are different techniques for aiding and supporting decisions. Most decision-aiding techniques use the MAUT model as the theoretical foundation, and start the aiding process with an exploration of fundamental needs, goals, and motivations of a client. The aim of this process is to find a common utility scale on which all the different motives can be mapped.

PROCESS-ORIENTED DECISION RESEARCH

In contrast to structural theories, *process theories* do not only aim at predicting the final decision but their primary goal is to model the processes leading to a decision. A number of process decision theories also model processes after a decision. In 1957, Festinger published his *Theory of Cognitive Dissonance*, a theory with great influence on later process approaches to human decision making. Festinger postulates that an individual strives toward consistence within herself or himself. If there is an inconsistency of cognitions, in the theory called dissonance, there is psychological discomfort. Festinger defined dissonance in the following way: "Two elements are in a dissonant relation if, considering these two alone, the obverse of one element would follow from the other" (1957, p. 13). Festinger introduced his basic hypotheses early in his book:

1. The existence of dissonance, being psychologically uncomfortable, will motivate the person to try to reduce the dissonance and achieve consonance.

2. When dissonance is present, in addition to trying to reduce it, the person will actively avoid situations and information which would likely increase the

dissonance.... Cognitive dissonance can be seen as an antecedent condition which leads to activity oriented toward dissonance reduction just as hunger leads to activity oriented toward hunger reduction (Festinger, 1957, p. 3).

Thus, Festinger identified the need of reducing cognitive dissonance and the goal of cognitive consonance. The magnitude of dissonance determines the strength of the motivation to reduce the dissonance. The magnitude of dissonance depends on the importance of the elements that are dissonant and the relative attractiveness of the non-chosen alternative to the chosen one. The more important the elements and the greater the relative attractiveness of the non-chosen alternative in comparison to the chosen alternative are, the stronger the motivation to reduce cognitive dissonance. Festinger was only interested in what happens after a decision, and paid no attention to what was happening before a decision. So, contemporary SEU theory treated antecedents to a decision and the decision itself, but the Theory of Cognitive Dissonance only covered postdecision processes. This was also the case in the volume by Festinger and collaborators who presented a number of empirical studies about a decade after the first presentation of the theory (Festinger, 1964).

Festinger's approach to studying postdecision processes was largely ignored by mainstream decision researchers who concentrated their efforts on investigating antecedents of a decision and the ensuing decision and not the consequences of decisions. Furthermore, Svenson's (1979) review of the few process studies of decision making in the 1960s and 1970s did not have one single reference to Festinger or any of the studies based on his theoretical concepts.

In most process studies of decision making there is an assumption of a process need to spend as little energetic effort as possible in a decision process. This motivates a decision maker to use simplifying rules requiring less information search and processing if this will not affect the decision quality in a serious way. In other situations, there may be a conflict between the needs of spending as little energetic effort and of finding the best solution of a decision problem, in turn leading to a trade-off between the corresponding motivations.

Janis and Mann (1977) followed in the Festinger tradition, but they did not agree with the focus on postdecision processes only. Instead, they claimed on empirical grounds that even before a decision, processes such as bolstering (selecting and interpreting information so that it supports the chosen alternative) take place. Janis and Mann concentrated their research on level-three decisions and focused on the effects of motivational conflicts on decision processes.

They used the term "psychological stress" "as a generic term to designate unpleasant emotional states evoked by threatening environmental events or stimuli" (Janis & Mann, 1977, p. 50).

There is always a need to avoid or decrease psychological stress, and this motivates decision processes that are able to relieve the decision maker from stress. Janis and Mann presented a number of ways in which the decision process can be affected as a result of different ways of solving decision conflicts under different conditions, activating other kinds of needs and motivations.

It is interesting to note that according to Janis and Mann, predecision reactions to decision conflict, such as bolstering, are motivated by anticipatory imagination of postdecision conditions. "We regard bolstering as one of the most common forms of defensive avoidance, and we assume that it is motivated primarily by a need to ward off the stress of postdecisional conflict rather than by an invariable tendency to reduce cognitive dissonance" (Janis & Mann, 1977, p. 85). This corresponds to the later concept of anticipated postdecision regret (Zeelenberg, 1999), which is a fundamental motive modeled as a negative cognitively based emotion experienced when imagining (or realizing) that the outcome of a decision would have been better after another choice.

According to Svenson (1992, 2003, 2006), who continued the process tradition with his Differentiation and Consolidation (Diff Con) theory, one goal of a decision process is a chosen alternative that is sufficiently superior in comparison to its closest competitor. If this is not the case from the beginning, a "winning alternative" has to be created in different kinds of differentiation processes. These processes start before the decision in differentiation and continue beyond the decision and its implementation in consolidation processes using different decision rules and changing mental representations of evaluations and facts to arrive at a superior alternative.

There are at least two groups of process and representation needs motivating differentiation and consolidation processes in Diff Con theory. The first group relates to cognitive prototype "gestalt" factors. "This set of driving factors can be related to predominantly cognitively driven explanations [Bem, 1967], to attribution theory [Kelley, 1967], and to self-serving biases [Greenwald, 1980]" (Svenson, 2003 p. 317). Also belonging to this set of factors is the need of dissonance reduction (Festinger, 1957), specified in terms of both predecision differentiation and postdecision consolidation in Diff Con. The stability and safety motive belongs to the second group of these needs-motivating differentiation and consolidation processes: [It] is related to a safety or stability motive and refers more clearly to a decision maker's predictions of aspects, images, or scenarios in the postdecision phase. This set of (motivating) components drives predecision differentiation in a process that is explicitly related to the future much more than the first set of (motivating) factors. After a decision the same set of components drives consolidation, so that in spite of adverse events and regret, the chosen alternative appears or becomes sufficiently superior to its competitors (Svenson, 2003, p. 318).

Montgomery was less explicit about motivation when he presented his Dominance structuring theory. However, striving for a decision with one alternative dominating the others can be perceived as the response to a process and representation need motivating the dominance structuring process (Montgomery, 1998). The trade-off between the goals of effort and accuracy (here interpreted as fundamental goal fulfillment) illustrates how process and fundamental motivation have been treated in process studies of decision making (Payne, Bettman, & Johnson, 1993; Weber & Johnson, 2009).

Process approaches have been concerned with process and representation motivation. In contrast, decision-aiding techniques focus on fundamental needs and motives and the trade off functions between different motives. These techniques typically impose the decision process on a client through eliciting evaluations concerning fundamental motives and mechanically integrating this information according to some model in interaction with the client. Traditional SEU-related research typically has had little to say explicitly about either fundamental or process and structural motivation.

STRUCTURAL DECISION RESEARCH

Decision research founded on SEU theory or its relatives postulates that a decision maker has two kinds of motives. First, a decision maker has a fundamental motive to maximize her or his own utility. Second, a decision maker has a process motive to use logically and statistically correct procedures when integrating the information about available alternatives. In empirical research, the theory is often so strong that when decision makers do not follow the theory, this is called biased behavior instead of evidence against the theory. Sometimes, the biases are explained by drawing on existing general knowledge and facts about human cognition and behavior. However, an approach to study behavior that discards disconfirmations of a theory of human behavior as human biases instead of a shortcoming of the theory seems very odd. Fortunately, there are other approaches now emerging in structural decision research.

Some researchers started to differentiate between different kinds of utility as motivating decisions. To exemplify, Frisch and Jones (1993) used the terms *decision utility* (when the decision was made) and *experienced utility* (when the outcome was evaluated). Kahneman, Wakker and Sarin (1997) distinguished between *instantaneous utility* (ongoing via sensory input), remembered utility, predicted utility, and decision utility (at the time of the decision). These interdependent utilities may create interacting motives at the time of a decision. Mellers, Schwartz, and Ritov (1999) developed and tested a theory that was centered around anticipated emotions as motivating decisions. The decision affect theory by Schneider and Barnes (2003) went further and investigated fundamental goals of decision makers, identifying eight different areas that were experienced as motivating their participants' decisions. Goals in these areas were elaborated and set into a context of essential motives according to evolutionary and motivational theories. Krantz and Kunreuther (2007) reintroduced goals and plans (Miller, Glanter, & Pribram, 1960) and multiple goal-based models, and used it in their decision research in a very fruitful way. They point out that one plan and its associated decision(s) may satisfy several goals (and not just maximize a common value function) at the same time, and that this is important when people make decisions.

For more than a decade, a number of structural-decision investigators have shown an interest in fundamental motivation related to emotion. Affect and emotion have been contrasted with cognitive evaluations and utility as motivating decisions. Zajonc's (1980) brought attention to the fact that affective and emotional reactions can be extremely quick, and that they do not have to be transmitted via elaborate cognitions. Zajonc's 1980 paper was important for decision researchers who started to include basic needs and motivations in structural approaches. Another important influence for these researchers was dual-process theories, in which a cognitive rational system and an emotional affective system are assumed to work in parallel. An example of this is Epstein (1994), who models an individual's interaction with the environment as transmitted by two different and parallel systems. The rational system is a deliberative analytic cognitive system following rules of logic. The experiential system perceives reality in an affective emotional way using feeling as an important component. Although the systems work in parallel they also interact.

As found by a number of decision researchers (e.g., Isen, 2000; Luce, Bettman, & Payne, 1997), affect and emotion may influence process and representation motivation (e.g., positive affect and mood are coupled with motivation to search less information) and fundamental motivation (e.g., decision makers in a positive affect and mood are motivated to recall and search more information that is positive in relation to fundamental goals). Affect and emotion can also influence fundamental motivations and the trade-offs between them (e.g., under some conditions, security becomes a weaker motive and predictive utility a stronger motive). Loewenstein and Schkade (1996) also pointed out that visceral motivation (e.g., addictions) totally dominates some decisions.

Anticipated postdecision regret (when the wrong choice was made) and disappointment (an unfortunate outcome of a "correct" choice) have been regarded as anticipatory emotional factors motivating decision makers (Connolly, Ordonez, & Coughlan, 1997). Loewenstein et al. (2001) distinguished between anticipated emotions and anticipatory emotions. The former are largely cognitively represented predictions of future emotional states; the latter are emotional reactions in the present when thinking of what may happen after a decision. Both kinds of emotions motivate decision makers.

Empirically, it is very difficult to differentiate between cognitive motives and emotional affect motives in a decision process (Svenson, 2003). Emotional reactions are often very fast, and faster than many cognitive reactions, but this does not lead to the conclusion that a quicker response is always only emotional and not cognitive. One should remember that the fastest perceptual-cognitive motor feedback loops require only about 250 ms. Slovic and colleagues circumvented the problem of differentiating emotion and cognition and defined affect in a new way, as will be shown in the next paragraph.

The most general and developed theoretical framework including affect as motivating decision makers has probably been presented by Slovic and his collaborators (Finucane, Peters, & Slovic, 2003). The meaning of affect is not well defined in the research literature and varies a lot. Slovic and colleagues used this uncertainty and provided their own definition of the concept. "We see affect as 'goodness' or 'badness' (1) experienced as a feeling state ... (2) demarcating a positive or negative quality of a specific stimulus.... Unlike emotion, we view affect as having the capacity to be subtle and to be without elaborate appraisal properties; unlike mood, we view affect as having a direct (rather than indirect) motivational effect" (Finucane et al., 2003 p. 328). This kind of affect is distinct from emotion but not from feeling in this framework. Thus, affect is not used in its more conventional way (most often including emotion and excluding cognition) by Slovic and his colleagues. There is an affective conditioning history of each individual, so identical decision problems can elicit different affects in different persons. This means that cognitive, emotion-free judgments in the past may have created an affective reaction to an alternative in a later decision. The affective heuristic is a name for decisions that are at least in part motivated by affect. Affect and more deliberate cognitive processes typically interact and motivate most decisions, according to Slovic and coworkers. Loewenstein and Schkade (1999) have presented (the maximization of) predicted (positive) feelings as a fundamental motive in decision making. In particular, they were interested in mispredictions of future feelings and how to debias decision makers in this respect, if possible.

From a social psychological perspective, Tetlock has drawn attention to accountability, both external and internal, as motivating decisions (Tetlock, 1992). He sees accountability as serving a critical rule-and-norm–enforcement mechanism. According to Tetlock, decisions are motivated by their justifiability. Tetlock is special because he is one of the few researchers of social psychology who has had an impact on mainstream decision research. There are also other related social psychological motives: a need of making the same decision as a group; to make the same decision as a significant other would; to follow habits; and so forth. However, there are not so many direct links from most structural decision research to social psychology, so one rarely finds this kind of fundamental motives in structural decision research with an exception of the justification motive. However, "A focus on goals may provide a natural way of further integrating social and cognitive psychological insights (with decision research)" (Weber & Johnson, 2009, p. 76).

CONCLUDING REMARKS

In this chapter, fundamental motives have been distinguished from process and representation motives. Other authors have presented similar distinctions. To illustrate, Weinberger and McClelland (1990) differentiate between cognitive motivation and more primitive motivation models. Samsone and Harackiewicz (1996) present an overview of different motivation models and differentiate between process and outcome motivation. For a long time, the fundamental motives of a decision maker were considered to be self-evident and never discussed in traditional decision theory and research. All fundamental motivations were assumed to be possible to evaluate in money or utility and to be integrated into a general motivation to get as much money or utility as possible in the long run, even if only a single decision was made. Process and representation motivation was assumed to coincide with the laws of logic and statistics. Empirical results showing that decision makers did not follow these laws were described as human biases and heuristics. However, quite early, individual differences in terms of risk aversive or risk prone behavior were included as motivating decisions.

In contrast, process-oriented decision researchers had a lot to say explicitly about motivation, but most of their interest concerned process and representation motivation and not much was said about fundamental motivation. Much of the process-oriented research was focused on the solution of conflicts between different motives in a decision situation.

Around 1990, the roles played by affect and motivation regarding decision making were brought into focus by structural decision researchers; thereafter, it became an important topic for many researchers. However, it is easier to differentiate affect and emotion from cognitive processes in theory than in empirical research, and there is yet much work to be done concerning this issue. Generally speaking, decision research has emphasized the creation of cognitive congruence between motives and decisions (Simon, Snow, & Read, 2004), postulated maximization of expected personal utility, acknowledged the effect of emotional and affective motivation in parallel with motivation grounded in cognitive processes, and pointed out the trade-off between needs of high-quality decisions and resource preservation (e.g., time, effort). At present, it seems as if decision research is slowly leaving the prison of a too-strong theory and moving into theoretical and empirical research driven by decision makers' motives, their own realities and psychological decision processes, and not by a theory that cannot be refuted. This is a promising trend for future developments of decision research.

References

Arkes, H. R., & Hammond, K. R. (1986). *Judgment and decision making: An interdisciplinary reader.* New York: Cambridge University Press.

Baron, J. (2008). *Thinking and deciding* (4th edition). Cambridge: Cambridge University Press.

Beach, L. R. (1990). *Image theory: Decision making in personal and organizational contexts*. Chichester: Wiley.

Bem, D. J. (1967). Self perception: An alternative interpretation of cognitive dissonance phenomena. *Psychological Review*, **74**, 183–200.

Cacioppo, J. T., & Petty, R. E. (1982). The need for cognition. *Journal of Personality and Social Psychology*, **42**, 116–131.

Connolly, T., Ordonez, L. D., & Coughlan, R. (1997). Regret and responsibility in the evaluation of decision outcomes. *Organizational Behavior and Human Decision Processes*, **70**, 473 485.

Edwards, W. (1954). The theory of decision making. *Psychological Bulletin*, **41**, 380–417.

Epstein, S. (1994). Integration of the cognitive and the psychodynamic unconscious. *American Psychologist*, **49**, 709–724.

Festinger, L. (1957). *A theory of cognitive dissonance.* Stanford California: Stanford University Press.

(1964). *Conflicts, decision and dissonance.* Stanford CA: Stanford University Press.

Finucane, M. L., Peters, E., & Slovic, P. (2003). Judgment and decision making: The dance of affect and reason. In S. L. Schneider & J. Shanteau (Eds.), *Emerging perspectives on judgment and decision research* (pp. 327–364). Cambridge: Cambridge University Press.

Frisch, D., & Jones, S. K. (1993). Assessing the accuracy of decisions. *Theory and Psychology*, **3**, 115–135.

Gilovich, T., Griffin, D., & Kahneman, D. (2002). *Heuristics and biases: The psychology of intuitive judgment.* New York: Cambridge University Press.

Goldstein, W. M., & Hogarth, R. M. (1997). *Research on judgment and decision making: Current connections and controversies.* New York: Cambridge University Press.

Greenwald, A. G. (1980). The totalitarian ego: Fabrication and revision of personal history. *American Psychologist*, **35**, 603–618.

Isen, A. M. (2000). Positive affect and decision making. In M. Lewis & J. M. Havieland (Eds.), *Handbook of emotions* (2nd ed., pp. 417–435). London: Guilford.

Janis, I. L., & Mann, L. (1977). *Decision making.* New York: Free Press.

Johnson, B. T., & Eagly, A. H. (1989). The effects of involvement on persuasion: A meta analysis. *Psychological Bulletin*, **106**, 290–314.

Kahneman, D., & Tversky, A. (1979). Prospect theory: an analysis of decisions under risk. *Econometrica*, **47**, 263–291.

Kahneman, D., Wakker, P., & Sarin, R. (1997). Back to Bentham? Explorations of experienced utility. *The Quartely Journal of Economics*, **112**, 375–406.

Kelley, H. H. (1967). Attribution theory in social psychology. In D. Levine (Ed.), *Nebraska Symposium on Motivation* (Vol. 15, pp. 192–238). Lincoln: University of Nebraska Press.

Krantz, D. H., & Kunreuther, H. C. (2007). Goals and plans in decision making. *Judgment and Decision Making*, **2**, 137–168.

Kwong, J. Y. Y., & Leung, K. (2002). A moderator of the interaction effect of procedural justice and outcome favourability: Importance of the relationship. *Organizational Behavior and Human Decision Processes*, **87**, 278–299.

Loewenstein, G., & Schkade, D. (1999). "Wouldn't it be nice?" Predicting future feelings. In D. Kahneman, E. Diener, & N. Schwartz (Eds.), *Well-being: The foundation of hedonic psychology* (pp. 85–108). New York: Russel Sage.

(1996). Out of control: Visceral influences on behavior. *Organizational Behavior and Human Decision Processes*, **65**, 272–292.

Loewenstein, G., Weber, E. U., Hsee, C. K., & Welch, E. S. (2001). Risks as feelings. *Psychological Bulletin*, **127**, 267–286.

Luce, M., Bettman, J., & Payne, J. W. (1997). Choice processing in emotionally difficult decisions. *Journal of Experimental Psychology: Learning, Memory and Cognition*, **23**, 384–405.

Mellers, B., Schwartz, A., & Ritov, I. (1999). Emotion-based choice. *Journal of Experimental Psychology: General*, **128**, 332–345.

Miller, G., Galanter, E., & Pribram, K. (1960). *Plans and the structure of behavior*. New York: Holt, Rinehart and Winston.

Montgomery, H. (1998). Decision making and action. The search for a dominance structure. In M. Kofta, G. Weary, & G. Sedek (Eds.), *Personal control in action. Cognitive and motivational mechanisms* (pp. 279–298). New York: Plenum Press.

Payne, J. W., Bettman, J. R., & Johnson, E. J. (1993). *The adaptive decision maker.* Cambridge: Cambridge University Press.

Plous, S. (1993). *The psychology of judgment and decision making.* New York: McGraw-Hill.

Samsone, C., & Harackiewicz, J. M. (1996). "I don't feel like it": The function of interest in selg-regulation. In L. L. Martin & A. Tesser (Eds.), *Striving and feeling* (pp. 203–228). Mahwah: Lawrence Erlbaum.

Schneider, S. L., & Barnes, M. D. (2003). What do people relly want? Goals and context in decision making. In S. L. Schneider & J. Shanteau (Eds.), *Emerging perspectives on judgment and decision research* (pp. 394–427). Cambridge: Cambridge University Press.

Schneider, S. L, & Shanteau, J. (2003). *Emerging perspectives on judgment and decision research*. Cambridge: Cambridge University Press.

Simon, H. A. (1955). A behavioral model of rational choice. *Quarterly Journal of Economics*, **69**, 99–118.

Simon, D., Snow, C. J., & Read, S. J. (2004). The redux of cognitive consistency theories: Evidence judgments by constraint satisfaction. *Journal of Personality and Social Psychology*, **86**, 814–837.

Svenson, O. (1979). Process descriptions of decision making. *Organizational Behavior and Human performance*, **23**, 86–112.

(1992). Differentiation and consolidation theory of human decision making: A frame of reference for the study of pre- and postdecision processes. *Acta Psychologica*, **80**, 143–168.

(2003). Values, affect, and processes in human decision making: A differentiation and consolidation theory perspective. In S. L. Schneider & J. Shanteau (Eds.), *Emerging perspectives on judgment and decision research* (pp. 287–326). Cambridge: Cambridge University press.

(2006). Pre- and post-decision construction of preferences: Differentiation and consolidation. In S. Lichtenstein & P. Slovic (Eds.), *The construction of preference* (pp. 356–371). Cambridge: Cambridge University Press.

Tetlock, P. E. (1992). The impact of accountability on judgment and choice: Towards a social contingency model. *Advances in Experimental Social Psychology*, **25**, 331–376.

Weber, E. U., & Johnson, E. J. (2009). Mindful judgment and decision making. *Annual Review of Psychology*, **60**, 53–85.

Webster, D. M., & Kruglanski, A. W. (1994). Individual differences in need for cognitive closure. *Journal of Personality and Social Psychology*, **67**, 1049–1062.

Weinberger, J., & McClelland, D. C. (1990). Cognitive versus traditional motivational models: Irreconcilable of complementary? In E. T. Higgins & R. M. Sorrentino (Eds.), *Handbook of motivation and cognition: Foundations of social behavior* (pp. 562–597). New York: Guilford.

Zajonc, R. B. (1980). Feelings and thinking: Preferences need no inferences. *American Psychologist*, **35**, 151–175.

Zeelenberg, M. (1999). Anticipated regret, expected feedback and behavioural decision making. *Journal of Behavioral Decision Making*, **12**, 93–106.

16

Cognitive Science and Knowledge Management

Reflecting the Limits of Decision Making

Rainer P. Born & Eva Gatarik

INTRODUCTION

Knowledge Management suffers in some way from the fact that *economic decisions* in many cases rest upon incomplete information. Far too often one believes in the correctness of decision calculi, for example, Decision Support Systems (DSS), and is at a loss if one needs experience in order to evaluate consequences and correct the actions (considered to be meaningful because they are supported by calculations or computations). What is missing is additional knowledge stemming from expertise; that is, an understanding of the signals (or the meaning of those signals) that come from experience – signals that help select good solutions and eliminate bad ones, insofar as we consider our expectations. These signals provide constraints to generate solutions that are acceptable both on a personal as well as societal (i.e., ethical and cultural) levels. As will be seen, one can argue for an interesting parallel to Jerome Bruner's (1990, p. 4) ideas concerning the need for a second cognitive revolution. Bruner seems to be very unhappy about the replacement in psychology of the "construction of meaning" by the algorithmic/computational "processing of information" in the first cognitive revolution.

The developments in Knowledge Management took a similar course. Instead of constructing meaning (for details, see following information) in psychology, it was, and in Knowledge Management it still is, important to construct the inherent/intrinsic knowledge (based on information and expertise in use) in order to explain, for example, the competitive advantages of enterprises. In Knowledge Management, knowledge is therefore considered to be essential in order to explain the economic success of an enterprise. It is understood that the missing knowledge could not be brought about simply by the monetary means to organize a firm.

So, in cognitive psychology, it is evident that meaning (constructed to explain behavior and make the “black box” of behaviorism translucent) cannot be established by information-processing techniques alone, leading to proper decisions to react to other people and adjust oneself to society. Similarly, in Knowledge Management we find it is not enough to *administrate information* (corresponding to processing information) to build up or generate the relevant knowledge in order to explain the economic success. Bureaucratizing *expertise* in an enterprise is not enough to ensure success. Instead, technical expert systems, for example, should take up the routines of actions and help us gain time for concentrating on creative and innovative solutions and establishing flexibility. They should not, however, replace creativity by some sort of algorithm to produce *interpretable signs* within whatever we already know. Bruner replaces the *processing of information* – if we understood him correctly – by a new cultural psychology. In Knowledge Management, however, we suggest that *sharing expertise* can take up this mission in comprising not only cognition but also both emotion and motivation.

The really important point now is the following one: Although one has recognized, in the context of Management and Administration, that knowledge by content – namely, constructed knowledge – is important, one still seems to think that management based solely on monetary control will work well. Looking carefully, one can see that merely providing information is not enough. We also need a technique to be able to use knowledge properly.

In Knowledge Management, one has not yet seen the point Bruner really wants to make – to see the necessity for a second revolution in cognitive approaches. The second revolution should take up (just as Bruner does) in some sense the pragmatic aspect of semiotics, the use of information, and therefore an understanding of the limits of syntax and semantics. Just providing well-processed information is definitely not enough. We need to improve on change and enable some learning concerning the knowledge of the users (e.g., managers). In the sequel, we shall do this within the framework of Language-Information-Reality (LIR), analyzing the relation between language, information, and reality in connection with the cognitive and emotional reflection, based on motivation and drive according to Antonio R. Damasio.

It seems that more or less implicitly we did assume that the reconstruction of knowledge by way of administrating information (without providing a correct understanding of meaning) might be sufficient, but it is not. The research by Damasio shows that signals from emotional evaluations of experience (so-called somatic markers) are necessary to establish those constraints that are essential to produce *acceptable solutions*, especially in business administration.

According to Damasio, the emotional knowledge residing in experience and expertise based upon motivations and drives produces those socially anchored linguistic categories, which enable us to use reflective knowledge for correction. They can thus help us identify the limits of the applicability of those algorithms, which we consider to be essential for producing meaningful or useful information in the context of decisions. By providing constraints, these signals should help us reduce the set of computable solutions and thus produce a set of meaningful, creative, innovative, and especially acceptable solutions depending on the concrete situation.

The technical means to achieve this are – as already mentioned – the scheme LIR and the influence of the "scissors of knowledge and life" on meaning. Besides the insights of Jerome Bruner, the work of Damasio is especially important because it highlights the influence of drives and motivations on emotions and feelings in the context of cognition and decision making. Errors and mistakes in decision making cannot be explained by the lack of cognition – for example, missing knowledge. On the contrary, in real life, cognition alone would provide too many possible solutions, which need to be reduced by an emotional estimation of similar experienced situations. Emotions/motivations are thus not a luxury, but an essential part in our successful adjustment to the world. Therefore, we need to differentiate between *sharing knowledge*, which concerns primarily cognition, and *sharing expertise*, which includes emotion as well as motivation to achieve a shared real aim. It thus links up to Bruner's cultural psychology.

In classical Knowledge Management, only the cognitive part of knowledge is provided for decision making, and there is a lack of emotional and motivational reflection of means and ends. In this context, decisions are built upon a cognitive processing of explicated information. Other problem solutions incorporating feelings, emotions, and motivations based on experience/expertise are not really admissible. The technical means to produce decisions are, however, much too weak; thus, an extension is necessary. The problems arising from applying Cognitive Science to Knowledge Management and its actualization in decision-making processes, based on the influence of cognition and motivation, pave the way to understanding the limits of the techniques for decision making and the necessity to improve on knowledge by a *new learning* (Robinson, 2001, 2009) in order to permit creativity, innovation, and flexibility in decisions attuned to a world in change.

SETTING UP THE SCENE

Bruner, together with and influenced by Egon Brunswik (Hammond, 1966), can be considered as one of the founding fathers of cognitive psychology, which in the sequel had a strong influence on the development of cognitive science in general. In *Acts of Meaning*, Bruner (1990, p. 2) emphasizes that we should try to "recapture the original momentum of [what he calls] the first cognitive revolution."[1] According to Bruner, the aim of this first revolution was to bring mind back into the human sciences (today, perhaps, especially into behavioristically orientated economics), "after a long cold winter of objectivism," not necessarily *mindlessness*, promoted especially by behaviorism.

As we shall see, however, this kind of revolution was not really successful in reintroducing mind and mindfulness into psychology as an explanation of and guide to handling human behavior. So Bruner (1990, p. 2) opts for what he calls a renewed, or second cognitive revolution, which should be "a more interpretive approach to cognition," an approach concerned especially with meaning-making.

The aim or approach of the first revolution was "to discover and to describe formally the meanings that human beings created out of their encounters with the world, and then to propose hypotheses about what meaning-making processes were implicated" (Bruner, 1990, p. 2). What was it that could be explained by those meanings, and in which way are those meanings considered to be necessary to "understand, explain and predict" and thus adjust/attune ourselves to the behavior of others?

Bruner (1990, p. 4) declares that from very early on, to render the black box of behaviorism translucent in the cognitive movement, "emphasis began shifting from meaning to information, from construction of meaning to the processing of information." What seemed to be essential was to find "mechanical[2] or other procedures" to be able to identify/produce/simulate/imitate meaning-making processes including cognition, and on a lower level, of emotion and motivations (Damasio, 2003), and to stimulate them.

Thus – Bruner (1990, p. 4) insists – very soon "computing became[3] the model of the mind, and in place of the concept of meaning there emerged the concept of computability." This concept was amplified by the idea of "computabilism," considered as the thesis that "the brain and the mind function basically like a computer" (see the discussions in Gödel, 1990; Wang, 1974).

In formal terms, computationalism might thus be considered or used as an explanatory approach concerning mental phenomena/processes. According to Wang (1974), Gödel was interested in the question of whether all thinking is computational, with special emphasis on mathematical thinking. Gödel's main interest, however, was to show that not all mathematical thinking is computational in the normal sense of the word (i.e., is based on some kind of calculation).

In trying to establish the connection between computations in computer simulation/informatics and the cognitive sciences, it may be helpful to understand the way in which we might try to grasp the so-called content of thoughts, especially by using formal systems (Frege, 1918). Gödel, for example, insisted that the concept of "Turing machines" (the abstract concept of computation that is then assumed to be the model of the mind) is an explication of what formal systems amount to. Throughout his life, he turned repeatedly to the issue of investigating the limits of formal systems in trying to grasp in which way the *mind* goes beyond usual conceptions of computation. Gödel even claims that Turing disregarded completely "the fact that mind, in its use, is not static, but constantly developing." Furthermore, he emphasizes "that we understand abstract terms more and more precisely as we go on using them, and that more and more abstract terms enter the sphere of our understanding" (Gödel, 1990, p. 306).

Bruner, on the other hand, claimed that there must be something wrong in taking the concept of computing too literally; that is, considering the formation of meaning (considered to be essential for explaining the reaction of human beings to signs as information bearers) as the result of some computational process concerning the processing of information (in the sense of some "inference engine," as implemented later in experts' systems).

Let us therefore start with the application of the computational paradigm within cognitive science. Why is it assumed that we cannot build up or produce meaning solely with the help of algorithms, and why are rules (in this context, usually considered as human instantiations of algorithms for handling information) insufficient for constructing meaning in order to be able to act properly upon information turning up in some situation? Maybe the following picture of understanding how to study the mind with the methods of natural sciences would be helpful to give a different flavor to the problem.

Consider we are observing some biological system – for example, a human being in a certain well-specified situation. A situation of this kind may be considered as reproducible in its essentials and therefore can turn up again, as we want to adjust ourselves to that person or attune ourselves to the world. Now, if we want to explain or predict behavior in that situation – and under the assumption that a person is reacting to some well understood and therefore as meaningfully interpreted information and is drawing conclusions in order to react properly – then we may well consider that this is a process going on in the mind of that person.

In formal logic, means have been developed to justify the validity of certain inferences. This technique can be programmed and the results can finally be computed. What we learn in practice – taking up some of Quine's (1990) ideas – is to argue and draw conclusions in such a way that the validity of the inference can be justified. The point here is that those means of justifying the validity of an inference are not necessarily literally descriptive of the causal mechanisms governing our brain-states and their transitions as far as the logical/formal side of thinking is studied. Why does this matter in our context? The question is of particular significance in view of Gödel's insistence that the mind can do more than a computer, at least in abstract mathematical thinking, or, as Hilary Putnam (1981) claimed: reason can transcend whatever reason can formalize.

As far as cognition is concerned, let us consider the fact (see the drummer's example, 9.3) that we think we were successful in calculating some of the information that an individual may have available in the situation, and that we know how it is encoded in the sign system/language in use at the level of that individual. In that case, we might be able to test our hypotheses by presenting to that individual meaningful signs (although calculated with formal means). We may test our hypotheses with respect to expected or predicted reactions. We may be able to predict reactions, reactions that could not be explained just mechanically, but as we think presuppose the working of a mind. Bruner (1990, p. 5) argued that a normal, mechanical, or plainly algorithmically working system cannot deal for example with "vagueness, with polysemy, with metaphoric or connotative connections" and other essential matters in daily life. Therefore, the construction of meaning/processing of knowledge or information need the "extra kick" of a mind, just as semantics is more than syntax. However, the essential point of the picture has not yet emerged. What is essential is that our means to calculate meaningful signs are a technical or reconstructive means to reproduce the meaningfulness of those signs (i.e., the cognitive part of formal/syntactical means). Those means, however, are not necessarily literally descriptive as the "reality guys seem to assume," according to Bruner,[4] just as logic when applied to a mathematical proof reproduces the validity of a mathematical theorem with respect to the mathematical/structural presuppositions.

So, the means to reproduce the meaningfulness (but not an understanding of the message per se) will not necessarily be the means employed by an individual to produce the information encoded in those signs in order to behave properly in the situation under investigation. The last and perhaps most important point, however, seems to be the following (see Figure 16.1): Even if we are successful in making good predictions of the behavior of some individual, we have to consider the pre-experience of that individual, the soil upon which the seeds of information fall that gives meaning to those calculated items of information. Wittgenstein (1953, p. 38) insists that

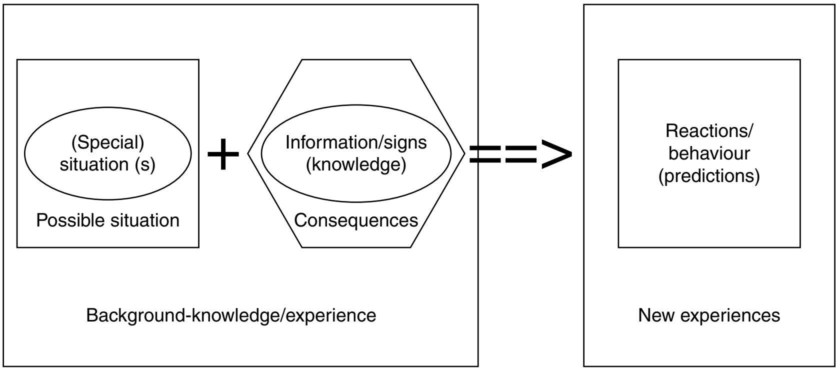

FIGURE 16.1. The importance of background knowledge.

we need “a greater clarity about the concepts of understanding, meaning, and thinking.” He goes on to remark that “it will then also become clear, what can lead us (and did lead me) to think that if anyone utters a sentence and means or understands it [s]he is operating a calculus according to definite rules.” This will lead us to the central topic of new ways of computation and some kind of solution and practical consequences, which we shall provide with the help of the semantico-pragmatic scheme LIR (language/information/reality)[5] from Born. So, this is not just a sophisticated critique; it is essential for explaining the success and danger, for example, of Deep Blue (the chess program that beat Kasparov) and similar devices (the ironical drummer’s example, 9.3).

Any successful test presupposes such pre-experience. If we take the latter as fixed, we can consider our formal system to calculate information as complete with respect to our aims and let evolution or the Lord take care of changing those pre-experiences. We do not interfere. If we think we do not have to care, we seem to be justified to use algorithms to reproduce meaningful signs in order to teach individuals to produce meaningful signs. We learn rules to process information. The building up of meaning or understanding of those signs as meaningful are supposed to be achieved with the same means. Meaning is studied as a *means to come to terms with reality*, but is it really the case that meaning/experience (in the sense of knowing how to apply information) can be built up in that way? Would our predictions about the behavior of individuals being tested in situations where there was another pre-experience available still be correct? Is the pre-experience really built up in the way suggested? Maybe this is not a topic of science. At least in physics, for example, we are not conscious of it, and it does not change our theoretico-explanatory ideas. Gödel (1990, p. 306), on the other hand, seems to have been well aware of the problem and addressed it (as mentioned above) in the following way: "We understand abstract terms more and more precisely as we go on using them." This use of the abstract terms belongs to the building up of experiences, the construction of meaning in Bruner's terms, which cannot be achieved simply by "following the rules" (Wittgenstein, 1952, § 190a) in the sense of instantiating algorithms to produce meaningful signs and sentences.

To our mind, Gödel's message can be reformulated as trying to become intimate with some mental matters (e.g., abstract concepts), and this will lead to some kind of new insights that can guide our behavior (e.g., the application of information in the light of those experiences), our use of the signs, and will also produce a new use according to some agreed-upon shorthand. Winterson (1995, pp. 79–80) expresses the same idea in the following way: "Communication between you and me relies on assumptions, associations, communalities and the kind of agreed shorthand, which no-one could precisely define but which everyone would admit exists. It would seem that for most of us, most of the time, communication depends on more than words." In other words, the signs are abbreviations for some new practices that cannot simply be built up in following rules but that need to be established by some kind of intimacy[6] with a topic that essentially rests upon what may be described as the possibility of "reflective correction." Taking up the quote from Winterson, one could say the agreed-upon shorthand establishes a new practice, a new tie, a new form of life, in the sense of Wittgenstein's *Philosophical Investigations*.

This kind of *practical knowledge* need not be *computational*; it cannot be reproduced with formal/syntactical means alone. It will become to be possible to see this only in pragmatical ways, however, taking into account the application, context, and use of processed information. On the other hand, it may well be possible to use it in many cases in everyday life, reducing the application of knowledge to rules and taking into account what all people have in common insofar as epistemic presuppositions are considered.

Thus, the problem is how can we build up knowledge, how can we communicate information in such a way that successful applications of knowledge are guaranteed? Needless to say, responsibility comes in here, and ethics in a more general way, as well. The technique to convey information in the sense that it has to rest upon experience is essential, however (and not only for being able to deal with abstract mathematical concepts). One chance to build up meaning differently might be found in the technology of virtual reality, but the direction of development in connection with information processing and diagrammatical reasoning may be interesting. In building up new experiences, one can see new consequences (i.e., new ways of processing information may be at hand). Further, a new character of persuasion for accepting conclusions will be established, as they rest much more on visualization and other means of experiencing than before. We would feel more compelled to see (accept) a consequence rather than just on the basis of a logical derivation. Thus, there will be a new quality of accepting consequences of given information in well-defined situations as meaningful. It rests upon the well-established semantic techniques called *semantic tableaus* developed by Evereth Beth (1965) and is also applied in Beth's *physical semantics*, which in philosophy of science lead to the state-space approach concerning theories, surviving in the model-theoretic approach.

The final practical consequence of this view of the matter would be to see some of the faults in daily life i.e., the inability to see the twofold role of background knowledge or in many cases the need to give it up, as argued by Putnam [1992, p. 14] in connection with the possibility of an unimaginative or algorithmic artificial intelligence.

BRUNER'S PROPOSAL

Bruner's (1990, p. 11) proposal for a sort of reassessing of the cognitive revolution is to "return to the question of how to construct a mental science around the concept of meaning and the processes by which meanings are created and negotiated within the community." One of Bruner's critical remarks is that:

> Information processing [especially in the context of preparing for and providing material for decision making etc.] cannot deal with anything beyond well-defined and arbitrary entries that can enter into specific relationships that are strictly governed by a program of elementary operations. Such a system cannot cope with vagueness, with polysemy, with metaphoric or connotative connections.... Information processing needs advance planning and precise rules (Bruner, 1990, p. 5).

In the sequel, we will try to produce solutions or at least a better understanding of those problems with the semantico-pragmatic scheme LIR,[7] a scheme both for understanding as well as doing something about building up meaning and seeing the influence of cognition, emotion, and motivations.

The aim of our own considerations in this context, therefore, is twofold:

We want to come to terms with Bruner's suggestion as well as to find a new or rather more adequate understanding of calculation/computation/

computationalism that can do justice both to Bruner's qualms and produce a better handling of some of the problems we may be up to in the cognitive sciences. The latter refer to the explanation of the mind, especially with respect to developments in Knowledge Management. Why do meanings seem to be so important? What can they be used for to explain or predict? How can they help us adjust to the world? The real problem or question might be: Why are computations not enough? What is missing if we just stick to "computing" (processing) information? If we "enact" those computations, could we produce *meaning* and how would we know?

If we assume that a person has understood the meaning of some kind of information, we can consider the acceptance of this information as a consequence in more than one respect. We can think that the acceptance is manifested or even generalized by the fact that the linguistic signs that codify that information can be derived from some other already accepted information. On the other hand, we may have already experienced that the adding of background knowledge (or learning more about the topic in question) can help to accept something that hitherto has not been accepted. In this case, we do not say that the information is literally derived, but we may say that there is no way of supplementing the original information such that the originally given information is fulfilled in that realm of experience or that set of models. However, what may be considered as new or consequence is not fulfilled. We could consider this idea or formulation as a formal criterion for accepting something as a consequence. (cf. the idea of Beth's [1962] "semantic tableaus")

WHY THE FORMAL "INCOMPLETENESS" (OF SOME MEANS OF EXPRESSION, E.G., SOME LANGUAGE) MAY MATTER TO THE MIND

Incompleteness as the result of some informal decision being not decidable formally comes into the picture whenever we try to formalize experience or knowledge of content in the sense of trying to reformulate it syntactically. However, if we wonder how the knowledge – which is conveyed with our syntactic or even model-theoretic means – is applied, we sometimes say that somebody has not understood what was intended as meaning to be conveyed, or we use some stronger expressions or else she/he would not act, given certain information, in a way we can observe. This is a gross and rough description of the situation, but it depicts some of our feelings, and we may now analyze where they stem from. We suggest that the problems of misapplication (if they depend on the use of information or knowledge) stem from a *pragmatic incompleteness*. Thus, if meaning matters to the mind, incomplete knowledge definitely does, as well.[8]

STARTING UP WITH BRUNER ONCE MORE

What we want to find out is where exactly (logically speaking and not just historically) *computationalism* came into the picture as a means to study the mind. Where eventually did it happen that the construction of meaning got replaced by the processing of information, in the sense of manipulating meaningful signs to produce further meaningful signs? Maybe the manipulation of signs was not considered a description of processes in the brain but rather as a paradigm for producing good programs to produce meaningful signs?

Bruner (1990, p. 33), however, insists that, "The central concept of a human psychology is meaning and the processes and transactions involved in the construction of meanings." Furthermore, "One must understand how his experiences and his acts are shaped by his intentional states … the form of these intentional states is realized only through participation in the symbolic systems of the culture." This is Bruner's way of going "back to his roots," or in other words, it is his motivation to overcome the incompleteness of a computational approach when it is being taken too literally.

The question concerning the development positively as well as negatively of cognitive science we want to pose here, however, goes much further, presupposing the direction in which we are looking for a sort of solution. Can we understand how models, say, of the mind come to be turned into reality, are used to replace reality, or are even projected onto reality? How does it come about that one studies a phenomenon such as the mind with the help of a computational model, but eventually ends up by identifying the model with the world, or for that matter, the means with its ends or the territory with the map (Houellebecq, 2010), and draws conclusions from the model or chart to orient oneself in the world? Thinking that there are many useful charts of the world does not turn the (three-dimensional) world into a two-dimensional object or chart.

Now of course we all know that folk-psychological concepts such as attitudes or the assumptions about other peoples' minds are practical, although some want us to believe they are not real and we should find new corresponding concepts if we take cognitive science seriously. Will they be as cute, however? In physics we know that the earth is approximately a revolving, moving sphere, but we still talk about a rising sun, as though the earth were at rest. The question is rather *when* it is essential to switch to other pictures as behavior- and action-guiding insights. The mind produces pictures, but how can we compute them, predict them, predict their efficiency, and use them in solving certain tasks? This concerns our own actions to reach our goals. What could motivate us to turn the tables on those action-guiding pictures?

Why should we be motivated to understand the limits of cognitive decision making? Are there rules with no exceptions?

BUILDING UP (CONSTRUCTING) MEANING OUT OF COGNITION AND EMOTION/MOTIVATION

The main point that we really want to investigate is that we have to give up – in order to avoid consequences that are not in our interest – the idea of providing meaning simply by computing signs (i.e., in a context-free manner such that the results can be multiply instantiated). How can we build up meaning by computing signs as meaning bearers? As will be shown later, the technique of virtual reality (VR) could be a first step in this direction for studying the phenomena properly (i.e., using the technique to convey meaning and communicate meaning in providing experiences that could help build up new meanings).

Thus, the problem is how to convey meaning, and furthermore how to build up knowledge. Notably, we no longer live in the age of information processing but in the age of creating knowledge that allows us to make use of data and information in an appropriate way so that we can take into account ethical evaluations, as well.

PROJECTING CONCEPTS: KNOWLEDGE AS COGNITION?

How can we reach anything of that sort? In order to not just project concepts but to use them with everyday connotations, we have to understand how we apply computations, or rather how we grasp in a logical way what we think is essential, for example, in and about thinking.

Way back in Aristotelian logic, what was essential was the kind of classifications or categorizations in the linguistic sense that were created by the use of verbal representations or concepts. In that field and way, one could identify the causal if-then (in the world) with the logical if-then (in language) (see the relation between causes and reasons in Figure 16.7) – in some sense, one could identify reasons with causes. Drawing conclusions in the sense of processing information would at the same time be descriptive of what is going on causally in the world, so that one could watch time sequences literally as causal connections of events. In a similar manner, nowadays we would like to watch a program stepwise to produce the desired results (i.e., taking the recursive functions underlying the topic to be descriptive of causal connections). Within the refined area of application of logic, there was no need to distinguish between logic and what nowadays is called effective causality.

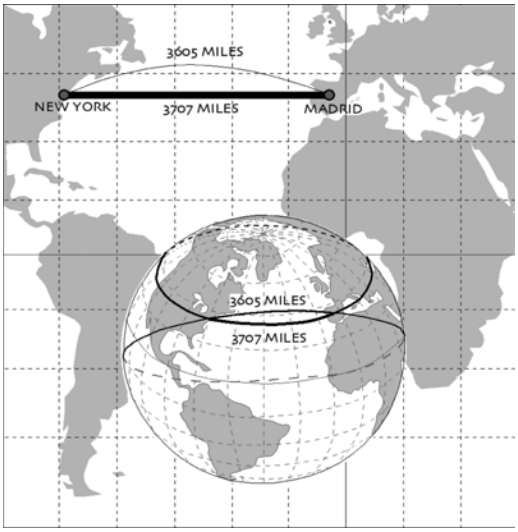

FIGURE 16.2. GEO example.

The classes that did correspond to some concepts had to consist of elements that had to have something in common all by themselves.[9] Later on, with the advent of modern science, it became clear that they did not need to literally correspond to reality and have something in common all by themselves.

Can we find new concepts or maps/charts/models to fulfill our urge for mixing causality and logic effectively, providing us with a new computationalism? Or are those concepts due to some research programs in cognitive science just a gleam in Paul Churchland's eyes, as Hilary Putnam (1992) once put it? Or can we find a compromise, something such as Dennett's "intentional stance" in a different guise? Sometimes we know that we are caught by perceptual deceptions, but the perceptions stay on – we cannot easily change our way of seeing the world.

If one looks at the graphic in Figure 16.2 as a plane and is told that the straight line from Madrid to New York is longer than the curved one just above it in the figure, one might easily mistrust this statement. One "sees" immediately that this cannot be correct if one looks at the map as a bidimensional object, which metaphorically speaking is governed by the grammar of Euclidean geometry in our modern understanding. If, on the other hand, the description of one line as above the other refers to the globe, one can easily see that Madrid and New York are approximately on the same circle of latitude and that another geodesic indicates a shorter distance if you want, for example, to fly. Your decision to follow the route of the straight line on a

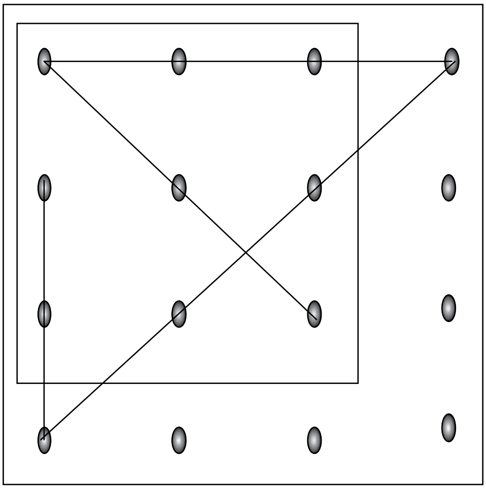

FIGURE 16.3. Nine-points example.

long-distance flight may prove to be disastrous if you run out of gas, the amount of which might have been calculated by someone else who thought you would fly along the geodesic. So the inference from the map to guide your actions using everyday imagination might be wrong with respect to your aims. Could you really provide an argument within everyday language to convey both the meaning and the validity of Figure 16.2, an argument that is not dependent on visualization, extra knowledge, and experience and still helps us survive in the situation above? There would then be a host of argumentative gaps to be filled up by intuition or common experiential and mental background knowledge. In any case, we do have to step out of the picture just as in the case of the solution of linking the 9 points (in Figure 16.3) by 4 lines without lifting the pencil.[10]

PHILOSOPHY IN THE FLESH

Lakoff and Johnson (1999, p. 3) listed several assumptions characterizing the cognitive sciences. We will concentrate only on one, namely, "Abstract concepts are largely metaphorical" (because they are explanatory and not literally descriptive).

If one considers the history of philosophy and Aristotelian logic and the latter's influence on modern thought, one can only agree with this claim. However, the problem concerns the conclusions to be drawn. The acceptance of conclusions is influenced by cognition and emotion. Furthermore, motivation and desires direct us to select appropriate simplifications to reach a goal (e.g., select the best chart or map).

Lakoff and Johnson (1999, pp. 373–391, especially pp. 381–382) rightly insist that classification was an important enterprise for Aristotle, because "Putting things in the right categories allows one to apply syllogistic logic to *produce* new causal knowledge. . . . For Aristotle logic was not a projection of the mind onto the world, but the opposite: a direct grasping by the mind of the rational causal structure of the world." In modern terms, however, this idea presupposes the world is such that the way our mind works is successful within that enterprise or that there is a mapping onto the resolution level of the mind that is at least a homomorphism. Yet, modern experience in processing knowledge shows that we cannot be so sure about that. If we circle the earth in a space shuttle and want to meet another object in the same orbit, we cannot simply accelerate to get closer, as we might expect from our experience in the everyday world. We would swerve off into another orbit!

Hence, the concepts in our mind should definitely not be projected literally onto the world. On the other hand, we should also not be too sure that there will be easygoing real and embodied concepts that can do the job. In that case, effective procedures, as, for example, computer programs, may also not be of much help if misunderstood all too literally or descriptively as ways to process information. We cannot expect all concepts to be literally applicable; that would drastically reduce our flexibility and richness of possible solutions. There is no complete description of the world that could use solely embodied concepts. The real problem is not to look where, how, and why sometimes-successful concepts are projected in an all-too literal way to understand the success but to look for compatible instantiations, instead. The real point, therefore, is to understand why and how it happens that people tend to use explanatory abstract concepts literally as action-guiding descriptions in the sense of producing action-guiding ideas through *acts of meaning* (Bruner, 1990).

THE SCISSORS OF KNOWLEDGE AND LIFE: UNDERSTANDING THE DEPENDENCE OF DECISION MAKING UPON EXPERTISE AS EMBODIED KNOWLEDGE (I.E., UPON COGNITION AND EMOTION/MOTIVATION)

1. The Basic Model (to Understand the Misguided Transformation of the Construction of Meaning into the Processing of Information)

Let us start from the observation that some people have successfully provided results or solutions either to some of their daily problems P or certain tasks Q

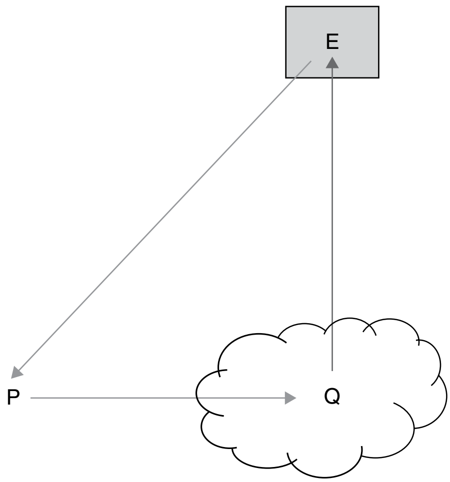

FIGURE 16.4. The background knowledge E applied to the problem P yields a solution Q.

(e.g., building a car or a technical machine). Retrospectively, they may have been asked how those solutions/results Q came about or were brought about, and essentially whether they could reproduce their success in a controlled nonarbitrary manner or have them copied by other people.

In this case, we presuppose that the solutions were sought in an intuitively given but not exactly described sort of solution-space (see Figures 16.4 and 16.5, where we use a "cloud" to describe possible solutions). The concrete solution/result[11] Q could then be understood to have manifested itself as some concrete Q*. We might explain this kind of success in using the assumption that there was some experiential special knowledge **E** available, which was applied to the given problem P and eventually did lead to the concrete solution Q*.

So, we might assume that some concrete solution Q* as such did not come about by chance. Therefore, we believe that it is possible to reproduce that solution Q* in a controlled manner which, however, is dependent on the special knowledge **E**. Very often, it is the case that we are in need of the experience of other people, especially if there are mistakes and irregularities. In this case, we need trust and the possibility to correct deviations.

We assume that other people with experiential knowledge **E** by themselves are also interested to repeat their own success (i.e., to reproduce their own solutions). In the case of Henry Ford, these other people were the engineers who could produce a car from certain ingredients. If one asked them, "How did you do it?" however, they became rather insecure and could not exactly tell

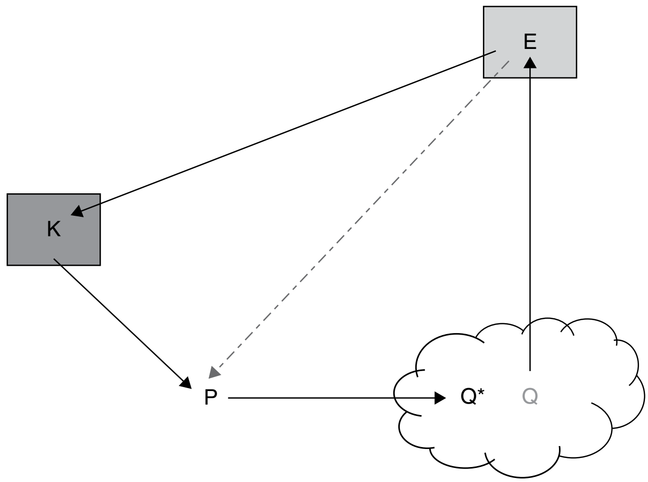

FIGURE 16.5. The rule system K applied to the problem P under the presupposition of the background knowledge E yields the solution Q*.

you how they did it. Now, there is a standard technique to ask for an exact documentation: One expects that with the help of this documentation one could reproduce the given results. Looking at the matter superficially this sounds correct. The problem, however, is that in many cases this kind of documentation is produced by the experts themselves, that is, from within the world of their experience. On the other hand, we are quite often unaware how documentations really work. In many cases, they consist of signs whose meaning or interpretation presuppose the existence of some experience **E** – the latter produces reference to reality (i.e., it is constitutive for meaning and practically relevant and therefore action-guiding). This can be understood in such a way that the experts – and in many areas of our daily life we are all experts with respect to our own personal experiences – in some sense establish rules that enable them to reproduce their positive results in a controlled manner.

Reflecting on and explaining success has led to the construction of a set of rules **K** with whose help one can explain the coming about of [Q*] and eventually reproduce the set [Q*] (presupposing that the conditions of production remain constant). In Figure 16.6, we depicted the situation visually by using the arrow from **E** → P for describing the original application of knowledge **E** to produce a concrete solution Q* (or a possible one Q), but now by way of a detour via **K**, i.e., we replaced the original path from **E** → P by a detour via **K**, i.e., **E** → **K** → P → Q or <**K**|**E**> (P) → Q [**K** under the condition of **E** applied to P to produce Q].

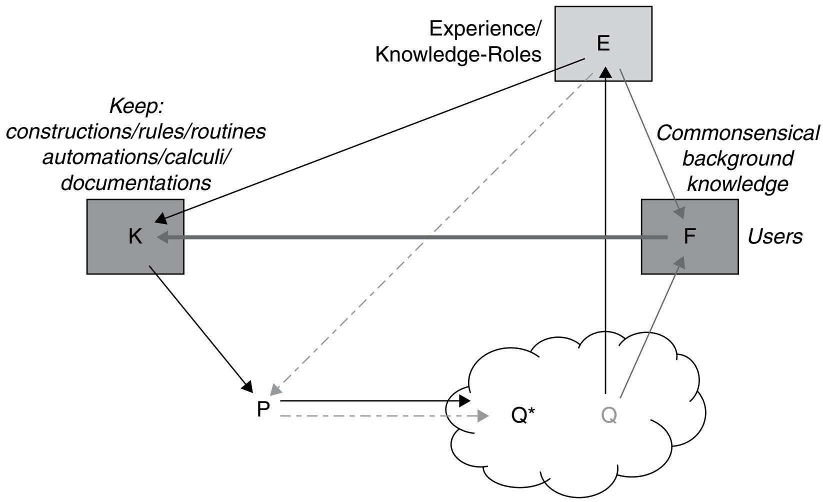

FIGURE 16.6. Implicitly, this graphic rests upon the following assumption: First-person experiential E-Knowledge can be used by every individual F and by every computer with the same logic K to produce the same results Q*. E contains the implicit first-person knowledge of experts and in the classical case it is fostered implicitly. Such that one can then talk about "implicit knowledge management."

The transitions from P to some concrete Q* (in general: P → Q) depend on using the rules **K** under the condition of knowledge **E** (in sign: <**K**|**E**>; **E** comprises cognition and personal experience/expertise as well as motivation/emotion). The set [Q] in Figure 16.7 is depicted as an ellipse, where Q is a possible result of the application of **K** under the condition or use of the experience **E** to the problem P (in sign: <**K**|**E**> (P) → Q). That is, the set of rules/routines **K** applied under the condition of background knowledge **E** applied to P (under the presupposition of a specified context) yields either a concrete Q* or a possible/acceptable solution Q.

Notably, the actual meaning of the set of rules **K** (routines, checklists) in connection with the knowledge **E** is not identical with an exact description for the generation of a concrete solution Q*. Actually, it is used by an expert E to remember how to produce the results in a way which can be understood by him/her and by persons with similar background knowledge **H** (comprising all knowledge components **K**, **F**, **E**, and **M** in Figure 16.7). Thus, experts' knowledge **E** contains personal motives (first person), common sense knowledge **F** containing culturally accepted (collective) motives, meta/model knowledge **M** containing explanatory or assumed motives to predict behavior.[12]

The case is exemplified by Henry Ford, who – influenced by Frederic Taylor – trained laymen to reproduce acceptable results Q* by using some

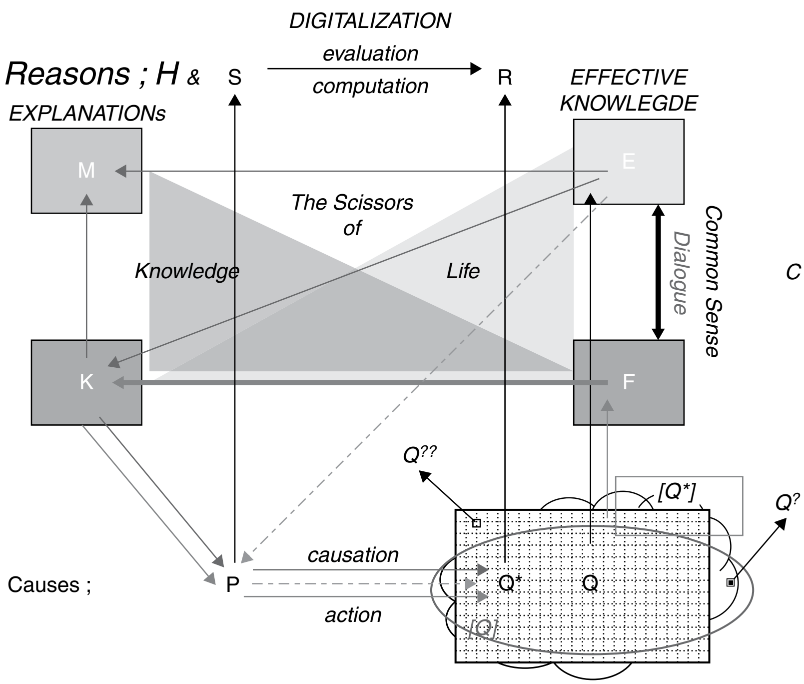

FIGURE 16.7. [Q*] denotes the (equivalence) class of the predetermined concrete/actual results Q*.

rules/routines **K** (provided most probably by experts). This method (or belief) works and is applicable in regard to a middle realm of experience, which is a more or less constant culture (studied in cultural psychology), but it would not work if the rules **K** were used in an inconsiderate way. One of the main or essential views for knowledge, such as in management, has been ignored: the need and possibility of correcting the results by individual experiences E ("tacit knowledge"[13]). Nonaka and Takeuchi (1997) discussed it by explaining the success of Japanese enterprises. The importance of the issue was originally recognized by Polanyi (1966), and even earlier its major role in mathematics and analytical philosophy was discussed in the philosophy of the "Vienna Circle" (Schlick, 1979, pp. 54–56) in the context of "implicit definitions" (Hilbert, 1913).

2. The Final "Picture"

In Figure 16.7, the ellipse can be seen as a symbol of the accepted and potential results[14] [Q], produced by people with expertise (sometimes experts, if they have not lost sight of the limits of their expertise!), experts who are using experiential knowledge **E** and rules **K**. The rectangle in Figure 16.7 is a symbol for the amount of concrete solutions [Q*] under the knowledge condition **F**. This set [Q*] symbolizes the equivalence class of predetermined possible concrete results Q*, insofar as the latter are brought about by **F** background knowledge by using the routines **K**.

As one can see from Figure 16.7, there can be cases of accepted results (in sign: Q?), which cannot be reproduced with rules and routines **K** and background knowledge **F** alone. Still, they are accepted as meaningful by the experts **E**, (i.e., **E**-acceptable and therefore elements of the ellipse [Q]). There are also cases (in sign: Q??), however, which can be produced by stubbornly and mechanically (i.e., by instantiating some algorithm) following the rules/routines with the help of **F**, but which are not accepted by the original experts **E** (but later on and occasionally they may be reconstructed via **K** and **E** plus some extra knowledge **F*** or even **E*** and motivation).

In order to explain the possible difference between the sets [Q] and [Q*], eventually, the term "implicit knowledge" (available in **E**) was introduced. Originally, Michael Polanyi used it in some more or less general scientific context. Later on, the idea was reintroduced by Nonaka and Takeuchi as "tacit knowledge" in the context of administrative business to explain the economic success of certain Japanese enterprises. Their use of the term seemed to imply that tacit knowledge could be explicated completely, and led knowledge management of the first generation astray into a technical information-processing system (also Bruner's qualms about cognitive science in the first place).

However, motivation (in **F**) can change common-sense knowledge **F** in such a way (toward an enriched **F***) that solutions Q*, which are brought about by applying **F*** to the rules **K**, can be incorporated into [Q], but not necessarily into [Q*]. As we can learn from Damasio and his brain research, we can find out that **F*** is more than a cognitive enrichment of pre-given common-sense knowledge **F**. **F*** (and furthermore, also **E*** as an enrichment of **E**) also depends on feelings/emotions based on experience.

In Figure 16.7, one can also see how the difference between the extension of the sets [Q] and [Q*] can be explained with the help of using different components of background knowledge (i.e., either **E** or **F**). In explanatory terms, we call this matter the "scissors of knowledge,"[15] and in operational terms, the "scissors of life (expertise)."[16] Such an explanation must not rest solely upon the inner (plainly cognitive) understanding of **E** (reconstructed in **M**), however. In many cases, **E** corresponds to something such as special and intensive experiences of a first person **E** (an ego) with a very special epistemic resolution level (based on an inseparable interplay of cognition and motivation, which is therefore in need of an interdisciplinary approach forged by the semantico-pragmatic schema LIR). In modern semantics, this kind of background knowledge is viewed as being essential for the effective reference of language to some selection of reality (i.e., especially for the selective and action-guiding relation of science to reality). The point of the scissors of knowledge and life is also to argue that just a set of rules **K** and/or a decontextualized cognitive part of knowledge **M** (a theory) cannot shape an expertise **E** to establish the action-guiding connection between language and reality. What we need, therefore, is an effective dialogue between **E** and **F**, not in order to sift the cognitive knowledge down to **F** but in order to enrich both and take care of an emotional change in the interplay between **F** and **E**. The difference between [Q] and [Q*] cannot be explained by cognition alone (i.e., solely on the basis of some explanatory knowledge **M** and just cognitively reflected expertise **E**). As Damasio points out, emotions and feelings and thus social experiences are essential in the process of making decisions. Studies in brain-damaged individuals showed that impairment of emotional-related signal transmission in order to activate emotion-related (social!) memory (concerning experience accumulated in a lifetime) lead to problems in decision making because categories of social situations are not taken into account. In this context, the work of Umberto Eco in semiotics is also relevant as well as that of the modern, more semantically oriented logic, linguistics, and analytical philosophy from Alfred Tarski to Hilary Putnam.

It should perhaps be added that the technical background for the presented approach and understanding is the semantic approach in logic explicated and turned into the computer-program Hyperproof, which uses Evert Beth's semantic tableau's in addition to the ideas of Gentzen (1969) concerning reasoning in natural logic. Furthermore, the reflective versions of Hempel (1965) and non-static generalizations of explanations in science have also been essential. Already Hempel brought up the idea of knowledge situations and Barwise and Perry (1998) developed situation semantics (referring to Frege). In the present context, the idea is that information processing must be understood as dependent upon knowledge situations and must be investigated via acceptance and use, namely, "S → R" (S implies R), if there is no situation or model that makes true or fulfils "S" (on interpretation in some set of situations) but does not fulfill "R." (Intuition: The construction of a counterexample can be shown to be impossible!)

F the communal or folkloristic knowledge relevant in everyday life action and use corresponds to the grammatical second person, to the "you" ("I and Thou" in Martin Buber's notation, 2004). In this context, especially the work of David Bohm (2004) in general and especially Dan Isaacs (1999) in knowledge management are important, as well as Eugene Gendlin's (1997) approach, but from a different perspective. The grammatical second person, the knowledge component **F**, is important for communication and therefore uses a weaker background knowledge.

The first possibility of some view from outside (a "View from Nowhere," Nagel, 1989) in the grammatical sense of a third-person singular corresponds to the knowledge component **K** (i.e., to rules and routines that can lead to different results, depending on the respective background knowledge in use, which is either **E** or **F**).

In order to be able to explain the difference between [Q] und [Q*] and the mistakes in decision making that can turn up in practice, we therefore need an external explanatory or meta-point of view **M**. We call this view theoretico-explanatory. It should make visible the cognitive part of implicit knowledge, which is there in **E**, but in many cases not directly explicable. To make it visible means to constructively model it in an explanatory meta-model **M** (i.e., we need some kind of sense-making, meaning stipulating reflection).

We still, however, need to explain the significance of **M**, which essentially expresses the advantage of multicultural approaches because it concerns an extra–epistemic resolution level and expressive power with regard to **H** (representation devices and background knowledge **K**, **F**, **E**, and **M**). One therefore has to differentiate between an "explanatory knowledge (**M**)" and an "operative knowledge (**E**)" in a more profound way. This differentiation goes beyond the usual difference between declarative and procedural knowledge as it is used in psychology as well as beyond the difference between explicit and implicit knowledge, but comprises both in a more general way.

HOW MEANING MAY MATTER TO THE MIND – THE LIMITS OF COGNITIVE SCIENCE WITH RESPECT TO DECISION MAKING (IF DEPENDING ON COGNITION ALONE)

1. The Relation between Theory/Model and Reality – The Scheme Language/Information/Reality (LIR) as a Sort of Multidimensional Semantics and a Tool for the "Forging of an Interdisciplinary Perspective" for Linking Cognition and Motivation

Thus, what we propose is a graphical analysis or description of the situation that gives us an idea of how we might go on in trying to understand the relation between theory or model and reality, and how both of them in theoretico-explanatory terms grasp meaning in order to explain the mind, or rather, the behavior of human beings under the assumption of processing information/knowledge in their mind and acting upon this knowledge. If we want to understand those processes as computational, however, we have to dig a little bit deeper and try to find out how or in which way computations can grasp causal connections in reality at all, what it really means, and how it could be applied properly.

The scheme Language-Information-Reality is an older version of the more general problem of the relation between representation, knowledge, and the world. It should lead to just that – an understanding of the relation between representation, knowledge, and the world.

2. The Abstract Foundations: Language, Information, and Reality – Ideas Concerning the Possibilities of Communicating Facts, Knowledge, and "Expertise"

The scheme in Figure 16.8 is a simplified meta-representation of communication unifying linguistic and nonlinguistic elements. Above all, it takes into account the coming about of an understanding through the interpretation of signs via different components of background knowledge and considers the dynamics of conveying knowledge and changes of meaning. Knowledge (e.g., implicit knowledge) results from the mutual relationships of the different components of background knowledge. Knowledge reveals itself in the handling of information. Knowledge emerges through the relations of things to each other. Knowledge mediates between language and reality, defines the handling of linguistically encoded information, and determines the relations of language with regard to reality.

If we want to communicate knowledge, we have to consider the background knowledge of the recipient in its multiplicity (all the components **E**, **F**, **K**, **M** in the scheme). If we want to communicate the transition of a state P into a new state Q in the world, an attitude, understanding, knowledge, or if we want to make it explicit or even create it in the recipient, we have to be clear about the means of representation (e.g., language) used. We also have to clarify through which components of background knowledge the signs in the representation space are related to sections of the world. The transition from P to Q is reflected linguistically, and therefore also in communicating the acceptance of the transition of S to R; it is reflected in the admission of the relationship of those signs that are assigned to the more or less real state-transitions from P to Q and shifted to the realm of representation. This acceptance of S → R in the realm of representation can be strengthened by a deliberate change of relevant components of the background knowledge responsible, in the last resort, for approval and the endowment with meaning.

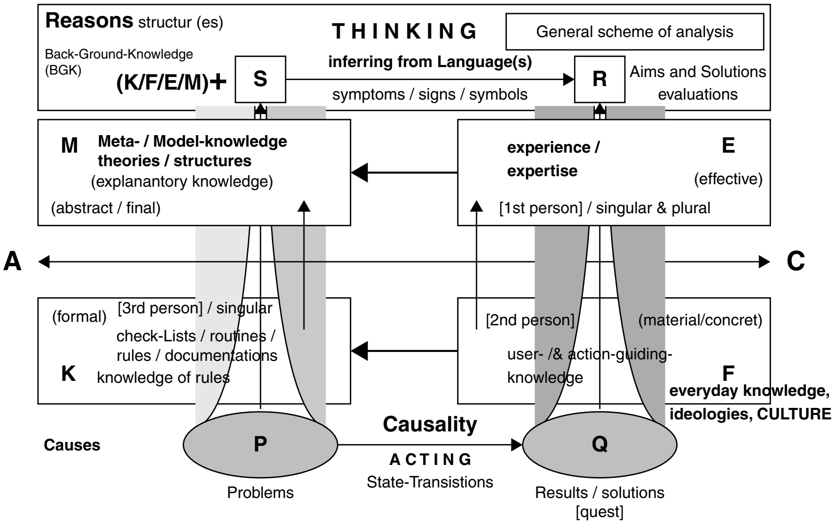

FIGURE 16.8. The basic scheme for LIR (Language-Information-Reality): E = feelings, emotions, and personal motivations and drives; K = heuristics, technical solutions, bureaucratizing (in combination with F); F = cultural motivations and drives; M = cognition, explanatory assumptions about motivations; H = optionally E, F, K, M as knowledge roles/components.

Whether we actually accept and therefore successfully communicate knowledge, especially when dealing with creating and conveying new views, frames of reference, and so forth, depends on the interplay of the respective components of our background knowledge. Here, the relationship between theoretical knowledge (selected general knowledge A; the left side of Figure 16.8) and vernacular knowledge (common-sense knowledge C; the right side of Figure 16.8) is decisive. The reason is that it determines the fine-tuning of new and old knowledge in the concretely chosen area as a section of world/reality (see lower part of Figure 16.8) and the representation as especially chosen representation (see upper part of Figure 16.8). Value judgments or general ethical considerations, human values, and aims in handling new knowledge are accepted and influence the handling of knowledge and information via the background knowledge components. Let us now illustrate this scheme with the help of some ironic comments.

3. Computer Poetry and the Drummers' Example versus Deep Blue – Or: Causes and Symptoms Mixed Up

The scheme LIR can be assumed to describe a sort of multidimensional semantics because it is based on at least four components of meaning that ought to be considered in their complexity but need not be taken into account all of the time. When we first introduced the basics of LIR, we invented a surrealistic example concerning the production of poetry with the help of computer programs and what would be needed to fake an understanding of the meaning of poems. At the time, the example was well ahead of technical practice, but Max Black thought it well described the reality of the refereeing system in poetry journals. The essential point with respect to the scheme LIR in Figure 16.8 was an evaluation function from **K** to **M** such that structure models in **M** – in the classical way of Tarskian Semantics (Bridge, 1977) – could be used to evaluate the meaningfulness of poems in a strictly technical way. Namely, that meaning would not literally be expressed but only somehow coded. This would be in contrast to the real-flesh referees in a journal who have to evaluate poems by understanding their content, so to speak, and express their ideas about the meaning of those poems. The point was: What would happen if the referees were replaced by some evaluation program in **M**? In which way would the explanatory encoding of meaning be used to freeze a certain fashion of the time, and when would a revolution by the next generation of poets occur? A careful analysis shows that in the last count, the same strategy was successful in programming the chess program Deep Blue, but the point is that meaning or the evaluation of situations in a game of chess is frozen, which further links up with Gödel's point against Turing (i.e., that meanings can evolve). In Gödel's case, the intimateness with abstract mathematical terms and their application lead to a new understanding essential for proper application. In the case of Deep Blue, we do not even know what it really is that has been grasped by an evaluation function. What would happen if we used Deep Blue as an experts' system to train chess students? In a medical-experts system this is quite clear. If students are trained just by the system and have no chance to learn corrective experience from outside, eventually they will be just as good as the program. If the medical-experts system has, say, a success rate of 80 percent, the remaining 20 percent will somehow get lost "in real life."

There is, however, another even more ironic illustration of the scheme that may somehow be considered as a "reductio ad absurdum" of the picture of simply transferring natural science to studying the mind, especially meaning in this case. A parallel idea is the following: Could we find out the meaning of messages sent by drums without having contact with the people or being able to communicate with them in another way except by drums? The only technical means allowed would be video cameras and special microphones as well as loudspeakers to fake the noise of drums and watch the reaction behavior of the addressees. Essential would be the difference between meaning as explicated with the help of **M** and the meaning of the drumming noises as given to the sound by the experts **E** who use the drums. When do we think we would be justified to say that some model in **M** has grasped the meaning of those noises? Grasping can be used in a theoretico-explanatory manner as well as literally in a descriptive way. It is essential to take into account the interplay of the two – of both the theoretical and vernacular (background) knowledge – which does not really happen in cognitive science nor in classical knowledge management when dealing only with the administration of information (or indirectly, of knowledge).

MEANING AND CULTURE: FROM THE PROCESSING OF INFORMATION TO CONVEYING KNOWLEDGE (CONSTRUCTING MEANING)

Bruner clearly insists on the meaning stipulating processes of culture. Let us finally reflect on that, but in only one respect: Could we invent rules to calculate or compute meaning (i.e., generate meaning out of the mechanical instantiation of rules in some culture or society)?[17] If we compare biological and cultural evolution, the decisive difference is that in biology the genetic – the internal transmission of information about the environment – in which an organism lives and to which it has adapted is, in general, fairly slow. From the point of view of population genetics, for an individual, it might even be detrimental.

In contrast to this, cultural evolution produces an essential speeding up of the transmission of information relevant for survival. The trick here is to externalize information; that is, to use signs that in certain situations represent/possess a useable content of information. The meaning of a word is its use within some language (in many but not all cases and not necessarily literally, Wittgenstein[18]). In the course of cultural evolution, various techniques for the transmission of information were developed that are based upon individual experiences and motivations, and to a different extent on different cultures, which reflect individual developments. Different cultures have different sign systems, ranging from the acoustic system of communication or the breaking of branches as a means of giving directions to the rock paintings of Australian aborigines or the small talk of the Internet community. In a way, what has been created are external information genes. Viewed from the outside and talking about the matter, each member of the culture has to learn how to handle these signs, how to react, how to use the information encoded in those signs in order to build up and understand the relevant knowledge. If we look at the potential of the Internet as a means to pragmatically understand the limits of the underlying concepts for communicating knowledge or deconstruct those conceptions, one can test the Internet as a possible means of extending cultural evolution.

We have to take care that the ideas to be transmitted fall onto a soil that has already been prepared. We need to have prior knowledge; we already have to have made experiences of our own in order to understand the signs of others. When knowledge is passed on through learning, it is reassembled from knowledge bricks.

The question now is what an evolutionist point of view is able to contribute to an understanding of the role of the Internet in further developing and improving our cultural evolution, for instance, in view of initiating a new phase of evolution. What, if anything, can be better understood, described, and predicted insofar as the development of a global information network through the Internet is concerned?

In cultural evolution, ideas are passed on for a better adaptation to the environment. Yet, they are not so much concrete ideas that can be passed on in a narrative but rather a kind of concept kernels. In analogy to the concept of the gene, Dawkins (2006) introduces the term "meme" to denote elements of cultural evolution, which are supposed to function in a way similar to the transmission of genetic material in a gene.

Concept kernels/cores (and meaning environments) have the advantage of enabling us to grasp different situations under one common aspect or one function and thus to adjust quickly to similar situations. We are able to recognize a wheel and we have certain expectations about its functioning. Yet in a different situation we can replace it with casters and move a heavy wardrobe that way. We have grasped the essence of the concept "wheel." Yet what is responsible for a successful conveyance of the meaning of concepts that denote environments and core competencies?

The real problem of cultural evolution is the passing on of experience/expertise (not the passing away, as it may sometimes seem). Knowledge has to be conveyed in a way that makes it useful in decisive decision situations. Genetic knowledge can only be corrected in the long run, through mutation or the dying out of a species. In contrast, external knowledge should be open for correction. It should be possible to avoid mistakes in the replication of knowledge by individuals, collective or artistic reflection, or those due to accidental mistakes. We consider this to be essential because nowadays we think a lot about how knowledge may get conveyed with the help of the Internet. However, knowledge in most cases gets transferred as texts. Hence, the medium is primarily a syntactic means to convey knowledge. Could we go as far as to say, metaphorically speaking, that knowledge is computed in the Net and thus conveyed? Where are the real limits? What is really going on and how does it work? These are the questions that need to be resolved if humans are to play the role of active agents rather than that of victims.

Notes

1. Emphasizes in quotes are ours, if not stated differently.
2. Today, we would say "algorithmic."
3. Thus, computing became the means to produce meaningful signs and was considered to be the means to build up meaning (especially expertise).
4. Personal communication by Jerome Bruner to Rainer P. Born at the conference "Reassessing the Cognitive Revolution", Glendon College, York University, Toronto, October 22–24, 1993. The reality guys are the ones who take the mechanical or other procedures to stimulate meaning-making processes for *real* or rather descriptively.
5. http://www.iwp.jku.at/born/mpwfst/06/LIR_engl_230607.ppt.
6. A. de Saint-Exupéry (1991). The Little Prince, pp. 63–64: "I cannot play with you," the fox said. "I am not tamed." … "What does that mean – tame?" "It is an act too often neglected," said the fox. "It means to establish ties." … "Just that," said the fox. "To me, you are still nothing more than a little boy who is just like a hundred thousand other little boys. And I have no need of you. And you, on your part, have no need of me. To you, I am nothing more than a fox like a hundred thousand other foxes. But if you tame me, then we shall need each other. To me, you will be unique in all the world. To you, I shall be unique in all the world."
7. Cf. the scissors of knowledge in chapter 8 and the scheme LIR in chapter 9.
8. We consider three postulates: 1. Our concepts are (with respect to reality) somehow fuzzy (according to an extensional cutting up of the world). 2. Our charts, models, theories are usually incomplete (in the reality, there may turn up cases that are accepted but neither justified nor predicted by theory). 3. Our theories are neither literally descriptive nor definitely action-guiding.
9. Think about the term "game." What do all games have in common (Wittgenstein) and how can language game produce "meaning"?
10. Usually, people search for the solution just within the set of 9 points. The way, in which we drew the graphic, shows that those 9 points are embedded in the 16 points. These can be considered as a solution space, where one can see the solution concerning the connection of the 9 points without lifting the pencil. In this case, one stays within the solution space!
11. Q stands for quest (e.g., in quest of the holy grail, still being searched for).
12. **M** (explanatory knowledge) ← **E** (expertise, emotion/motivation)
13. "Sense-making" concerns models to orientate ourselves in the world.
14. [Q] is defined as the set of "possible" solutions (sometimes possible according to assumptions/presuppositions).
15. The "Scissors of Knowledge" in the scheme LIR roughly concern the different influence of the knowledge components **K** (rules) and **M** (explanatory meta-knowledge/principles) on the coming about and acceptance of problem solutions [Q] and [Q*]. After splitting up expertise **E** into a cognitive/explanatory knowledge component **M** and the action-guiding part of the original expertise **E** based upon emotion and motivation, one can thus explain the difference between the sets [Q] and [Q*] by

using **M** to identify/construct the relevant cognitive part of knowledge in **E**, which is not available in **F**.

16. The "Scissors of Life" in the scheme LIR concern – roughly speaking – the different influence of the knowledge components **E** (personal experience and expertise) and **F** (common sense) on the coming about and acceptance of problem solutions [Q] and [Q*].
17. Motivation together with **F** leads to constructing some **K** in order to understand and reproduce the influence of **E** on the use and application of **K**.
18. Cf. Wittgenstein, L.: Philosophical Investigations. 1953, PI 43: For a large class of cases – although not for all – in which we employ the word "meaning," it can be defined thus: the meaning of a word is its use in the language, and the meaning of a name is sometimes explained by pointing to its bearer.

References

Barwise, J., & Perry, J. (1998). *Situations and attitudes*. Stanford, CA: Center for the Study of Language and Information.

Beth, E. W. (1962). *Formal methods: An introduction to symbolic logic and to the study of effective operations in arithmetic and logic*. Dordrecht: D. Reidel.

(1965). *Mathematical thought: An introduction to the philosophy of mathematics*. Dordrecht: D. Reidel.

Beth, E. W., & Piaget, J. (1966). *Mathematical epistemology and psychology*. Dordrecht: D. Reidel.

Bohm, D. (2004). *On dialogue*. London: Routledge & Kegan Paul.

Born, R. (1987). *Artificial intelligence: The case against*. London: Routledge & Kegan Paul.

(1993). Sprache – Information – Wirklichkeit. In H. J. Schneider & R. Inhetveen (Eds.), *Enteignen uns die Wissenschaften?* (pp. 141–178). München: Wilhelm Fink Verlag.

Bridge, J. (1977). *Beginning model theory: The completeness theorem and some consequences*. Oxford: Oxford University Press.

Brinton, C. (1967). Enlightenment. In P. Edwards (Ed.), *Encyclopedia of philosophy* (pp. 519–525). London: Crowell Collier and Macmillan.

Bruner, J. (1990). *Acts of meaning: Four lectures on mind and culture*. Cambridge, MA: Harvard University Press.

Buber, M. (2004). *I and Thou*. London: Continuum.

Cassirer, E. (1983). *Kant's life and thought*. New Haven: Yale University Press.

Damasio, A. R. (2003). *Looking for Spinoza: Joy, Sorrow, and the Feeling Brain*. Orlando, FL: Harcourt.

Dawkins, R. (2006). *The selfish gene* (3th ed.). Oxford: Oxford University Press.

de Geus, A. (1997). *The living company*. Boston: Harvard Business School Press.

(2006). *Learning together in teams*. DVD: SOL Conference 2006 – Fire, passion and excellence, Helsinki, 13./14.11.2006.

de Saint Exupéry, A. (1991). *The little prince*. London: Egmont Childrens Books. Encyclopedia Britannica (2000). CD-Rom Version.

Frege, G. (1918). Der Gedanke – Eine logische Untersuchung. In G. Patzig (Ed.), *Logische Untersuchungen*. Göttingen: Vandenhoeck, pp. 35–62

(1991). *Collected papers on mathematics, logic, and philosophy*. Oxford: Basil Blackwell.
Gendlin, E. (1997). *Experiencing and the creation of meaning: A philosophical and psychological approach to the subjective*. Evanston, IL: Northwestern University Press.
Gentzen, G. (1969). *The collected papers of Gerhard Gentzen (Studies in logic and the foundations of mathematics)*. Amsterdam: North-Holland Publishing.
Gödel, K. (1990). *Collected works* (Vol. II). New York: Oxford University Press.
Hammond, K. R. (Ed.) (1966). *The psychology of Egon Brunswik*. New York: Holt.
Handy, Ch. B. (1995). *The age of paradox*. Watertown, MA: Harvard Business School Press.
Hempel, C. G. (1965). *Aspects of scientific explanation*. New York: The Free Press.
Hilbert, D. (1913). *Grundlagen der Geometrie* (4th ed.). Leipzig: Teubner Verlag.
(2010). *The foundations of geometry*. Oxford, UK: Nabu Press.
Houellebecq, M. (2010). *La carte et le territoire.* Paris: Flammarion.
Isaacs, D. (1999). *Dialogue and the art of thinking together: A pioneering approach to communicating in business and in life*. New York: Random House.
Kant, I. (1784). Beantwortung der Frage: Was ist Aufklärung? *Berlinische Monatsschrift. Dezember-Heft 1784*. 481–494. http: //www. Uni-potsdam.de/u/ philosophie/texte/kant/aufklaer.htm, DL: 19.8.2009.
(1959). What Is enlightenment? In I. Kant (Ed.), *Foundations of the metaphysics of morals* (pp. 85–92). New York: Library of the Liberal Arts.
Lakoff, G., & Johnson, M. (1999). *Philosophy in the flesh: The embodied mind and its challenge to Western thought*. New York: Basic Books.
Maturana, H. R., & Varela, F. J. (1991). *Autopoiesis and cognition: The realization of the living (Boston Studies in the Philosophy of Science)*. Dordrecht: D. Reidel.
McElroy, M. W. (2003). *The new knowledge management: Complexity, learning, and sustainable innovation*. Amsterdam: KMCI Press.
McMaster, M. D. (1996). *The Intelligence advantage: Organizing for complexity*. Boston: Butterworth-Heinemann.
Mérö, L. (2002). *Die Grenzen der Vernunft*. Reinbek: Rowohlt Taschenbuch.
(2004). *Die Logik der Unvernunft*. Reinbek: Rowohlt Taschenbuch.
Michaels, A. (1997). *Fugitive pieces*. London: Bloomsbury.
Nagel, T. (1989). *The view from nowhere*. Oxford: Oxford University Press.
Nonaka, I., & Takeuchi, H. (1997). *Die Organisation des Wissens*. Frankfurt am Main: Campus Verlag.
Polanyi, M. (1966). *The tacit dimension*. Gloucester, MA: Routledge & Kegan Paul.
Putnam, H. (1981). *Reason, truth and history.* Cambridge, MA: Cambridge University Press.
(1988). *Representation and reality*. Cambridge, MA: The MIT Press.
(1992). *Pragmatism*. Oxford: Basil Blackwell.
(1992). *Renewing philosophy*. Cambridge, MA: Harvard University Press.
(2004). *Ethics without ontology*. Cambridge, MA: Harvard University Press.
Quine, W. v. O. (1990). *Roots of reference*. La Salle, IL: Open Court Publishing.
Rifkin, J. (2004). T*he European dream: How Europe´s vision of the future is quietly eclipsing the American dream*. New York: Jeremy P. Tarcher.
Robinson, K. (2001). *Out of Our Minds: Learning to be Creative.* Chichester: Wiley.

(2009). *The element: How finding your passion changes everything.* New York: Viking Penguin.
Sen, A. K. (2006). *Identity and violence: The illusion of destiny*. New York: W. W. Norton.
Sennett, R. (2006). *The culture of the new capitalism*. New Haven: Yale University Press.
Schlick, M. (1979). *Allgemeine Erkenntnislehre*. Frankfurt am Main: Suhrkamp. 1st ed.: 1925.
(1985). *General theory of knowledge*. La Salle, IL: Open Court Publishing.
Wang, H. (1974). *From mathematics to philosophy*. London: Routledge & Kegan Paul.
(1988). *Beyond analytic philosophy: doing justice to what we know*. Cambridge, MA: The MIT Press.
(1997). *A Logical journey: From Gödel to philosophy*. Cambridge, MA: The MIT Press.
Winterson, J. (1995). *Art objects: Essays on ecstasy and effrontery*. London: Jonathan Cape.
(2007). *The stone gods*. London: Hamish Hamilton.
Wittgenstein, L. (1953). *Philosophical investigations*. Oxford: Basil Blackwell.
(1961). *Gesammelte Schriften* (Vol. I). Frankfurt: Suhrkamp.

17

Interest, Cognition, and the Case of L- and Science

K. Ann Renninger & Kathryn R. Riley

In her most recent interview, 15-year-old L – comments: "Every year they ask me, do I want to be a scientist? And, every year I tell them no, I don't want to be a scientist. I don't like science. It's not for me." Yet participant observation notes indicate that L – has been staying after the workshop every day to work on her lab notebook and to help get materials ready for the next day. She also uses this time to engage in discussions and to ask questions. She seems to like thinking about connections between the day's focus and those of previous days. She appears to want to understand how the experiments they have been doing fit together. (Interview, Year 5)

Interest is a cognitive and affective motivational variable that is dependent on cognition. A learner typically has four to six reasonably well-developed interests and can develop new interests at any age – although the types of supports that are likely to be needed may vary based on age and experience (Renninger, 2009).

In order to engage, a learner needs to perceive the features of particular content such as science as something to which to attend. Although interest may be supported to develop through use of metacognitive strategies such as questioning and prompted reflection, it is often an unreflective state or process. When engaged due to interest, a person is not necessarily thinking about his or her interest but rather about the particulars of the activity or content of interest. Interest can be triggered without a learner being aware of its occurring, and interest is not always something that learners (especially younger learners) can simply will themselves to experience (Renninger, Sansone, & Smith, 2004). However, when the learner is aware of his or her interest, this can support interest to develop (Sansone & Thoman, 2005a, 2005b; Renninger & Su, 2012).

It is now generally accepted that when interest is present, learner attention, goal setting, and strategy use are positively influenced (Hidi & Renninger, 2006): interest, as James (1890) wrote, "schools attention." In her model of domain learning, Alexander (2004) described interest as linked to knowledge and strategic efforts, and suggested that competence can be nurtured by immersing learners in meaningful learning experiences. Thus, for example, calling learners' attention to the meaning that a writing task holds for them has been found to improve learners' connections to tasks and yield improved performance (Hulleman et al., 2008). Type of activity (e.g., group work, computers, and novel tasks) has been shown to have an influence on learner engagement (Mitchell, 1993; Palmer, 2009). Inserting interest into tasks in reading or math has also been shown to affect the depth of learners' processing (Renninger, Ewen, & Lasher, 2002; Schiefele & Krapp, 1996). It appears that interest is not only dependent on cognition but that it also influences the "what" of cognition: to what the learner attends and how he or she engages.

Yet until relatively recently, interest was often described and studied as if it were dichotomous – a learner either has or does not have interest – suggesting to some (sometimes including the learner) that interest does not and is not likely to develop. This is not the case, however. There is now research evidence to confirm that interest in its earliest phases needs to be supported by other persons and requires ongoing support if it is to develop, placing responsibility for whether interest develops on other people and the types of opportunities that are available to the learner (Gisbert, 1998; Renninger & Hidi, 2002; Tsai et al., 2008). In the neuroscientific literature, interest-based activities are referred to as "seeking behavior" (Panksepp, 1998; see discussion in Hidi, 2006). Brain reactions have been found to differ when a learner is and is not engaged with content (Ashby, Isen, & Turken, 1999; Hidi & Ainley, 2008). Learner attention is triggered and sustained depending on (a) what a person perceives when presented with disciplinary content (see Renninger, 1990, 2000, 2009; Renninger & Lipstein, 2006); (b) his or her interactions with others; and/or (c) the conditions of the environment (Azevedo, 2006, 2011; Barron, 2006; Cobb & Hodge, 2004; Sansone & Thoman, 2005a; 2005b).

The present chapter describes research that bears on the relation between the development of interest and cognition. As such, although interest is elsewhere conceptualized as an attitude, belief, reward, or vocational pursuit, interest is here discussed as *both* a psychological state and a predisposition to return to engagement with particular disciplinary content (e.g., music, softball, science; Hidi & Renninger, 2006; see also discussions in Ainley, 2006; Alexander, 2004; Barron, 2006; Renninger & Hidi, 2011; Sansone, 2009; Silvia, 2006). Based on the empirical literature, phases in the development of interest have been identified as ranging from an initial triggered situational interest that may only last for a few moments to a well-developed individual interest that is relatively long-lasting (Hidi & Renninger, 2006; see Table 17.1).

TABLE 17.1. *Learner Characteristics and Needs in Interest Development*

	Phases of Interest Development			
	Triggered Situational	**Maintained Situational**	**Emerging Individual**	**Well-Developed Individual**

Learner Characteristics	• Attend to content, if only fleetingly
	• Need support to engage
	  • From others
	  • Through instructional design
	• May experience either positive or negative feelings
	• May or may not be reflectively aware of the experience
		• Re-engage content that previously triggered attention
		• Are supported by others to find connections between their skills, knowledge, and prior experience
		• Have positive feelings
		• Are developing knowledge of the content
		• Are developing a sense of the content's value
			• Are likely to independently re-engage content
			• Have curiosity questions that lead them to seek answers
			• Have positive feelings
			• Have stored knowledge and stored value
			• Are very focused on their own questions
				• Independently re-engage content
				• Have curiosity questions
				• Self-regulate easily to reframe questions and seek answers
				• Have positive feelings
				• Can persevere through frustration and challenge in order to meet goals
				• Recognize others' contributions to the discipline
				• Actively seek feedback

Needs/More Closed Learning Environment	• To have their ideas respected • To feel genuinely appreciated for their efforts • To have others understand how hard work with this content is • Limited concrete suggestions	• To have their ideas respected • To feel genuinely appreciated for their efforts • Support to explore their own ideas	• To have their ideas respected • To feel genuinely appreciated for their efforts • To feel that their ideas and goals are understood	• To have their ideas respected • Information and feedback • To balance their personal standards with more widely accepted standards in the discipline • To feel that their ideas have been heard and understood

	Phases of Interest Development			
	Triggered Situational	Maintained Situational	Emerging Individual	Well-Developed Individual
			• Feedback that enables them to see how their goals can be more effectively met	• Constructive feedback • Challenge
Needs/More Open Learning Environment	• To have their ideas respected • To feel genuinely appreciated for the efforts they have made • To know that they understand the content	• To have their ideas respected • To feel genuinely appreciated for the efforts they have made • To know what they have learned and what they still want to learn	• To have their ideas respected • To express their ideas • *Not* to be told to revise present efforts • To feel that their ideas and goals are understood • To feel genuinely appreciated for their efforts • Feedback that enables them to see how their goals were met	• To have their ideas respected • Information and feedback • To balance their personal standards with more widely accepted standards in the discipline • To feel that their ideas have been heard and understood • Constructive feedback • Challenge

Interest develops through a process of triggering: interactions or circumstances that result in the reorganization of learner thinking and activity (Alexander, 2004; Renninger & Hidi, 2002). Triggers for interest have been described as promoting uncertainty, surprise, novelty, complexity, or incongruity (Berlyne, 1960; see also Durik & Harackiewicz, 2007; Renninger, Bachrach, & Posey, 2008). For example, in earlier phases of interest these might include group work in the classroom or content that is personally meaningful (Hidi et al., 1998; Mitchell, 1993); in later phases, triggers could stem from instructional conversations (Yamuchi, Wyatt, & Carroll, 2005), content-informed scaffolding (Renninger et al., 2005), or self-generated curiosity questions (Renninger, 1990, 2010).

As interest develops, the learner's evolving knowledge about, valuing of, and feelings for content change. The earliest phase of interest may be easily identified by positive or negative affect, but the development of principled knowledge about the discipline and the accompanying recognition of value account for changes in the learner's phase of interest (Nolen, 2007; Renninger, Bachrach, & Posey, 2008). In later phases of interest, the learner's commitment to, skills with, and identification with content are readily distinguished from those in earlier phases of interest (Azevedo, 2006, 2011; Barron, 2006; Renninger, 1990, 2009, 2010; Renninger et al., 2002; Renninger & Hidi, 2002). In later phases, the learner generates, reflects on, and pursues his or her curiosity questions – questions that are novel to the learner but not necessarily new to those who have more information (Renninger 2000, 2010; Renninger & Su, 2012).

The case of L – illustrates the process of interest development and presents a context for its further examination. L – was 10 years old when we first began studying her cohort of 8 (5 girls, 3 boys) participants in the Science-for-Kids Workshop, an out-of-school, inquiry-oriented science workshop for at-risk youth.

> She was a child who appeared extremely moody and presented as a disengaged learner; she alternately seemed to enjoy and resist workshop activities. Her engagement seemed linked to whatever she wanted to know more about. (Notes, Year 1)

The participant observation notes and her interviews indicated that she thought about science the way she would think about anything else; she was more philosophical than scientific.[1] For example, her questions during the week she and her workshop group learned about worms included: "What do worms die from?" "What kind of culture do they have?"

Five years later, L – asked to be a teaching assistant in the Chemistry Workshop, a position that had not previously existed.

She was now aware that science was fun for her. After some deliberation, the workshop programming was adjusted to allow her to help out with the younger children as a peer tutor. She worked with the younger children alongside a college student. Even before the workshop addressed acid-base neutralization, and only two weeks into the workshop, she asked to take an experiment further by combining an acid and base and observing the resulting solution. The instructors suggested that she share this idea with the group of children to whom she was assigned. She did and engaged them all in thinking with her about each of the trials (and, as it turned out, all of the other children's groups decided to explore this issue as well). (Notes, Year 5)

L – 's thinking about science had clearly changed, as had that of her peers. She had a broader perspective. She now focused on patterns in phenomena and how they could provide explanation. She was willing to think about content generally and to explore new materials.

The studies in which L – and her peers were participants focused on what needs to be in place in order for children with little to no background knowledge in a discipline to seriously engage and learn. Data from L – 's participation in the workshops are congruent with those of her peers, and allow consideration of the interplay between interest development and cognition. For the first few summers of workshop participation, L – had a triggered situational interest in the scientific material. Her affect could be heightened; she clearly was attending and had some questions, but it was not until the fourth year that her phase of interest began to shift, signaled by her independent efforts to understand.

Although L – was aware and engaging in the workshop during the first several years, she had not yet made the kind of connection to science content that leads to asking curiosity questions and wanting to seek out, reflect on, and raise more questions. Thus, although L – and her peers engaged excitedly at times in the inquiry-informed workshop activities (e.g., group work to dissect a mink) during their first years, five weeks following the workshop they only retained an impression that science could be fun, with little if any science-related content (Renninger et al., 2008). It was not until L – shifted from simply engaging with the activities of the workshop to focusing on thinking about and wanting to explore their content that her interest changed; her interest shifted in relation to its shifting focus, her cognition.

INTEREST AND COGNITION

With few exceptions, the relation between interest and cognition has received little explicit attention in the recent theoretical or empirical literature. In early theorizing, the relation between interest and cognition concerned the development of attention. James (1890), for example, described interest in terms of the organization of experience. He suggested that interest improved the ability to discriminate, and noted that interest, along with practice, improved attention. Baldwin (1911), on the other hand, described interest in terms of the activities in which a learner engaged. He focused on the cognitive structures that the learner brings to activity, the competence that is experienced, and its accompanying affect. Dewey (1913) elaborated on this relation by suggesting that interest was in the content itself, suggesting that the interest value of activities was related to whether they led to continuous engagement. Finally, Piaget (1968) linked interest to both cognition and motivation, suggesting that, "Interest is the proper orientation for every act of mental assimilation" (p. 34). Taken together, the early theorists suggested that interest organizes experience and channels attention, and they highlighted the roles of both knowledge and value as components of interest.

The differing (and complementary) foci of the early theorists on the relation between interest and cognition also characterize the discussions and studies that followed. The research has focused on the role of interest in cognitive processing; the text, task, or people who contribute to the generation of interest; and the relation of knowledge and value as components of interest. Findings from each are reviewed briefly.

INTEREST AND COGNITIVE PROCESSING

Research that addresses both interest and cognitive processing has focused on the same issues, albeit in different contexts: free play in the nursery and work with text, math problems, or representational design. Building on the findings of early theorists whose work suggested that interest had a reciprocal relation with attention (e.g, Arnold, 1910; Bartlett, 1932), Renninger and Wozniak (1985) studied the effects of interest on young children's attentional shifts, recognition, and recall memory. They identified play objects (e.g., trains, dolls) of high and low interest for each child based on naturalistic observation of interest similar to that used in the study of L –, and inserted these into experimental tasks in order to assess the effect of interest across cognitive processing. Their findings revealed that interest exerted a strong influence on shifts in focal attention; interest was found to influence the likelihood that an item would be correctly recognized and recalled, and that the item would be recognized and recalled first. Renninger (1990) further demonstrated that patterns in the children's naturally occurring free play mirrored those of the experimental tasks; with identified objects of interest, the children were more likely to play longer, use more types of play, shift between types of play, employ more types of action, and repeat particular sequences of action than with other objects that were familiar and of less interest. Krapp and Fink (1992) replicated these findings, and in discussing them, pointed to the differentiation of interest based on experience. They reported data showing that two children engaged in interest with the same play object would not necessarily engage the object similarly. They and Neitzel and her colleagues (Neitzel, Alexander, & Johnson, 2008) also documented that the interest object could serve as a transition object as children moved from one learning context to another (e.g., from the preschool to kindergarten).

Another line of research on interest and attention focused more specifically on text. During the 1980s, two hypotheses emerged in studies of text: (a) that increased interest might increase attention and lead to better memory (Anderson, 1982); and (b) that increased interest might require fewer cognitive resources for basic text processing, freeing up resources for higher-order processing (Hidi & Baird, 1988; see Hidi 1990, 1995). In order to test these hypotheses, McDaniel et al. (2000) conducted studies of undergraduates reading stories that they rated as being of higher or lower interest. Their findings confirmed that more interesting text requires fewer cognitive resources than less interesting text, and that text-based interest results in qualitative differences in the kind of information that is processed and encoded. In conclusion, they suggested that optimal learning of text might require assignment of study strategies aligned with the particular level of interest for text. As with the studies of young children's play, it appears that what was of interest for one person was not necessarily of interest to another. This then indicated that although interest might free up resources for higher-level processing, the expectation that one topic, for example, would be of similar interest to all students was not appropriate.

Renninger et al.'s (2002) findings corroborate the conclusions of McDaniel et al. (2000) regarding likely processing differences and instructional needs introduced by the presence of interest. Renninger et al. (2002) studied within-student differences in both the reading of text and work with mathematics problems, using interviews, think-alouds, and artifact analysis. Passages and problems presented to middle-school–aged students were individualized with contexts of interest and adjusted for level of difficulty. Their findings suggested that well-developed interest served as a scaffold for working with assigned tasks. It allowed students to focus on meaning and task demands. Well-developed interest also appeared to mask the level of passage and/or problem difficulty, enabling the students to persevere to work with difficult tasks.

Similarly, in a qualitative analysis of high school students' engagement, Azevedo (2006) reported that opportunities to explore and prioritize activities resulted in distinctively different and enhanced problem solving. He pointed to four findings from this work that provided support for interest: students' feelings of competence, task features that promote feelings of competence, time to explore, and a flexible learning environment.

THE GENERATION OF INTEREST

Studies that have addressed the features of text or sources of interest in classroom activity do not typically reference the role of cognition or problem solving in the generation of interest. Rather, they point to the impact of interest on engagement, where engagement refers to some form of connection to the task, including, for example, a grade that has been assigned, a positive attitude, achievement goals, feelings of competence, or specificity of writing. In these studies, learners have been assessed as having more or less interest for the feature or task. Thus, for example, in a high school math class, group work, puzzles, and computers have been identified as triggers for interest, and the presence of meaningfulness or personal relevance and involvement of students may result in sustained engagement (Mitchell, 1993; see also Laukenmann et al., 2003; Palmer, 2009).

Based on Laukenmann et al.'s (2003) suggestion that situational interest promotes learning, Palmer (2009) interpreted his high school science students' spontaneous reporting of "learning" as a source or trigger for interest. He described the novelty of the information they were referencing as the trigger for their interest. Novelty, one of the collative variables that Berlyne (1960) originally identified, has been repeatedly identified as a feature of text and tasks that generate interest (Silvia, 2005a, 2005b; Turner & Silvia, 2006). However, that Palmer's (2009) high school students mentioned learning as the source of their interest is also consistent with Arnold's (1910) suggestion that interest is reciprocally related to attention and learning; that in addition to situational interest promoting learning, learning may promote situational interest. This line of analysis is also consistent with findings reported by Chen and Darst (1999, 2001), who found that increased cognitive demand (based on a comparison of activities) was related to learners' experiencing novelty, challenge, attention, and increased situational interest.

Harackiewicz and her colleagues (Harackiewicz et al., 2002; Harackiewicz et al., 2008) have similarly suggested that mastery goals have a reciprocal relation to later and earlier phases of interest. They also report that mastery goals may provide conditions through which interest can be triggered (Senko

& Harackiewicz, 2005) and demonstrate that when participants are asked to write out an explanation of the importance of a task they are assigned, this triggers interest for the task (Hulleman et al., 2008). Their work on achievement goals and interest is complemented by studies demonstrating that when participants are provided with goals such as trying to become experts (Hidi et al., 1998) or participating in a community (Cobb & Hodge, 2004; Nolen, 2007), that this, too, results in increased interest.

Research has also indicated that the quality of social interactions (eye contact, verbalization) influences the experience of interest and whether interest is generated (Thoman, Sansone, & Pasupathi, 2006). Talking together after an activity, for example, was found to increase interest, and the responsiveness of a listener was more powerful than differences in interest in determining interest in the activity (Thoman et al., 2006). Findings such as these further extend those from both studies of talent development, in which changes in the teacher and music-student relationship have been documented, and those pointing to a reciprocal relation between interest and identity development (Krapp, 2007; Renninger, 2009).

Based on retrospective interviews with accomplished musicians, for example, Sloboda (1996; see also Sosniak, 1990) reports that the musicians' first experiences included having fun with music without being pushed to be systematic or to have specific skills. The first teacher was ideally friendly and enthusiastic, able to communicate well, and to share a love of music. The teachers could be said to be triggering and helping to maintain their students' interest. As the prospective musicians were ready to focus on skill acquisition, Sloboda notes that they also required more support from others to sustain their skill development and positive feelings. During this phase of instruction, many of their peers decided not to continue to study music. This was a time when Sloboda observes that both teachers and parents encounter difficulty knowing how to provide music students with support. In terms of interest theory, they could be said to have difficulty helping music students maintain their situational interest for music. Those who continue to study music reportedly came to identify with music, and eventually studied with a master teacher who enabled them to become artists. In other words, their interest had developed to the point that they identified as musicians. With interest, they were better able to self-regulate and needed less oversight than they had in earlier phases of interest.

In describing the interest experience, Sansone and Thoman (2005a, 2005b) suggest that motivation and interest fluctuate in relation to the value a person places on the goals of particular activities and any expectations about attaining those goals. They suggest that interest can be regulated both intra-individually and interpersonally. In earlier phases of interest development, learners may self-regulate activity in order to productively engage content that is of little interest, or they may need to have the learning context adjusted so they can connect to it, just as the first music teachers made music fun and something to which those who eventually became musicians could connect. In later phases of interest development, on the other hand, learners who have their own identification with curiosity questions and the questions of the domain generally are more likely to self-regulate, to seek out and reflect on answers that then lead to other questions. Interpersonal support in later phases of interest is not necessarily about engaging with the activity per se, but rather with the specifics and challenges of the content of the activity (Renninger, 2009, 2010). In both earlier and later phases of interest development, the generation and regulation of interest is a function of both the individual (his or her goals or lack of goals) and the learning context.

KNOWLEDGE AND VALUE

As noted earlier, interest has been and can be conceptualized in a number of different ways. When it is conceptualized as a variable that develops over time, it has three components: stored knowledge, stored value, and feelings (Renninger & Su, 2012; see also Häussler & Hoffmann, 2002; Hidi & Renninger, 2006; Renninger, 1990, 2000). This conceptualization of interest has been explored in studies that have assessed the impact of earlier and later phases of interest, revealing an impact of differing levels of stored knowledge, stored value, and feelings on participation and learning (Durik & Harackiewicz, 2007; Frenzel et al., 2010; Katz et al., 2006; Lipstein & Renninger, 2007; Tsai et al., 2008).

In earlier phases of interest development, it appears that knowledge and value may be limited to recognition, and affect may be either positive or negative. With interest development, knowledge provides a basis for reflecting and questioning that in turn supports the development and deepening of interest (Hidi & Renninger, 2006). Thus, the development of knowledge is also understood to contribute to the development of value for and feelings about engaging with content (Renninger, 2000; Renninger & Su, 2012).

Before the four phases of interest were identified, however, affect had been the focus of some conceptualizations of interest, and was used to assess interest (Alexander, Jetton, & Kulikowich, 1995; Alexander, Kulikowich, & Jetton, 1994; Tobias, 1994). In these studies, interest was examined in relation to knowledge and/or value (Schiefele & Krapp, 1996). Tobias (1994), for example, suggested that there was a linear relation between interest (defined as positive affect) and prior knowledge. He concluded that interest made more of a contribution to comprehension and emotional associations than prior knowledge, but also observed that as students develop familiarity, the development of knowledge could be assumed. In an investigation of undergraduates in statistics and psychology classes, Lawless and Kulikowich (2006) examined this premise and reported that interest (defined as affect) and knowledge were correlated with each other regardless of domain. They also found that the relation between interest and domain knowledge changed based on academic level and preparation. Consistent with these findings, Alexander (1997, 2004) described interest development in terms of developing expertise. Although she described the relation of affect and cognition as distinct across each of the stages of developing expertise, she and her colleagues began to use liking and participation (which requires knowledge) to make distinctions between types of interest (Alexander, 2004).

Schiefele and Krapp's (1996; see also Krapp, 2003, 2007; Krapp & Prenzel, 2011; Schiefele, 2009) work has increasingly centered on feelings and value in their discussion and assessment of interest, although they, too, have begun to acknowledge the role of experience or knowledge in the development of interest. Feelings and value are considered essential to personal significance: "Positive evaluation results from the degree of identification with the object of interest" (Krapp, 2003, p. 63). Krapp (2003) explains that although a person may learn something new without being aware of this growth (and, as such, knowledge), they are aware of personal significance. For this reason, he argued that emphasis on feelings and value in interest development is needed.

SUMMARY

The relation between interest and cognition has been examined in terms of attention and cognitive processing, characteristics of the learning environment, and the components of knowledge and value. Each of these foci points to the impact of differences in interest. The work on attention and cognitive processing suggests individual variation in the types of questions and/or topic interest of the learner. The work on the characteristics of the learning environment calls attention to the role of others and objects as supports for engagement and likely differences in learners' needs for support in their interest development. The work on knowledge and value as components of interest underscores potential differences in the contributions of each to interest and also to their coordination as interest develops.

How interest develops within individuals and how interest can be supported to develop are critical questions for interest research. Although research on interest generation or sources of interest has pointed to one or another potential triggers for interest, these studies have largely been descriptions of particular phases without consideration of what learners need in order to shift from one phase of interest to another and begin asking curiosity questions, seeking resources, and making use of feedback. As a result, learners such as L –, who initially have little to no interest for learning content such as science, pose a challenge for educators as well as researchers. Their interest can be triggered, but little interest means little affect and/or knowledge. As they age, they develop greater awareness that others have more developed skills with respect to particular content than they do, making it even more difficult for them to persevere to master that content even though it is possible for them to do so (see discussion in Renninger, 2009). There is the possibility that their attention, and as a result interest, can be triggered by some external event (e.g., the excitement created by burning marshmallows and other foods to see which burns faster), but it is also recognized that this type of triggering may result in only momentary attention (Renninger et al., 2008). Sustaining interest for unknown content and supporting engagement is difficult, because there is too little knowledge to set goals or to know what questions to ask. Happily engaging in an activity is not the same as reflecting on the content of the activity, asking questions, exploring, and reorganizing understanding (Flum & Kaplan, 2006).

INTEREST DEVELOPMENT

Interest always refers to one or another of four phases in a learner or group of learners' cognitive and motivational engagement with particular content: triggered situational, maintained situational, emerging individual, and well-developed individual interest (Hidi & Renninger, 2006; see Table 1). Interest may reference a domain such as science or a more focused topic such as structure and function, and always co-exists with a number of other interests and potential interests.

People typically think of the most developed phase – well-developed individual interest – when they reference interest. Learners with a well-developed individual interest for science, for example, can be expected to be attentive, goal-oriented, and strategic (Renninger, 2000). Their feelings or affect are generally positive (Ainley, 2006); they have a sense of possibility (Markus & Nurius, 1986); and they know that they can be successful (Bandura, 1997). Learners with developed interest have enough knowledge about their subject of interest to make effective choices (Flowerday & Schraw, 2003), and they need little prodding to take advantage of opportunity and make use of the feedback they receive (Lipstein & Renninger, 2007). When faced with the need to revise a plan or practice, they persevere (Prenzel, 1992). As their interest continues to develop, they are increasingly likely to self-identify with the discipline – to think of themselves as someone who can do science, and as someone who could be a scientist (Renninger, 2009). In the classroom, however, learners in this phase of interest are exceptions. For example, in a study of 178 academically oriented middle school students, only 4 students were identified as having a well-developed individual interest for writing (Lipstein & Renninger, 2007). The other students were almost equally likely to be in one of the three earlier phases of interest development.

Lipstein and Renninger (2007) used structured in-depth interviews and questionnaires to compile representative descriptions or portraits of students in each phase of interest development for writing. Here, these characteristics are compared to those of L – and to data chronicling her engagement in the science workshops.[2] Comparison of the writing students' experiences with those of L – and her peers in the science workshops provides further insight into the relation between interest development and cognition. The experiences:

(a) confirm that in each phase of interest, learner perceptions influence what learners are able to connect to, whether they pick up on concepts and are led to ask questions, or whether they do tasks just to get them done even if they do not really understand why they are doing what they have been asked to do;
(b) highlight the amount of time that a learner might be in the earliest phases of interest development, even though the learning environment is rich with possibilities;
(c) underscore the impact of the learning environment on interest development, here revealed in the comparison of data from studies of students' phases of interest both in and out of school; and
(d) point to the critical role of others (instructors, peers) as supports for engaging potential triggers for interest and developing confidence and a sense of possibility about engagement.

TRIGGERED SITUATIONAL INTEREST

Students with a triggered situational interest for writing were likely to have their interest captured in the moment by, say, the assignment to write about a topic of interest (e.g., basketball), but their interest was also likely to extend only to completing the task. They did not identify as writers and would not revise what they wrote, and for the most part they wanted to be told what to do. They did not want to have to think about or work with feedback. Although they might have heightened affect when their interest was triggered – when working to write about basketball, for example – they were not aware that their interest had been triggered, and did not seem to have enough knowledge about writing to make choices about how to effectively provide details and organize the information that they included about basketball.

Over the first three years of the workshop, L – is identified as having only a triggered situational interest:

> One day, for example, she and the other participants are looking at worms under the microscope. At the end of the session, they put their worms back and as everyone is packing up and preparing to leave, L – suddenly turns, runs back and picks up a worm and takes it into the corner to look at it. Told that it is time to put the worm back, she obliges but does not want to leave and sits on the steps of the science building pouting. (Notes, June Year 1)

Similar to the student writer who had only a triggered situational interest for writing but was momentarily excited to focus on an assignment to write about basketball – a well-developed individual interest – L – experiences heightened affect in the session focusing on worms and then does not follow through to re-examine the worms in subsequent workshop sessions.

A few weeks later, during the week in the biology workshop on skulls, notes on L – suggest that she chooses not to look at skulls or what animals they must have come from based on size and teeth. Rather, she wanted to know if "these [skulls] are real"; "how the skull fits with the rest of the animal"; and "how it could move around."

> She had difficulty asking her questions though. She began to ask a question several times, beginning with: "Not to be retarded or anything…" but had some difficulty making herself clear and was seemingly frustrated by the other children talking. By the time it was quiet enough for her to ask her first question, she initially forgot what she was trying to ask but then remembered. Although the purpose of the activity was identification of species, L – wanted to know about structure and function, and how this one part of the animal fits with the other parts. (Notes, July, Year 1)

L – does not think of herself as a scientist and really only wants information specific to her questions. Although her and her peers' interest is triggered by the worms and the skulls, she has difficulty learning with her peers. She has trouble listening to others' questions and issues and making her own connections to these as a member of the group.

In terms of interest development and its relation to cognition, the learner's relation to a triggered situational interest is idiosyncratic and tentative, especially when the content of the triggering interest is a more developed interest (e.g., basketball) that is being used as a scaffold for working with content that is not of interest and challenging (e.g., writing). Data from L – and the other workshop participants' case material suggest that being encouraged to personalize content is critical to the ability to make connections to it, and that connections are essential to both interest development and cognition.

MAINTAINED SITUATIONAL INTEREST

Similar to the students with a triggered situational interest, students with a maintained situational interest for writing were primarily dependent on others to tell them to write. Their interest for writing was sustained in the sense that the students would return to class and the activities of the class feeling positive about their engagement and confident that they could do well. They felt this way because of the instructional activities (e.g., group work) (Hidi et al., 1998; Mitchell, 1993) and personally meaningful topics (Mitchell, 1993) that their teacher employed. They did little writing outside of class, yet they self-identified as writers. Because they sought to please the teacher, this meant that they were receiving good grades. From their perspective, their grades indicated that they were successful and that writing was an identity, even though they only did writing when it was assigned in class. However, it was difficult for the writing students to ask and pursue questions of their own in their writing (e.g., to try out different voices, to experiment with words), and they were not comfortable with choice; they preferred learning the rules for writing and being told what to do. They used feedback as a set of rules, not as a resource for thinking about writing.

Unlike the writing students, by the fourth year, L – had ideas about what she wanted to know, although these topics were not always linked directly to the plan for the day.

During the fourth year of the workshop, following the "celery experiment," in which a stalk of celery is placed in water dyed with food color, L – interrupts discussion of why the leaves change color to focus on the stalk: "Excuse me, isn't that decent?" She points to the red coloring of the "veins" in the stem and breaks open the stem to look at how the inside of the stalk was affected. (Notes, July, Year 4)

L – and her peers are not dependent on others in order to engage with the content to be learned, but rather for making this content available to them and supporting them to engage with it, even if what they engage with is not necessarily what the instructors had anticipated as the focus of the activity.

By this point, L – was increasingly comfortable asking questions in the group, and seemed more able to think about her peers' questions, especially if they informed her understanding of the phenomena with which she and the others were working. She did not yet really understand the scientific process, as her question about whether they could collect data and then predict what would happen suggests.

By the second day of this workshop, L – chose to hang around after each workshop session, helping to clean up and do lab set-ups for the next day. She also would question and think with the instructors about the day's experimentation. (Notes, June, Year 4)

Unlike the writers with a maintained situational interest, L – did not have a need to please the instructor in order to receive better grades. She and her peers were not in school and were not being graded (see Brophy, 1999). The opportunity to log more time alongside the instructor was her choice, and this (together with the structure and facilitation of the workshops) appeared to enable L – to further solidify her connections to science. Within a few days during the fourth year, she shifted into and out of the phase of maintained situational interest and into the phase of emerging individual interest.

There were at least three features of the fourth-year workshop that may have contributed to the development of L – 's interest. Modeled on Springer's (2006) description of a democratic classroom, fourth-year participants helped build the curriculum for the workshop by identifying questions to which they wanted answers. They kept records of what they understood (responses to *ICAN* probes[3]) in their lab notebooks. They were also engaged in tutoring the younger children of the first-year workshop. Thus, in addition to triggers for engaging science implicit in inquiry-oriented project-based learning, the curricular structure included multiple opportunities for L – and her peers to both make connections to and then reflect on these triggers (CTGV, 1997).

For L –, generating questions to help build the curriculum was not a difficulty. Documenting what she understood in her lab notebook was something on which she often worked in the time that she remained after the workshop sessions were over. The tutoring component of the workshop did pose a challenge for her, however. In order to prepare for tutoring, L – and her peers practiced talking about how they would introduce the properties of Oobleck (a mixture of cornstarch, water, and green food coloring). L – seemed to enjoy squishing the goo and the prospect of sharing the activity with the younger children, but the next day, she did not engage with the younger children at all.

She looks on, sitting at the side of the table, leaving any "tutoring" to her teaching partner. Her affect suggests that she is not comfortable with the tutoring role. (Notes, June, Year 4)

The course of L – 's interest development suggests that a person who is supported to have questions early in the triggering process may transition through the phase of maintained situational interest quickly because his or her interest does not continue to need another person to facilitate it. In other words, when the perceived learning environment offers opportunities to attend and engage, is not over-specified, and has rich content, it appears that knowledge and value develop, and that the learner may easily engage in a process of pursuing his or her own curiosity questions. Such questions are not novel to those who have more information, but are novel for the learner and allow the learner to build knowledge (Renninger, 2000). On the other hand, as L – 's case suggests, the ability to engage in asking curiosity questions may not extend to sharing these with others – at least initially.

EMERGING INDIVIDUAL INTEREST

The students with an emerging individual interest for writing had curiosity questions. They had their own ideas about writing and expression, and had developed some facility in using writing for communication. They had begun to identify themselves as writers presumably because they invested free time in writing and liked it (not because they received good grades for their work). In school, they enjoyed having choices about assignments, but they often posed and sought answers to their own questions that could lead them to deviate substantially from their assignments. They were not particularly interested in the canon of the discipline or in receiving feedback that required revision. They were self-assured about their work and its quality.

By the third week of the fourth-year workshop, L – 's interest had shifted to an emerging individual interest. Because the curricular structure of the workshop focused on the participants' questions, there was little oppositional behavior like that characterizing the students with an emerging individual interest for writing. Instead, L – re-engaged the questions she had raised in other contexts, appeared to feel positive about her work with others in her group, and seemed responsive to feedback that allowed her to understand how she and her group were addressing their goals.

One of the questions that L – 's group decides to study is, What is in lip gloss? L – 's group makes vanilla-scented lip gloss, following a set of procedures that include combining several components (coconut oil, petroleum jelly, aloe vera gel) and heating the mixture in order to facilitate mixing, as it was easier to combine in a liquid state. They decide to use food coloring to add color and try adding food coloring to the already prepared mixture. However, because the food coloring is water-based and the lip gloss contains oil, the two do not mix. There are small beads of food coloring in the lip gloss. Following this discovery, discussion focuses on hypothesizing about what went wrong and experimental design. L – 's group decides to revise their procedure by adding the food coloring before melting the components. This revision works and produces pink lip gloss. It does not matter that the science in which they are engaging is more about chemistry than biology. (Notes, June, Year 4)

L – appeared able to refocus and explore her questions along with those of the others in the hypothesis-generating and testing of their work to produce colored lip gloss.

Differences between L – and the others are also evident. In addressing a question about how sleep affects the amount of energy a person has, L – and her peers decide that they should keep a sleep log over a long weekend, detailing the times they go to sleep, wake up, and how they feel at each time point. No one remembers to do this except L –, possibly because she thinks of the assignment as an experiment, and the others think that it is work (like school). (Notes, July, Year 4)

With the development of interest, L – appeared to have a broader range of topics in which she was interested. She was increasingly willing to explore novel content and, unlike her peers, did not appear to think about workshop-related content as work, even if it did extend into the weekend. In turn, it also seemed that she was more able to be open to her peers' ideas, and was more confident about her ability to work with the younger children.

Despite more willingness to work with the younger children, L – continued to be anxious about this part of the workshop.

In the second week, they are working on measurement, documenting the length of each person's leg and then the length of their jump to answer the question: "How do our legs affect the height and distance of a jump?" She forgets that they are to use centimeters. In disgust, she exclaims, "Man, I took the measurements in inches. My first day as a teacher and I ruined the experiment." The others in her group tell her that she can convert them; but she is so frustrated that she withdraws from the group for almost 10 minutes, repeating, "I feel so stupid, so stupid." When one of the younger children approaches for help calculating the average distance jumped, she is able to help. She seems to regain her self-confidence as she helps a group of the younger children to graph their data. (Notes, June, Year 4)

The participation observation notes provide a number of instances in which it is L – who helped the younger children to think in terms of their predictions and why they think their prediction "came through," or who reached out to help one of the younger girls to spell "calculator," saying, "I mess up spelling that all the time."

Lipstein and Renninger (2007) reported that it was only those with developed interest for writing who liked to work in groups. In earlier phases of interest, the students in the writing classrooms primarily wanted to be told what to do and were not interested in engaging in conversations about options. They also had little interest for learning the canon, and little opportunity to generate the questions on which their writing would focus. They were given opportunities to do "free writes" or choose the topic on which they would write, but not only was the structure and the form of their writing specified, there were also expectations about format, development, and content. The students who were in the phase of emerging individual interest were described as wanting to establish autonomy so they could work on the kind of writing that they themselves defined.

In the workshop context, L – not only helped develop the curriculum, but was also free to refocus it with her questions. This type of context was enabling (see related discussion in Cobb & Hodge, 2004). She generated curiosity questions based on her knowledge, the other things she knew and valued, and her developing knowledge for this new content. This meant that she needed less direct support to participate and engage than she did in the earlier workshops, and less than the writing students needed. She also further developed her willingness and ability to work with others, but she was concerned about how she engaged with others in relation to the content of this work and felt anxious about doing it correctly.

L – and her group were not constrained by the canon in science. They were asked to generate questions and were encouraged to understand the science in them. L – 's approach to working with the younger children did suggest that she had formed some sense of the way in which this work could unfold, however. Presumably, her understanding was modeled on the way in which her instructors had worked with her. [4]

WELL-DEVELOPED INDIVIDUAL INTEREST

Students with a well-developed interest for writing sought feedback that would allow them to continue to develop their understanding of writing. For them, the feedback process was an opportunity to deepen their interest (Azevedo, 2006; Barron, 2006; Hidi & Ainley, 2008; Lipstein & Renninger, 2007). These students had identified as writers and had positive feelings about writing that appeared to sustain them even when writing posed difficulties for them. They spent time outside of school writing, and appreciated having choices about assignments.

Neither L – nor the others in her group had yet reached the phase of well-developed individual interest in her last year of workshops.

By the fifth year, when L – volunteers to work as a teaching assistant in the Chemistry Workshop, she has a good understanding of what it means to do science and its process and likes taking experiments one step further by testing additional substances or mixing chemicals. Moreover, she is able to help the younger students to fill in the ICAN statements in their lab notebooks even though she is not doing the experiments herself. (Notes, June, Year 5)

L – was not yet independently pursuing her own questions. Nor did she seem aware that there were generally accepted disciplinary standards for science beyond those of the workshop context. She appeared to need the support of the workshop environment that provided resources and opportunities for learning in order to know how her goals were met.

SUMMARY AND DISCUSSION

L – and the others in her group did not bring any formal experience with science to the workshops. The curricular structure of the workshop sessions was explicitly inquiry, and the instructors' goals for them centered on understanding that they could do science and that science is fun. They wanted L – and her peers to feel that they are capable of doing and enjoying science and worked to ground the activities in L – and her peers' prior experience. The instructors provided time and opportunities for them to question and reflect, and all questions were taken seriously. The science workshop as a learning environment is a contrast to that of the writing students. The writing students' classes included open-ended opportunities (e.g., free writes), but they also included instruction in the cannon of the five-paragraph essay and analysis, content to which only those with well-developed individual interest were receptive. The learning environments of each varied; the workshop was more open and the writing classes were more closed. Comparison of the participants in each suggests that the phase of learner interest influences to what and also how he or she attends (see Table 17.1).

The data from L – 's case provide further details about the nature of the questions with which a learner engages and the shift in such questions over time. Although her questioning appears to have focused on structure and function, there was a shift from wanting to understand how the skull connects to the body of the animal (a question that was not in the workshop plans) in year one to wanting to use experimentation to explore the acid-base relation (a question that anticipated upcoming workshop plans) in year five.

Not only do these data document a particular focus in her questioning over the years, they reveal an increasing capacity to think and do science.[5] They also call attention to the time that this type of development can take, even when the conditions of the learning environment include rich content, supportive others, and opportunities to self-structure questions and engage. It was four years before L – 's interest began to shift from a triggered situational interest to a maintained situational interest. It then took three weeks for her interest to shift from a maintained situational interest to an emerging individual interest.

The data from L – 's case also highlight differences between learning environments and the way in which learners engage content in each environment, and their needs in this process. As summarized in Table 17.1, L – and her group seemed to benefit from and need additional information from others, whereas in earlier phases of interest the student writers wanted to be told only what they needed to know and no more – unless this information acknowledged what they did. Only those student writers identified as having a well-developed individual interest sought out and seemed positioned to work with feedback.

There were differences in the participants' perceptions of these learning environments, in the goals and roles of the teachers and the instructors, and in the backgrounds of the participants. Whereas the writing classrooms focused on supporting the students to learn the rules of academic writing, the science workshop environment was open-ended and did not have grades; it was designed to promote fun and engagement with science. Although the writing students' teachers thought of themselves as supporting their students in the same way that the instructors supported L – and her peers, this was not the way that the writing students understood the expectations of their teachers. The goals and roles of the workshop instructors changed, depending on the activity and L – and her group's responses; they provided information and resources, asked and answered questions, stood back and allowed L – and her group to explore, make mistakes, and reason.

The two groups of participants varied, as well. The writing students had had instruction in writing throughout their schooling and came from families that valued education and had placed them in an academically oriented school. L – and her group were learners new to science; only in the last two years of the workshops had there been science instruction in their schools; they came from families and a community with few or no scientists. Although it is inappropriate to simply point to one or another feature of these environments as accounting for differences, it is possible to note that the two participant groups engaged content differently and that their perceptions influenced their engagement. It also appears that differences in their perceptions informed what they needed from others who were supporting them to learn.

CONCLUSIONS AND QUESTIONS

Current research suggests that a learner can be supported to develop an interest for any content, through interactions with others and the texts, tasks, and opportunities in the environment (Renninger, 2010). However, this same research suggests that due to the nature of a person's interactions with the environment and, by implication, the quality of these interactions, interest may or may not develop or deepen, and may instead regress or disappear altogether (Bergin, 1999; Renninger, 2000). In other words, although interest can be supported to develop, the phases of its development are termed "phases" rather than "stages" because interest develops in relation to the environment and can fall off if support is not available (Hidi & Renninger, 2006).

Findings from existing research on interest indicate that it is the opportunities and experiences available to learners early in their work with a subject that affect the kinds of connections they make to that subject, and, as a result, their readiness to begin to engage it independently (Nolen, 2007). The others with whom learners come into contact contribute to the connections that are made – by providing feedback and supporting learners early in their work to have fun and enjoy the content in ways that also build knowledge and enable them to know that they know. Later in the development of interest, the needs of learners in the out-of-school environment continue to include support, but also include opportunities to explore and work with knowledge, know what they have learned and what they have still to learn, and provide feedback that enables them to know when goals have been met.

Based on the data from L – 's case, it appears that shifts in the development of interest can be expected but are not likely to be immediately obvious to an interviewer, although patterns of engagement – such as the kinds of questions asked and the extent to which these questions map onto the questions of the discipline – and behaviors can be tracked. The quote from L – 's interview at the opening of this chapter in which she says that she does not like science came from her year-five interview. In contrast to what she said to the interviewer, she has just requested and been granted a role as a teaching assistant for a younger group in the Chemistry Workshop. Her response to the interviewer (a familiar adult) reflects the same attitude that L – presents during the first days of the first year of the workshop; it suggests that she is uncomfortable talking about herself. It is possible that L – has difficulty reconciling her successes in this out-of-school workshop with her experience of school science. She may not believe that a summer workshop can result in change, although her workshop instructors can see otherwise.

Prior findings have suggested that with the development of interest, learners need less direct support to participate and engage and more opportunities to stretch what they know. The presence of the ability to ask and seek answers to curiosity questions coupled with learners' apparent resistance to information in the academic context seemed to suggest that indirect methods of support might be most useful (e.g., instructional conversations, resources, and opportunities to work with others) (see Lipstein & Renninger, 2007; Mitchell, 1993; Palmer, 2009). Findings from L – 's case qualify this understanding by suggesting that learners with more developed interest might be more responsive to receiving the kind of information that could help them further develop their interest were the learning environment more open, the learner feeling sure of him or herself, the need to master particular forms of information unspecified and untimed (Azevedo, 2006; Springer, 2006), and the environment responsive (Thoman et al., 2006).

With the development of interest, it appears likely that L – and her peers have attentional resources that are freed up. L –, for example, began thinking about science with her peers and the younger children. Before this, it appears that her own questions took so much of her energy that she did not have the capacity to fully benefit from her peers, although it is in the workshops with them that she continues to grow.

The workshops and their content were new to L – and her peers. Their design involved full participation, no explicit comparisons among the participants, and no specific expectations about content to be mastered.[6] L – learned through her participation. It appears that autonomy, per se, is not what L – needed. Learners such as the writing students may need to strive for autonomy because they are responding to academic demands or pressure. The questions and engagements of L – and her peers, on the other hand, appear to be increasingly aligned with the disciplinary goals and skills of science over the course of the workshops.

Comparing the data from the writing students and those of L – and her peers underscores the complexity of the interest development and cognition relation. It seems that the more open yet structured form of inquiry in the workshop context led L – to build her knowledge, and this in turn was motivating. Of importance is the fact that L – determined the "what" of the content with which she engaged. Her peers were not focused on structure and function in their questions, although they, too, could be said to have been consistent in the framing of the questions that they held.

Data from the writing students and those of L – and her peers also raise questions about the interplay between interest development and cognition in the learning environment. Is the interest of L – and her peers subject to the kind of regression and possible change as that of the writing students? Is it possible that L – and her peers have grown into thinking and doing science in such a way that they internalize the questioning, predicting, experimenting, modeling, applying, and identifying additional questions, and that these experiences and the enjoyment of the process of engaging them cannot fall off?

Does what triggers interest vary if learners are free to respond to the opportunities and resources that are available to them, rather than feeling that their engagement is controlled? Is it possible that in more open learning environments, learning does serve as a trigger for interest?

What are the differences in the nature of goals that learners set for themselves as opposed to those that are set for them? Could L – have developed her interest for science without the group of peers who also participated in the workshop – other learners who not only shared the experience but talked with her about the workshop and listened to her?

When did L – start to realize that she was indeed learning science? What were the supports that were in place for her that made a difference? How different would the experience of the writing students have been had they been participants in a more open learning environment – and would it have made a difference if they had been in an earlier phase of interest for writing?

How do knowledge and feelings work together to provide a basis for deepening value? How do affect and value change as interest develops? What does L – perceive science to be? What types of interactions would be needed in order for L – to claim that she enjoys science or that she might want to be a scientist?

L – 's case and the experiences of her peers together with data from the writing students indicate that the phase of learner interest and his or her perceptions of the learning environment are likely to affect whether one or another content is something to which to attend – how he or she engages and whether interest is likely to develop. They also underscore the importance of knowledge building and reflection as supports for and outcomes of interest development, an interaction that is as critical for education as it is for theory and research.

ACKNOWLEDGEMENTS

We would like to acknowledge the role of many in the data reported in this chapter and our thinking about it. We appreciate: the ongoing encouragement and involvement of Elizabeth Vallen and the participants of the Science-for-Kids workshops over the years; the help of Jessica Bachrach, Robin Collin, Melissa Emerson, and Alicia Niwagaba, who collected interview data and participant observation notes that provided the basis of the data reported in this chapter; editorial support from Nadine Kolowrat and Melissa Running; student fellowship support from the Howard Hughes Medical Institute to Swarthmore College; and for work on this chapter from the Swarthmore College Faculty Research Fund.

Notes

1. Participant observation notes were collected continuously throughout the five weeks of the workshop each summer; these were continuous anecdotal observational records (Carini, 1975) that were collected by one researcher who was blind to study questions. The records chronicled instructors' and participants' conversations and observable behaviors.

   Interviews were conducted with workshop participants at three points during each of the summers: before the workshop began, at the end of the workshop, and five weeks following workshop completion. The interviews were used to identify participant interest, feelings of self-efficacy, experience of the workshop, and abilities to work with adaptations of established science tasks.
2. Data on L – 's workshop participation included participant observation notes and interviews before and after each of the workshops. The participant observation notes consisted of running records of all classroom activities on each day of the workshop. They chronicled instructor and participants' conversations and behaviors. To the extent possible, individual participation was systematically tracked. Following each workshop session, the instructor(s) and the observer reviewed each day's session, at which time the observer adjusted the records to clarify confusion and/or record additional information (e.g., things that happened on the other side of the room).

   Identification of L – 's and her group's phase of interest was informed by both the interviews, whose questions were an adaptation of the questionnaire items completed by Lipstein and Renninger's (2007) writing students, and by an adaptation of Renninger and Wozniak's (1985) analysis of young children's behavioral records – the likelihood of their voluntary reengagement, engagement overall, independent engagement, and complexity of engagement.
3. *ICANs* (adapted from Chaconas; see Renninger & Nekoba, 2010) are a lab notebook activity that involves reflecting on the concepts and skills of the day's instructional objectives in relation to those that have preceded. The day that the celery experiment was set up, the *ICAN* probes in the lab books were:– I CAN use simple observations about light to explain why we see rainbows and why the sky is blue.

   – I CAN use chromatography to find out what is in markers.
4. In other discussions, the workshop participants drew clear lines between schoolwork and the workshops, along lines of the tasks, discipline, and interactions with instructors.
5. Control data were collected and no such shifts were identified.
6. The workshop instructors were professors and their students in the particular field of science (biology, chemistry).

References

Ainley, M. (2006). Connecting with learning: Motivation, affect and cognition in interest processes. *Educational Psychology Review*, **18**, 391–405.

(2007). Being and feeling interested: transient state, mood, and disposition. In P. A. Schutz & R. Pekrun (Eds.), *Emotions in education* (pp. 147–163). New York: Elsevier.

Alexander, P. A. (1997). Mapping the multidimensional nature of domain learning: The interplay of cognitive, motivational, and strategic forces. In M. L. Maehr & P. R. Pintrich (Eds.), *Advances in motivation and achievement* (Vol. 10, pp. 213–250). Greenwich, CT: JAI Press.

(2004). A model of domain learning: Reinterpreting expertise as a multidimensional, multistage process. In D. Y. Dai & R. J. Sternberg (Eds.), *Motivation, emotion, and cognition: Integrative perspectives on intellectual functioning and development* (pp. 273–298). Mahwah, NJ: Erlbaum.

Alexander, P. A., Jetton, T. L., & Kulikowich, J. M. (1995). Interrelationship of knowledge, interest, and recall: Assessing a model of domain learning. *Journal of Educational Psychology*, **87**(4), 559–575.

Alexander, P. A., Kulikowich, J. M., & Jetton, T. L. (1994). The role of subject-matter knowledge and interest in the processing of linear and nonlinear texts. *Review of Educational Research*, **64**(2), 201–252.

Anderson, R. C. (1982). Allocation of attention during reading. In A. Flammer & W. Kintsch (Eds.), *Discourse processing* (pp. 292–335). Amsterdam: North-Holland.

Arnold, F. (1910). *Attention and interest: A study in psychology and education.* New York: Macmillan.

Ashby, F., Isen, A., & Turken, A. (1999). A neuropsychological theory of positive affect and its influence on cognition. *Psychological Review*, **106**(3), 529–550.

Azevedo, F. S. (2006). Personal excursions: Investigating the dynamics of student engagement. *International Journal of Computers for Mathematical Learning*, **11**, 57–98.

(2011). Lines of practice: A practice-centered theory of interest relationships. *Cognition and Instruction*, **29** (2), 147–184.

Baldwin, J. M. (1911). *Thought and things: A study of the development of meaning of thought* (Vol. 1). New York: Macmillan.

Bandura, A. (1997). *Self-efficacy: The exercise of control.* New York: Freeman.

Barron, B. (2006). Interest and self-sustained learning as catalysts of development: A learning ecology perspective. *Human Development*, **49**, 193–224.

Bartlett, F. C. (1932). *Remembering: A study in experimental and social psychology*. New York: Cambridge University Press.

Bergin, D. (1999). Influences on classroom interest. *Educational Psychologist*, **34**(2), 87–98.

Berlyne, D. (1960). *Conflict, arousal, and curiosity.* New York: McGraw-Hill.

Brophy, J. (1999). Toward a model of the value aspects of motivation in education: Developing appreciation for particular learning domains and activities. *Educational Psychologist*, **34**(2), 75–85.

Carini, P. F. (1975). *Observation and description: An alternative methodology for the investigation of human phenomena.* Grand Forks, ND: North Dakota Study Group on Evaluation.

Chen, A., & Darst, P. (2001). Situational interest in physical education: A function of learning task design. *Research Quarterly for Exercise and Sport*, **72**(2), 150–164.

(1999). Influential factors on instant interest in learning tasks: A preliminary analysis in middle school students. Research Consortium, AAHPERD. *Research Quarterly for Exercise and Sport*, **70** *(supplement)*, 79.

Cobb, P., & Hodge, L. (2004, June). An initial contribution to the development of a design theory of mathematical interests: The case of statistical data analysis. Paper presented as part of the symposium. *Design Theories of Interest, Motivation, and Engagement for the Learning Sciences*. Sixth International Conference of the Learning Sciences, Santa Monica, CA.

Cognition and Technology Group at Vanderbilt (CTGV). (1997). *The Jasper project: Lessons in curriculum, instruction, assessment, and professional development.* Mahwah, NJ: Lawrence Erlbaum Associates.

Dewey, J. (1913). *Interest and effort in education.* Boston: Riverside.

Durik, A. M., & Harackiewicz, J. M. (2007). Different strokes for different folks: How individual interest moderates the effects of situational factors on task interest. *Journal of Educational Psychology*, **99**(3), 597–610.

Flowerday, T., & Schraw, G. (2003). Effect of choice on cognitive and affective engagement. *Journal of Educational Research*, **96**, 207–215.

Flum, H., & Kaplan, A. (2006). Exploratory orientation as an educational goal. *Educational Psychologist*, **41**(2), 99–110.

Frenzel, A. C., Goetz, T., Pekrun, R., & Watt, H. M. G. (2010). Development of mathematics interest in adolescence: Influences of gender, family, and school context. *Journal of Research on Adolescence*, **20**(2), 507–537.

Gisbert, K. (1998). Individual interest in mathematics and female gender identity: Biographical case studies. In L. Hoffmann, A. Krapp, K. A. Renninger, & J. Baumert (Eds.), *Interest and learning: Proceedings of the Seeon conference on Interest and Gender* (pp. 175–184). Kiel, Germany: IPN.

Harackiewicz, J. M., Barron, K. E., Tauer, J. M., & Elliot, A. J. (2002). Predicting success in college: A longitudinal study of achievement goals and ability measures as predictors of interest and performance from freshman year through graduation. *Journal of Educational Psychology*, **94**(3), 562–575.

Harackiewicz, J. M., Durik, A. M., Barron, K. E., Linnenbrink, L., & Tauer, J. M. (2008). The role of achievement goals in the development of interest: Reciprocal relations between achievement goals, interest, and performance. *Journal of Educational Psychology*, **100***(1)*, 105–122.

Häussler, P., & Hoffmann, L. (2002). An intervention study to enhance girls' interest, self-concept, and achievement in physics classes. *Journal of Research in Science Teaching*, **39**(9), 870–888.

Hidi, S. (1990). Interest and its contribution as a mental resource for learning. *Review of Educational Research*, **60**, 549–571.

(1995). A reexamination of the role of attention in learning from text. *Educational Psychology Review*, *7(4)*, 323–350.

(2006). Interest: A motivational variable with a difference. *Educational Research Review*, 7, 323–350.

Hidi, S., & Ainley, M. (2008). Interest and self-regulation: Relationships between two variables that influence learning. In D. H. Schunk & B. J. Zimmerman (Eds.), *Motivation and self-regulated learning: Theory, research, and application* (pp. 77–109). Mahwah, NJ: Erlbaum.

Hidi, S., & Baird, W. (1988). Strategies for increasing text-based interest and students' recall of expository texts. *Reading Research Quarterly*, **23**(4), 465–483.

Hidi, S., & Renninger, K. A. (2006). The four-phase model of interest development. *Educational Psychologist*, **41**(2), 111–127.

Hidi, S., Weiss, J., Berndorff, D., & Nolan, J. (1998). The role of gender, instruction and a cooperative learning technique in science education across formal and informal settings. In L. Hoffmann, A. Krapp, K. A. Renninger, & J. Baumert (Eds.), *Interest and learning: Proceedings of the Seeon conference on interest and gender* (pp. 215–227). Kiel, Germany: IPN.

Hulleman, C. S., Durik, A. M., Schweigert, S. A., & Harackiewicz, J. M. (2008). Task values, achievement goals, and interest: An integrative analysis. *Journal of Educational Psychology*, **100**(2), 398–416.

James, W. (1890). *The principles of psychology.* London: Macmillan.

Katz, I., Assor, A., Kanat-Maymon, Y., & Bereby-Meyer, Y. (2006). Interest as a motivational resource: Feedback and gender matter, but interest makes the difference. *Social Psychology of Education*, **9**, 27–42.

Krapp, A. (2003). Interest and human development: An educational-psychological perspective. *British Journal of Educational Psychology Monograph Series, Development and Motivation*, 57–84.

(2007). An educational – psychological conceptualization of interest. *International Journal of Educational and Vocational Guidance*, **7**, 5–21.

Krapp, A., & Fink, B. (1992). The development and function of intrests during the critical transition from home to preschool. In K. A. Renninger, S. Hidi, & A. Krapp (Eds.), *The role of interest in learning and development* (pp. 397–431). Hillsdale, MJ: Erlbaum.

Krapp, A., & Prenzel, M. (2011). Research on interest in science: Theories, methods, and findings. *International Journal of Science Education*, **33**(1), 27–50.

Laukenmann, M., Bleicher, M., Fuβ, S., Gläser-Zikuda, M., Mayring, P., & Rhöneck, C. (2003). An investigation on the influence of emotions on learning in physics. *International Journal of Science Education*, **25**, 489–507.

Lawless, K. A., & Kulikowich, J. M. (2006). Domain knowledge and individual interest: The effects of academic level and specialization in statistics and psychology. *Contemporary Educational Psychology*, **31**, 30–43.

Lipstein, R., & Renninger, K. A. (2007). "Putting things into words": 12–15-year-old students' interest for writing. In P. Boscolo & S. Hidi (Eds.), *Motivation and writing: Research and school practice* (pp. 113–140). New York: Kluwer Academic/Plenum Press.

Markus, H., & Nurius, P. (1986). Possible selves. *American Psychologist*, **4**, 954–969.

McDaniel, M. A., Waddill, P. J., Finstad, K., & Bourg, T. (2000). The effects of text-based interest on attention and recall. *Journal of Educational Psychology*, **92***(3)*, 492–502.

Mitchell, M. (1993). Situational interest: Its multifaceted structure in the secondary school mathematics classroom. *Journal of Educational Psychology*, **85**, 424–436.

Neitzel, C., Alexander, J., & Johnson, K. E. (2008). Children's early interest-based activities in the home and subsequent information contributions and pursuits in kindergarten. *Journal of Educational Psychology*, **100***(4)*, 782–797.

Nolen, S. B. (2007). Young children's motivation to read and write: Development in social contexts. *Cognition and Instruction*, **25**, 219–270.

Palmer, D.H. (2009). Student interest generated during an inquiry skills lesson. *Journal of Research in Science Teaching*, **46***(2)*, 147–165.
Panksepp, J. (1998). *Affective neuroscience: The foundations of human and animal emotion*. New York: Oxford University Press.
Piaget, J. (1968). The mental development of the child. In D. Elkind (Ed.), *Six psychological studies by Jean Piaget* (pp. 3–73). New York: Random House.
Prenzel, M. (1992). The selective persistence of interest. In K. A. Renninger, S. Hidi, & A. Krapp (Eds.), *The role of interest in learning and development* (pp. 71–98). Hillsdale, NJ: Erlbaum.
Renninger, K. A. (1990). Children's play interests, representation, and activity. In R. Fivush & K. Hudson (Eds.), *Knowing and remembering in young children* (pp. 127–165). New York: Cambridge University Press.
(2000). Individual interest and its implications for understanding intrinsic motivation. In C. Sansone & J. M. Harackiewicz (Eds.), *Intrinsic and extrinsic motivation: The search for optimal motivation and performance* (pp. 375–407). New York: Academic.
(2009). Interest and identity development in instruction: An inductive model. *Educational Psychologist*, **44***(2)*, 1–14.
(2010). Working with and cultivating interest, self-efficacy, and self-regulation. In D. Preiss & R. Sternberg (Eds.), *Innovations in educational psychology: Perspectives on learning, teaching and human development* (pp. 107–138). New York: Springer.
Renninger, K. A., Bachrach, J. E., & Posey, S. K. E. (2008). Learner interest and achievement motivation. In M. L. Maehr, S. Karabenick, & T. Urdan (Eds.), *Social psychological perspectives Volume 15: Advances in motivation and achievement* (pp. 461–491). Bingley, UK: Emerald Group.
Renninger, K. A., Ewen, E., & Lasher, A. K. (2002). Individual interest as context in expository text and mathematical word problems. *Learning and Instruction*, **12**, 467–491.
Renninger, K. A., & Hidi, S. (2002). Student interest and achievement: Developmental issues raised by a case study. In A. Wigfield & J. S. Eccles (Eds.), *Development of achievement motivation* (pp. 173–195). New York: Academic Press.
(2011). Revisiting the conceptualization, measurement, and generation of interest. *Educational Psychologist*, **46***(3)*, 168–184.
Renninger, K. A., & Lipstein, R. (2006). Come si sviluppa l'interesse per la scrittura; Cosa volgliono gli studenti e di cosa hannobisogno? [Developing interest for writing: What do students want and what do students need?] *Età Evolutiva*, **84**, pp. 65–83.
Renninger, K. A., & Nekoba, W. (2010, September). *Identifying the phase of student interest in mathematics for a study of classroom practices for at-risk students*. Paper presented at the meetings of the International Conference on Motivation, Oporto, Portugal.
Renninger, K. A., Ray, L. S., Luft, I., & Newton, E. L. (2005). Coding online content informed scaffolding of mathematical thinking. *New Ideas in Psychology*, **23**, 152–165.
Renninger, K. A., Sansone, C., & Smith, J. L. (2004). Love of learning. In C. Peterson & M. E. P. Seligman (Eds.), *Character strengths and virtues: A classification and handbook* (pp. 161–179). New York: Oxford University Press.

Renninger, K. A., & Su, S. (2012). Interest and its development. In R. M. Ryan (Ed.), *Oxford Handbook of Motivation* (pp. 167–187). New York: Oxford University Press.

Renninger, K. A., & Wozniak, R. H. (1985). Effect of interest on attentional shift, recognition, and recall in young children. *Developmental Psychology*, **21***(4)*, 624–632.

Sansone, C. (2009). What's interest got to do with it?: Potential trade-offs in the self-regulation of motivation. In J. P. Forgas, R. Baumiester, & D. Tice (Eds.), *Psychology of self-regulation: Cognitive, affective, and motivational processes* (pp. 35–51). New York: Psychology Press.

Sansone, C., & Thoman, D. B. (2005a). Does how we feel affect what we learn?: Some answers and new questions. *Learning and Instruction*, **15**, 507–515.

(2005b). Interest as the missing motivator in self-regulation. *European Psychologist*, **10***(3)*, 175–186.

Schiefele, U. (2009). Situational and individual interest. In K. Wentzel & A. Wigfield (Eds.), *Handbook of Motivation at School* (pp. 197–222). New York: Routledge.

Schiefele, U., & Krapp, A. (1996). Topic interest and free recall of expository text. *Learning and Individual Differences*, **8**, 141–160.

Senko, C. M., & Harackiewicz, J. M. (2005). Achievement goals, performance and task interest: Why perceived difficulty matters. *Personality and Social Psychology Bulletin*, **31**, 1739–1753.

Silvia, P. J. (2005a). What is interesting? Exploring the appraisal structure of interest. *Emotion*, **5**, 89–102.

(2005b). Emotional responses to art: From collation and arousal to cognition and emotion. *Review of General Psychology*, **9**, 342–357.

(2006). *Exploring the psychology of interest.* New York, NY: Oxford University Press.

Sloboda, J. A. (1996). The acquisition of musical performance expertise: Deconstructing the "talent" account of individual differences in musical expressivity. In K. Ericsson (Ed.), *The road to excellence: The acquisition of expert performance in the arts and sciences, sports, and games* (pp. 107–126). Mahwah, NJ: Lawrence Erlbaum Associates, Inc.

Sosniak, L. A. (1990). The tortoise, the hare, and the development of talent. In M. Howe (Ed.), *Encouraging the development of exceptional skills and talents* (pp. 149–164). Leicester, UK: British Psychological Society.

Springer, M. (2006). *Soundings: a democratic student-centered education.* Westerville, OH: National Middle School Association.

Thoman, D. B., Sansone, C., & Pasupathi, M. (2006). Talking about interest: Exploring the role of social interaction for regulating motivation and the interest experience. *Journal of Happiness Studies*, **8**, 335–370.

Tobias, S. (1994). Interest, prior knowledge, and learning. *Review of Educational Research*, **64**, 37–54.

Tsai, Y. M., Kunter, M., Lüdtke, O., Trautwein, U., & Ryan, R. M. (2008). What makes lessons interesting? The role of situational and individual factors in three school subjects. *Journal of Educational Psychology*, **100***(2)*, 460–472.

Turner, S. A., Jr., & Silvia, P. J. (2006). Must interesting things be pleasant? A test of competing appraisal structures. *Emotion*, **6**, 670–674.

Yamuchi, L. A., Wyatt, T. R., & Carroll, J. H. (2005). Enacting the five standards for effective pedagogy in a culturally relevant high school program. In A. E. Maynard & M. I. Martini (Eds.), *Learning in cultural contexts: Family, peers, and schools* (pp. 227–245). New York: Kluwer.

18

Metacognition, Motivation, and Affect in the School Context

Metacognitive Experiences in the Regulation of Learning

Anastasia Efklides

INTRODUCTION

The perspective in this chapter is on the relations of metacognition with cognition, affect, and motivation in the context of school learning. The framework within which these relations will be explored is that of self-regulated learning (SRL; Boekaerts, 1999; Winne, 2004; Zimmerman, 1998). Extant SRL theories posit various phases in SRL starting with the thoughts, motivation, and activities preceding the execution of a task to those during and, finally, to those following the execution of the task (e.g., Zimmerman, 1998). In this conceptualization of SRL, person characteristics at the trait level (that is, motivation and person characteristics that influence the person's involvement in SRL), metacognition (mainly in the form of strategies for the control of cognition) as well as self-reflection and self-evaluation process are advocated.

However, the theoretical approach adopted here, namely the Metacognitive and Affective model of Self-Regulated Learning (the MASRL model, Efklides, 2011), differs from other approaches because it draws attention to the metacognitive and affective aspects of the person's interaction with the task at hand (Task x Person), that is, the subjective experiences the person has in relation to learning tasks as cognitive processing takes place. Subjective experiences during cognitive processing are influenced by and in their turn influence person characteristics and motivation as well as control decisions. Such an approach to SRL brings together the person's situational, momentary, and changing experiences that are associated to a specific learning task and its processing with the relatively stable and general person characteristics implying that cognition, metacognition, affect, and motivation act in synergy in the person's short- and long-term SRL.

The learning situations to which the MASRL model applies can be shown through the following examples: (1) A student is working on a mathematical problem, solves it, and feels confident that the solution produced was the proper one; (2) a student feels difficulty during mathematical problem solving, solves the problem correctly (or incorrectly), and feels uncertain about the correctness of the solution; (3) a student refuses or avoids getting involved in problem solving because the problem is unfamiliar or novel; and (4) a student produces a solution to a mathematical problem but avoids reflection on the feelings experienced during problem solving. In all these examples, the following questions are raised: Which is the nature of the feelings students experience in relation to the task at hand? How are task-related experiences and reactions formed? Are they related to motivation and affect or only to cognitive processing? Do such task-specific subjective experiences and reactions influence the person's short- and long-term SRL? The position taken here is that these subjective experiences are metacognitive in nature (i.e., metacognitive experiences) and inform the person on the progress that is being (or has been) made toward achieving the learning goal posed. Moreover, it is posited that metacognitive experiences are related to both motivation/affect and cognition, and form an indispensable part of both the short- and long-term SRL.

This claim is based on the idea that metacognition (i.e., monitoring and control of cognition) cannot be effective unless it is guided by the goal(s) the person pursues. Monitoring of cognitive processing – that is, monitoring whether processing is fluent and leads to the attainment of one's goal – is crucial for both effort regulation and strategy use to achieve the goal(s) set (Efklides, 2006). Effort regulation is determined by cognitive processing demands as well as by metacognitive awareness of these demands. It is also determined by motivation and affect – that is, the drive that gives direction and energizes behavior and action (Efklides, 2007). Thus, in the self-regulation of behavior and action (Carver & Scheier, 1998; Kuhl, 1985; Kuhl & Fuhrmann, 1998), both the metacognitive and affective regulatory loops are contributing. Usually, each regulatory loop is studied by researchers on its own, without considering the links between them; metacognitive experiences, however, provide such a link (Efklides, 2006, 2011).

To sum up, the MASRL model (Efklides, 2011) serves two goals: to highlight the interrelations of person characteristics as traits (including motivation), functioning at what is called the Person level with metacognitive experiences – that is, metacognition functioning at what is called the Person × Task level; and to highlight the interrelations of metacognitive experiences with affect and their impact on short- and long-term SRL. In what follows, I shall briefly refer to SRL and then to the various facets of metacognition, one of which is metacognitive experiences. The role of metacognitive experiences in SRL will then be pointed out and, particularly, their interaction with motivation and affect. Finally, the implications of the proposed MASRL model for the conceptualization of the role of metacognition in SRL will be discussed.

SELF-REGULATED LEARNING

There is no doubt that school learning involves acquisition of content knowledge as well as skills that form a very significant part of cognition. However, learning is an effortful, long-lasting process in which previous acquisitions form the building blocks for new higher-order and more-demanding learning to be achieved. Moreover, learning requires awareness of thinking and its regulation, so that learning goals are attained. Consequently, learning requires not only knowledge acquisition and knowledge restructuring but also persistence and effort expenditure in face of adversity. For this to occur, motivation and positive affect are required (Aspinwall, 1998; Efklides, 2007; Efklides et al., 2006) as well as metacognition and volition (i.e., self-regulation) to secure action against distracters or obstacles (Kuhl, 1985; Kuhl & Fuhrmann, 1998). However, in the SRL process, we need to distinguish a Person level that involves person characteristics functioning at a more general level and determines what the person brings into various learning situations (long-term SRL) and a Task x Person level; that is, what the person actually does and feels during specific task processing (short-term SRL). These two levels are depicted in Figure 18.1.

Before looking at the specific features of the MASRL model, some basic components of SRL will be pointed out based on extant research. These components will be presented from the perspective of the MASRL model, particularly in connection to its levels. Specifically, motivation in learning contexts may take various forms, ranging from basic needs such as autonomy, competence, and relatedness (Ryan & Deci, 2000) to expectancy-value beliefs (Wigfield & Eccles, 2000) and achievement goal orientations (Nicholls, 1984; Thrash & Elliot, 2001). Motivational needs or traits are task-independent; thus, they function at the Person level and are setting the direction of one's action as well as the general policy on how much effort is to be invested in the pursuit of one's goal(s) (Kahneman, 1973). The actual effort, however, is a function of both the task-specific motivation and the task difficulty (Brehm & Self, 1989; Efklides, 2007; Efklides et al., 2006). Therefore, motivation at the Person level is involved in the estimation of the effort to be exerted on a learning task at the Task x Person level, but this estimation (and actual effort) would change as cognitive (task) processing takes place and more accurate monitoring (e.g., in the form of feeling of difficulty) of task demands is made.

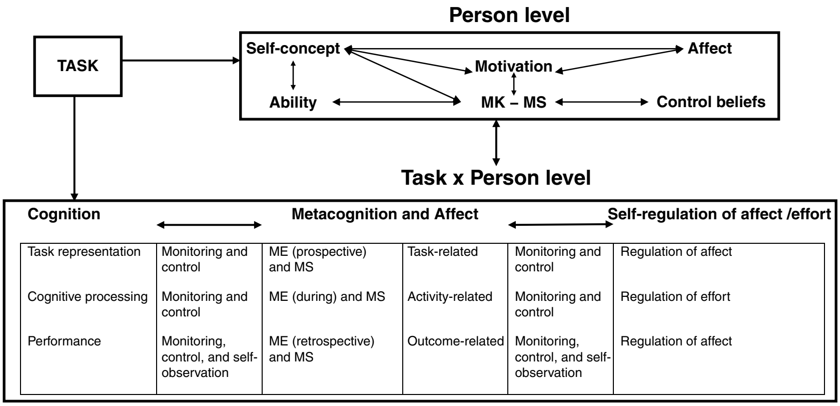

FIGURE 18.1. The MASRL model. Adopted from Efklides (2011). Interactions of metacognition with motivation and affect in self-regulated learning: The MASRL model. *Educational Psychologist, 46(1)*, 6–25.
Note: ME = metacognitive experiences; MK = metacognitive knowledge; MS = metacognitive skills.

At the Task x Person level, affect (e.g., mood) can also influence effort exertion (Efklides & Petkaki, 2005; Gendolla & Brinkmann, 2005), and so do achievement-related emotions such as interest (Hidi, 2006; Hidi & Ainley, 2007; Renninger, Sansone, & Smith, 2004; Sansone & Thoman, 2005). The latter influence the extent to which students will engage in learning tasks and will persist on them. Other emotions such as fear, anger, anxiety, pride, or shame are also experienced before, during, or after working on learning tasks (Pekrun, Elliot, & Maier, 2006; Pekrun et al., 2002) and have an impact on or interfere with learning behaviors or the regulation of learning. These emotions can be related to the task itself, to the activity related to the task, or to the outcome of one's performance on the task. Emotions, unlike motivation that functions at the Person level, are associated with the particular task or learning situation; that is, they are functioning at the Task x Person level. Yet, some emotions can also function at the Person level. For example, anxiety-trait (Spielberger, 1980) or interest in a particular knowledge domain as disposition (Hidi & Renninger, 2006) can be more general in scope and independent of the specific task at hand. If triggered by situational cues, then anxiety-trait and dispositional interest can influence the decision to go on with task processing and effort exertion. Thus, although emotions are critical for short-term task-specific SRL, they can also influence long-term SRL if they come to function at the Person level as dispositional characteristics.

Another person characteristic that is crucial for SRL is self-concept. Academic self-concept, including self-esteem and self-efficacy in specific school subjects or knowledge domains (Byrne, 1996; Dermitzaki & Efklides, 2000; Harter, 1986), is important for SRL. For instance, the higher a student's self-concept in a school subject the higher the attainment in this subject and the more positive the feelings experienced during processing of similar learning tasks (Efklides & Tsiora, 2002). Thus, self-concept represents a person characteristic that motivates the student in broader domains and impacts SRL at the Task x Person level.

On the other hand, one cannot self-regulate learning behaviors unless she/he has *control and agency beliefs* (Skinner, 1995); that is, beliefs about one's ability to exert control on the self and others or the environment using particular means (strategies) in different situations. Such control and agency beliefs are crucial for the self-regulation of learning-related behaviors and the exercise of volitional control.

It has to be pointed out, however, that none of the person characteristics as traits by itself suffices to explain how task or situational characteristics come in to determine cognitive processing of learning tasks. Task processing requires, first of all, task-related cognition, knowledge, and abilities as well as metacognition. Cognition and metacognition represent the cognitive resources the person brings along when faced with a task; hence, they function at both a general level (Person level) and a specific level (Task x Person level).

To sum up, SRL stresses autonomy and personal control over learning, with the students monitoring, directing, and regulating their behavior and actions in order to achieve, acquire knowledge, expand expertise, or improve themselves (Paris & Paris, 2001). For monitoring, directing, and regulating cognitive processing, metacognition along with motivation and affect is needed. However, the interaction of trait-like person characteristics (at the Person level) with task-specific characteristics and demands as well as with the task-specific cognitive processing at the Task x Person level is not well understood. To be able to delimit how metacognition interacts with motivation and affect, the facets of metacognition need to be pointed out.

METACOGNITION

Metacognition is defined as cognition of cognition; that is, monitoring and control of cognition (Flavell, 1979; Nelson, 1996). It is associated with conscious awareness (but not only; see Efklides, 2008) and regulation of cognition, whereas cognition is functioning mainly at a nonconscious, non-explicit level, as in automatic (or automatized) processing. What makes metacognition particularly important is that it monitors and consciously controls cognition when automatic (or automatized) processing fails. However, metacognition has many different facets and each of them contributes differently to SRL.

Monitoring of cognition is continuous and can be online, synchronous to cognitive processing, or offline based on reflection, observation, and communication with others. One facet of metacognition related to online monitoring is *metacognitive experiences* (ME), and particularly metacognitive feelings, metacognitive judgments/estimates, and online task-specific knowledge (Efklides, 2001, 2006; Flavell, 1979). Metacognitive feelings comprise, among others, feeling of familiarity, difficulty, confidence, and satisfaction. Metacognitive judgments/estimates comprise judgment of learning, estimate of effort expenditure, estimate of time needed or spent, and estimate of solution correctness. Finally, online task-specific knowledge is task information that we are attending to; for example, the words used in a problem and their meaning and/or implications for problem solving as well as ideas or thoughts regarding the task and others similar to it that we are aware of during task processing, such as procedures we are applying (Efklides, 2001, 2006).

Another facet of metacognition is *metacognitive knowledge* (MK) that represents offline monitoring and comprises knowledge, beliefs, or theories about cognition and the persons as cognitive beings; it is not bound to here and now, although it can include information coming from online monitoring, as well. More specifically, MK is declarative knowledge stored in memory (Flavell, 1979) and comprises models of cognitive processes such as language, memory, and so forth (Fabricius & Schwanenflugel, 1994). It also encompasses information regarding persons – the self and the others as cognitive beings; that is, how we or other people process various tasks, how well we do on them, what we felt during processing specific tasks as well as information about tasks, strategies, and goals (Flavell, 1979). More specifically, metacognitive task knowledge involves task categories and their features and relations between tasks as well as the ways they are processed. Metacognitive strategy knowledge involves knowledge of strategies as well as of the conditions for their use – when and how a strategy should be used. Metacognitive goal knowledge, on the other hand, involves knowledge of what types of goals people pursue when dealing with specific tasks. Also, MK is involved in epistemic beliefs (Kitchener, 1983; Kuhn, 2000) – beliefs about knowledge and knowing – and is related to theory of mind (Bartsch & Wellman, 1995; Lockl & Schneider, 2007).

In general, MK, being based on the person's self-awareness as well as on reflection and socially shared theories of cognition (Nelson, Kruglanski, & Jost, 1998), is continuously updated and used to guide the representation and control of cognition at a conscious level. However, unlike ME that function at the Task x Person level, MK in the form of beliefs and theories is functioning at the Person level.

Besides monitoring, metacognition is also involved in the control of cognition. Control of cognition takes two forms. The first regards the deliberate use of cognitive strategies that are initiated, terminated, or sequenced when automatic processing fails (Nelson & Narens, 1994; Reder & Schunn, 1996), whereas the other regards the deliberate regulation of cognition. Deliberate regulation of cognition is based on *metacognitive skills* (Efklides, 2001, 2006; Veenman & Elshout, 1999), another facet of metacognition. Metacognitive skills comprise strategies of orientation, planning, and regulation of cognitive processing and effort as well as strategies for monitoring the execution of planned action and the evaluation of the outcome of task processing (Veenman & Elshout, 1999). They are called in when online monitoring of task processing, namely ME (e.g., feeling of difficulty) denote that conscious control of cognition is needed; MK is then activated along with metacognitive skills (Efklides, Samara, & Petropoulou, 1999) in order to guide the regulation of cognitive processing according to one's goal and the situational characteristics and demands.

Metacognition, Affect, and Motivation

Metacognition is basically a cognitive phenomenon. However, as already mentioned, one of the facets of metacognition – namely ME – can take the form of metacognitive feelings that have a cognitive and experiential character (Koriat & Levy-Sadot, 1999; Efklides, 2006); that is, they provide information about features of the cognitive processing (e.g., fluency) and, at the same time, have a feeling state that can have a positive or negative quality. For example, ease of processing "puts a smile on the face" (Winkielman & Cacioppo, 2001). The affective character of ME can be explained by two feedback loops (see Carver, 2003; Carver & Scheier, 1998; Efklides, 2006). The first one is related to the outcome of cognitive processing and detects the discrepancy from the goal set. Estimate of solution correctness, feeling of confidence, and feeling of satisfaction are outcome-related ME based on this feedback loop (Efklides, 2002a, 2002b). The higher the discrepancy from the goal the more the negative affect experienced. On the contrary, the closer the persons come to their goals the more satisfied they feel; this is a positive affective state (Efklides, 2002b; Efklides & Petkaki, 2005).

The second feedback loop, which is called meta-loop, monitors the *rate* of discrepancy reduction – the rate at which one progresses toward one's goal.

The meta-loop gives rise to affect (positive or negative) and a hazy expectancy about the effect of the rate of progress on one's goal (Carver & Scheier, 1998). Presumably, feeling of difficulty is a processing-related ME that draws from this feedback loop (Efklides, 2002a). Specifically, an indicator of the rate of progress in task processing is fluency. Fluency is a powerful cue for both feeling of knowing and feeling of familiarity (Koriat, 1997, 2007). However, feeling of difficulty denotes lack of processing fluency (Efklides, 2002a), possibly due to task complexity and increased processing demands on working memory resources. Lack of fluency is also due to processing interruption or conflict of response (Touroutoglou & Efklides, 2010; van Veen & Carter, 2002) as well as error detection (Fernandez-Duque, Baird, & Posner, 2000). In all these cases, negative affect arises because error probability increases (see also Efklides & Petkaki, 2005 for association of feeling of difficulty with negative affect).

However, fluency or the lack of it also has implications for outcome-related ME, such as feeling of confidence. For example, if feeling of difficulty is experienced, uncertainty also increases, even if the outcome of processing is objectively correct (Efklides, 2002a, 2002b). In contrast, the person can feel high confidence (overconfidence), even if the outcome of cognitive processing is not correct, just because the response was produced fluently. This is particularly true for cases in which the person is not aware of the task demands and of his/her ignorance (Kruger & Dunning, 1999). In such a case, she/he has the illusion that the task is easy and the response correct (Efklides, 2002a). What needs, therefore, to be stressed is that metacognitive feelings, through their cognitive and affective quality, are making the person aware of qualities of cognitive processing (e.g., interruption of processing, conflict, etc.) as well as about the impact of cognitive processing on the attainment of one's personal goal.

Metacognitive judgments/estimates, on the other hand, are cognitive in nature (Koriat & Levy-Sadot, 1999). They may refer to the probability to learn something (e.g., judgment of learning) that is crucial for the regulation of effort (e.g., study time). They may also refer to one's and others' cognition. For example, one may use normative information to judge the probability to remember something or individualized information regarding one's self or other persons in similar situations (Lories, Dardenne, & Yzerbyt, 1998; Salonen, Vauras, & Efklides, 2005). Social comparison processes or stereotypic knowledge can also be used to make judgments/estimates about one's own or others' cognition (Salonen et al., 2005). Thus, metacognitive judgments are interwined with social cognition and serve not only self-regulation but also co- and other-regulation in peer collaborative learning or teacher/parent regulation of a child's cognitive processing.

Most importantly, people make *attributions about their ability* depending on the negative or positive judgments/estimates they make about their cognition and/or the negative or positive metacognitive feelings they experience (Metallidou & Efklides, 2001). Therefore, awareness of ME does not only provide input and motivation for cognitive and metacognitive control but also for attributions about the self.

Having outlined the facets of metacognition, it is evident that at least at the Task x Person level, metacognition can be related to affect and is crucial for motivation and online self-regulation of cognition and effort. Moreover, ME trigger causal attributions about the outcomes of cognitive processing that have implications for long-term motivation. The relations of cognition, metacognition, affect, and motivation in the process of self-regulation are depicted in the MASRL model.

THE MASRL MODEL

The MASRL model (Efklides, 2011; see Figure 18.1) emphasizes the interaction of two levels of functioning of the person: the *Person level,* comprising person characteristics as traits; and the *Task x Person level*, which comprises cognition as well as affect along with their respective regulatory systems – metacognition and self-regulation of affect. The assumption is that cognitive task processing can be either conscious/analytic or nonconscious/automatic; however, the ME and emotions arising in response to task processing are part of the person's conscious awareness and provide the self-awareness needed for short-term SRL of both cognition and affect. Moreover, ME and affect as well as conscious regulatory activities that function at the Task x Person level contribute to long-term SRL because they feed back onto the Person level, shaping the more stable person characteristics.

The basic tenets of the MASRL model are the following:

1. The task by itself has its own features; namely domain-specificity (in terms of representational and processing demands), complexity, capacity demands, novelty, attractiveness, and so forth. Moreover, it is embedded in a specific situation/context that also contributes to the representation of the task and its demands.
2. The person (Person level) has representation of his/her competences (self-concept), motivational needs, beliefs, and tendencies (e.g., expectancy-value beliefs, achievement goal orientations) as well as attitudes (i.e., affective, cognitive, and behavioral tendencies) and affective dispositions such as interest or emotions as traits. The person

also has domain-specific knowledge, cognitive ability and skills as well as metacognitive knowledge and skills. Moreover, the person has control and agency beliefs related to his/her ability to exert control (i.e., volition).

3. The interaction of the person with the task (Person × Task level) refers to the task-specific cognitive processing and its concomitants. It involves the following constituents: (a) *Cognition* – task and goal representation, cognitive processing, and the outcome of cognitive processing as manifested in cognitive performance; (b) *metacognition* – task-related ME (e.g., feeling of familiarity), processing-related ME (e.g., feeling of difficulty, estimate of effort needed, estimate of time needed), and outcome-related ME (e.g., feeling of confidence, feeling of satisfaction). It also involves metacognitive skills (e.g., planning, use of strategies) called in by ME and MK; (c) affect – one's mood state when entering task processing and emotions related to the task (e.g., interest, anxiety), to the processing of the task (e.g., joy, boredom, anger) as well as to the outcome of task processing (e.g., pride, shame); and (d) *self-regulation of affect and effort*, depending on the ME and emotions experienced.
4. There are also interrelations between the Person and the Task x Person level. Information coming from the online task-specific self-regulation processes feeds back onto the Person level and updates its constituents, and the updated person information influences the subsequent policy decisions and self-regulation at the Task x Person level. Evidence that supports the interrelations of the Person level, particularly of motivation, with the Task x Person level as well as the relations of ME with affect is presented below.

Metacognitive Experiences and Motivation

The effects of cognitive ability on ME have been shown in several of our studies (Dermitzaki & Efklides, 2001; Efklides et al., 1997, 1998 ; Efklides & Tsiora, 2002). This effect is understandable considering that both cognitive ability and ME are related to cognitive processing. What is less predictable is the relation of self-concept with ME (Dermitzaki & Efklides, 2001; Efklides & Tsiora, 2002). The relations of self-concept with ME suggest that monitoring is not simply a reflection of cognitive processing; rather, one's perceived competence and self-efficacy interact with information coming from the monitoring of cognitive processing to guide the self-regulation process. Feeling of difficulty, confidence, and estimate of effort expenditure are ME that are influenced by self-concept (Efklides & Tsiora, 2002). In their turn, ME feed back onto self-concept and trigger attributions about one's competence (Metallidou & Efklides, 2001).

However, the association of ME with self-concept is a complex process because often the person has no analytic awareness of the factors that affect his/her ME. For example, in the case of feeling of difficulty, the factors range from task features (e.g., complexity; see Efklides, 2002a) to cognitive processing features (such as cognitive interruption or response conflict; see Touroutoglou & Efklides, 2010; van Veen & Carter, 2002) and to mood (Efklides & Petkaki, 2005) – for example, negative mood increases the reported feeling of difficulty. Thus, for understanding the source of one's feeling of difficulty, the person has to make inferences based on online task-specific knowledge as well as MK regarding tasks. In all these cases, the person attributes his/her feeling of difficulty to the task or to the situation; thus, attribution to ability is minimized.

Yet, in other cases the person may attribute the source of feeling of difficulty to one's lack of knowledge or skills. This attribution is based on one's self-concept, because self-concept summarizes the person's self-representation of competence as well as self-efficacy in specific domains (Dermitzaki & Efklides, 2000, 2001). When dealing with academic tasks, domain-specific academic self-concept is activated, leading to expectancies of success/failure as well as to attributions about the difficulties to be experienced and the outcome of cognitive processing. Feeling of confidence is directly related to self-efficacy (Bandura, 1986) and in its turn triggers attributions of ability (Metallidou & Efklides, 2001). Estimate of effort also feeds back on the self-concept in the sense that the higher the estimated effort the less the perceived ability (Efklides & Tsiora, 2002; Nicholls, 1984). Thus, self-concept, ME, and attributions are interrelated in a loop that connects metacognition and motivation at the Task x Person level with motivation at the Person level, where the general representation of the self lies. This loop gives coherence and continuity to one's self-regulatory behaviors and is getting updated through intrinsic feedback about one's competence coming from ME (Efklides & Tsiora, 2002; Metallidou & Efklides, 2001) as well as by significant others' external feedback that affects ME (Efklides & Dina, 2004, 2007) and, through them, the self-concept.

Our research on ME and motivation has also shown that students' achievement goal orientations are differentially related to students' ME (Efklides & Dina, 2007). The effects of achievement goal orientations are not on the intensity of ME but on their calibration. Specifically, students with mastery and performance-approach goal orientations have better calibrated ME than students with performance-avoidance goal orientations. Mastery-oriented students seem to closely monitor all their ME, even if ME convey negative information about one's self as feeling of difficulty and estimate of effort do. On the other hand, performance-approach oriented students mainly monitor their outcome-related ME (e.g., estimate of solution correctness, feeling of confidence, and feeling of satisfaction), particularly when negative external feedback is provided. This finding suggests that these students are interested in their performance outcome and use their ME as a basis to evaluate external feedback. On the contrary, performance-avoidance oriented students do not show any calibration of their ME in relation to their performance, indicating that they are unwilling to engage in a self-reflection process or that they base the self-reports of their ME on cues (e.g., social comparison) other than those emanating from the monitoring of cognitive processing and its outcome. This lack of calibration, however, has adverse effects on SRL, because neither effort regulation nor strategy use is adapted to task demands. As we found in another of our studies (Efklides, 2002a; Efklides et al., 1999), students who right from the beginning of task processing turned to others for help did not show any change in their strategy use during problem solving, and their reports of strategy use were not related to their task performance. For students who changed strategy during task processing, however, their reports on strategy use correlated with their task performance. Considering that strategy use was also related to the reported feeling of difficulty, it is evident that the latter students monitored task-processing demands and adapted their strategy use to the demands of task processing.

Taken together, our findings suggest that achievement goal orientations may not directly impact the effort exerted on a task, as Efklides et al. (2006) showed. They can do so, however, indirectly through their impact on the calibration of the monitoring of task processing. Performance-avoidance goals, by driving the person's attention away from task processing, do not allow effective monitoring and control of cognitive processing and therefore undermine SRL and achievement. This issue, however, merits further research because students often have multiple goals as well as emotional dispositions, such as interest, and attitudes toward knowledge domains that have motivational power. Attitudes, for instance, affect ME (Dina & Efklides, 2009) and may lead to differentiation of SRL. If we look at ME in light of these findings, then it is clear that ME are connected to motivation in multiple ways that can be understood if we accept that the Person and the Task x Person levels have their own functioning as well as interrelations between them.

Metacognitive Experiences and Affect

The MASRL model posits that, along with ME, both positive and negative affect and emotions can be experienced in learning situations from the beginning of the learning task to its end. Affect and emotions are not equated to ME because they are triggered by various stimuli that are not necessarily related to features of cognitive processing as it happens with ME. Positive affect can arise from interest as dispositional or situational characteristics (Hidi, 2006), expectancies for successful learning based on self-efficacy beliefs (Bandura, 1986), fluency in cognitive processing (Efklides & Petkaki, 2005), positive feedback on the outcome of cognitive processing (Efklides & Dina, 2004), social interaction (Salonen et al., 2005), or a positive mood state that is independent from the learning situation (e.g., remembering a pleasant event; Efklides & Petkaki, 2005).

How, then, do affect and emotions impact SRL and what are the relations of affect and emotions with ME? Positive affect is a resource (Fredrickson, 2001) that can support SRL through its effect on goal selection as well as on effort and persistence (Ainley, Hidi, & Berndorff, 2002). Positive affect arising during task processing due to fluency of processing or the monitoring of the outcome of task-processing as captured in ME is also input that informs the person on the progress towards one's goal (Carver & Scheier, 1998; Efklides, 2006), thus raising expectations for success (Aspinwall, 1998). Moreover, positive affect interacts with cognition, making the person more willing to take risks, more flexible, and open to creative approaches. Yet, positive affect is also associated with more holistic and less analytic thinking (Kuhl, 2001), and this can have adverse effects on performance in cases that require critical evaluation of the situation or the outcome of one's efforts.

Positive affect also makes the person more willing to accept negative feedback about himself/herself (Trope, Hassin, & Gervey, 2001). With respect to SRL, this finding implies that positive affect filters the impact of ME with negative valence, such as feeling of difficulty, uncertainty, or lack of confidence as well as of corrective external feedback so that these ME and external feedback can be integrated into the self system without threatening one's self-concept. In this way, negative feedback makes self-concept more realistic vis-à-vis learning tasks and outcomes.

Another implication of positive affect for SRL is coasting. Coasting is a by-product of positive affect due to a fast progress toward one's goal (Carver & Scheier, 1998). Coasting entails that the person engages in activities not directly related to one's goal. This is helpful because it broadens one's interests and perspectives but has the risk for the student to give up the main goal, particularly if coasting starts early, before the student accomplishes his/her main goal. One condition that can foster coasting is when the student is ill-informed by his/her ME – for example, overconfidence that decreases effort although the task is demanding. In such cases, coasting increases potential distracters and endangers the learning process.

All of the above considerations make clear that bringing metacognition and affect at the forefront of the Task x Person level and in immediate connection with cognition can accommodate findings that refer to a direct relationship of cognition with metacognition and affect – with each one of them separately. It can also allow testing of hypotheses regarding mediational effects of ME in the relation of affect with cognition as well as of cognition and affect with person characteristics, functioning at a more general level. For example, as Touroutoglou and Efklides (2010) found, the same underlying feature of task processing (e.g., cognitive interruption) leads to the formation of ME (e.g., feeling of difficulty) and emotions (e.g., surprise). On the other hand, one may expect to do well on a task when she/he starts task processing and this expectation triggers positive affect; if later on, during cognitive processing, she/he feels difficulty, then this feeling might trigger an emotion such as surprise, anger, and so forth. The same can happen when starting task processing with negative affect ends up with less than expected difficulty and a successful outcome of processing; then, an emotion such as joy is triggered. In such cases, ME provide the cues for the change of affect.

On the other hand, negative affect can be due to situational characteristics that give rise to fear, anxiety, boredom, anger (Pekrun et al., 2006); ME regarding task processing and/or its outcome such as lack of fluency or undesired outcomes (e.g., feeling of difficulty, high estimate of effort, low feeling of confidence); low expectations for success because of a negative self-concept (Bandura, 1986) as well as social rejection (Hubbard, 2001); negative external feedback that affects ME and through them state anxiety (Dina & Efklides, 2009); and factors unrelated to the learning task or situation. Negative affect constrains students' self-regulation efforts because it turns their attention to potentially harmful stimuli or undesirable outcomes and away from task features that can facilitate processing (Ellis et al., 1997). It also lowers expectations for performance (Cervone et al., 1994) and reduces effort and persistence, thus facilitating disengagement and goal abandonment (Carver, 2003).

Despite its potential threats for self-regulation, negative affect is associated with more critical, analytic, and systematic processing that can be beneficial for performance depending on task requirements (Kuhl, 2001). Moreover, negative affect can be beneficial for self-regulation if it focuses the person's attention on the task (e.g., monitoring of solution correctness) rather than on emotional stimuli (Basso, Schefft, & Hoffmann, 1994; Martin & Davies, 1998). These findings imply that the effects of affect on cognition can be direct (e.g., triggering analytic or holistic processing) or indirect via ME and the cognitive regulatory loop. Increased negative mood, for example, increases feeling of difficulty (Efklides & Petkaki, 2005) and, through it, the control decisions – namely, change of strategy use (Efklides et al., 1999). If the strategy is successful, then positive affect is experienced, thus changing the person's mood state. An alternative route could be the following: one starts cognitive processing with negative mood, the negative mood triggers analytic processing, and engagement with the task is leading to mood absorption (Erber & Erber, 1994). This change of mood state may then impact the intensity of feeling of difficulty. Which of the two patterns of interaction of affect with cognition, and under what conditions, is actually taking place has to be determined by future research.

Nevertheless, the dynamic interplay between positive and negative affect is important for understanding the interrelations of cognition and metacognition with affect in SRL, rather than the positive or negative affect by themselves. This dynamic interplay is also evident in ME; for example, a student may start with negative mood when processing a task, but as she/he is getting involved in it and processing is fluent, positive affect is restored (Efklides & Petkaki, 2005). Moreover, progressing toward the goal makes the student more confident and willing to get engaged in similar tasks again. Therefore, the change of ME and the affect that goes with them can have an impact on cognitive processing as well as on SRL because a change from negative to positive affect can reinforce the activities that brought about that change. Moreover, a change toward positive affect can moderate the impact of ME on the self-concept, directing the control decisions in a self-congruent way. Depending on a student's affective state, feedback from ME can be integrated to the self system and guide the control processes efficiently or aggravate the student's already negative affect and lead to disengagement from the task or maladaptive SRL (Efklides & Dina, 2007).

On the other hand, the person can self-regulate his/her affective state based on the awareness of his/her ME and emotions. Such self-regulation of affect can be successful or unsuccessful. This might have implications for both cognition and metacognition. For example, if students experience difficulty and make negative self-evaluations for their academic competence based on attributions of lack of ability but at the same time they value school achievement (Paris, 2002), then negative affect and self-focus increase, particularly in ruminative and depressed individuals as well as in females (Mor & Winquist, 2002); this decreases the efficiency of SRL. Social rejection can also lead to negative affect and negative self-evaluations (Rudolph, Caldwell, & Conley, 2005), possibly aggravating mood, and through it, ME regarding task processing. Emotional distress then leads to decreased perceptions of competence over time (Pomerantz & Rudolph, 2003) and devaluation of academic learning (Jacobs et al., 2002). Negative self-concept and ME then strengthen avoidance goals, making students unwilling to reflect on their ME and integrate feedback from them in SRL (Efklides & Dina, 2007).

Summing up the relations of metacognitive experiences, affect, and SRL, it becomes clear that metacognition informs and is informed not only by cognition but by affect and self-concept. Because of the relations of ME with affect and self-concept, metacognition can impact students' performance and well-being both in the short- and long-term. A positive outcome in the interplay of positive-negative affect is a condition for successful SRL.

TOWARD A BROADER CONCEPTUALIZATION OF METACOGNITION

Placing ME and metacognition, in general, in the service of self-regulation, co-regulation, or other-regulation of learning makes it obvious that their role is much broader than the usual conceptions of metacognition admit. In what follows, an overview of what metacognition can (or cannot) do in the context of SRL is presented.

The role of Metacognition in SRL

(a) Metacognition is instrumental for *self-representation and self-awareness* vis-à-vis reality, the object world (e.g., cognition), and the other persons as agents and carriers of mental states that may differ from our own (see also Bartsch & Wellman, 1995);
(b) it is crucial for *awareness of knowledge states and their constraints* offering the substratum for epistemological thinking, rational knowledge, and the negotiation of knowledge at a social level (Kuhn, 2000; Newell, 1990);
(c) it supports *conscious and analytic knowledge and skills acquisition* when there is no previous knowledge or the automatic (or automatized) routines need to be decomposed in order to be reorganized and sequenced in a novel way (Paris, 2002);
(d) it facilitates *trouble-shooting* when controlled action is needed to restore a failed system or course of action (Paris, 2002);
(e) it provides the subjective basis for self-regulation of online *cognitive processing*, *effort*, and *affect* so that there is efficient use of resources (affective, cognitive, social, time, etc.) for goal attainment. Judgment of learning and study time (Dunlosky & Nelson, 1992) is such an example as well as feeling of difficulty (Efklides et al., 2006);
(f) it is necessary for *co-regulation and other-regulation of cognition* in cases in which people have to monitor their own as well as the other

person's thinking in order to control their joint action (Iiskala, Vauras, & Lehtinen, 2004; Salonen et al., 2005). It is even more important for learning, both in school and family, because teachers, peers, and parents monitor students' thinking and affect – as observed in students' behavior and ME – and the feedback they provide is based on this monitoring and/or on their own MK of what might be the factors that could have impacted students' thinking and affect.

The Effectiveness of Metacognition in SRL

Being part of the self-regulation, co-regulation, and other-regulation system does not entail that metacognition is always effective in guiding the regulation process. As we have already mentioned, metacognition can be flawed (e.g., illusions of familiarity, knowing, understanding, difficulty) and can be inaccurate or deficient as regards MK and MS. As a consequence, people can make faulty control decisions or inefficient strategy use. Moreover, metacognition in the form of MK and ME may have no impact on cognition if there is no connection to and triggering of control processes. This may happen, for example, in thinking-aloud situations or post hoc conjectures about thinking processes of which we were not aware during task processing or when involved in wishful thinking (Paris, 2002).

The Interaction of Metacognition with Person Characteristics and Affect

The interaction of metacognition with self-concept, motivation, and affect is often overlooked. However, because of this interaction, SRL can be in congruence with one's self as the MASRL model depicts. Moreover, because affect has its own functioning and regulation, there can be a crossover of the metacognitive control (i.e., the cognitive regulatory loop) to the affective control (i.e., affective regulatory loop), and vice versa. The conditions that promote this crossover and when this crossover is effective for SRL are not yet studied.

Metacognition in Collaborative Learning

In the co-regulation of cognition in collaborative learning situations, the representation of the other person's cognition and affect is based on attributions and extrapolations that emanate from one's own ME and MK. This entails that the feedback provided to the other person may (or may not) correspond to what the other person is actually thinking, feeling, and doing, and may (or may not) lead to successful control decisions at the individual or interpersonal level. The situation becomes even more complicated if interpersonal relations and dynamics enter the co-regulation process (Salonen et al., 2005), particularly because emotions are also triggered by situational characteristics and ME as well as by the others' responses (e.g., feedback) to our learning outcomes (Dina & Efklides, 2009). Consequently, the co-regulation of learning cannot be successful if metacognition makes use of only the cognitive regulatory loop; it should be orchestrated with affect and regulation of affect.

CONCLUSION

In this chapter, the relations of metacognition with motivation and affect in the context of SRL were pointed out. The MASRL model was the theoretical framework that allowed the delimitation of interrelations between these components of SRL. Moreover, self-regulation, co-regulation, or other-regulation is a dynamic process, and understanding it is a challenge for future research. By focusing on ME and their relations with person characteristics on the one hand and affect at the Task x Person level on the other, a link between ME and both the short- and long-term SRL was established. Motivation, self-concept, and affect at the Person level can have an impact on ME, and ME on them, thus enhancing (or impeding) students' SRL. Moreover, the interplay between affect (positive or negative), cognition, and metacognition at the Task x Person level is important for efficient online self-regulation. More research is needed in order to reveal whether metacognition exerts a direct effect on affect and motivation or mediates the relations of cognition with affect and motivation. Also, research is needed in order to understand the potential role of ME, through self-awareness, to the functioning of the affective regulatory loop.

The MASRL model entails that all students, successful or not, self-regulate their learning continuously but do it differently, because they pursue different goals, have different ME, and use different regulatory strategies that lead to different learning outcomes. An implicit assumption in SRL theory is that SRL leads to successful learning outcomes because students autonomously select their learning goals and strategies, enjoy learning activities, and take pride in their achievements (Ryan & Deci, 2000). This assumption, however, cannot be generalized to all students, because not all students self-regulate successfully, nor all learning outcomes – even successful ones – give joy and pride, as research on attribution theory has shown (Weiner, 1985). Anxiety, shame, and boredom can be experienced as well as joy and pride, depending on how (e.g., with how much effort) success was achieved and to what it was attributed (Nicholls, 1984; Pekrun et al., 2006). Metacognition is a crucial constituent of this process because ME provide the intrinsic feedback that the person is using during self-reflection and self-evaluation. Intrinsic feedback through ME can be congruent or incongruent, with external feedback coming from others. The interaction of ME with external feedback (e.g., Dina & Efklides, 2009) is a field that merits further research if we are to understand the development of self-regulation/co-regulation/other-regulation of learning. Finally, the interaction of ME with affect can provide a theoretical basis for describing different patterns of SRL so that more targeted and differentiated interventions can be undertaken to change ineffective SRL.

References

Ainley, M., Hidi, S., & Berndorff, D. (2002). Interest, learning, and the psychological processes that mediate their relationship. *Journal of Educational Psychology*, **94**, 545–561.

Aspinwall, L. G. (1998). Rethinking the role of positive affect in self-regulation. *Motivation and Emotion*, **22**, 1–31.

Bandura, A. (1986). *Social foundations of thought and action: A social cognitive theory*. Englewood Cliffs, NJ: Prentice-Hall.

Bandura, A., Caprara, G. V., Barbaranelli, C., Gerbino, M., & Pastorelli, C. (2003). Role of affective self-regulatory efficacy in diverse spheres of psychosocial functioning. *Child Development*, **74**, 769–782.

Bartsch, K., & Wellman, H. M. (1995). *Children talk about the mind*. New York: Oxford University Press.

Basso, M. R., Schefft, B. K., & Hoffmann, R. G. (1994). Mood-moderating effects of affect intensity on cognition: Sometimes euphoria is not beneficial and dysphoria is not detrimental. *Journal of Personality and Social Psychology*, **66**, 363–368.

Boekaerts, M. (1999). Self-regulated learning: Where we are today. *International Journal of Educational Research*, **31**, 445–457.

Brehm, J. W., & Self, E. A. (1989). The intensity of motivation. *Annual Review of Psychology*, **40**, 109–131.

Byrne, B. M. (1996). *Measuring self-concept across the life span: Issues and instrumentation*. Washington, DC: American Psychological Association.

Carver, C. S. (2003). Pleasure as a sign you can attend to something else: Placing positive feelings within a general model of affect. *Cognition and Emotion*, **17**, 241–261.

Carver, C. S., & Scheier, M. F. (1998). *On the self-regulation of behavior*. Cambridge, UK: Cambridge University Press.

Cervone, D., Kopp, D. A., Schaumann, L., & Scott, W. D. (1994). Mood, self-efficacy, and performance standards: Lower moods induce higher standards for performance. *Journal of Personality and Social Psychology*, **67**, 499–512.

Dermitzaki, I., & Efklides, A. (2000). Aspects of self-concept and their relationship with language performance and verbal reasoning ability. *American Journal of Psychology*, **113***(4)*, 643–659.

(2001). Age and gender effects on students' evaluations regarding the self and task-related experiences in mathematics. In S. Volet & S. Jarvela (Eds.), *Motivation in learning contexts: Conceptual advances and methodological implications* (pp. 271–293). Amsterdam: Elsevier.

Dina, F., & Efklides, A. (2009). Metacognitive experiences as the link between situational characteristics, motivation, and affect in self-regulated learning. In M. Wosnitza, S. A. Karabenick, A. Efklides, & P. Nenniger (Eds.), *Contemporary motivation research: From global to local perspectives* (pp. 117–146). Goettingen, Germany: Hogrefe & Huber.

Dunlosky, J., & Nelson, T. O. (1992). Importance of the kind of cue for judgments of learning (JOLs) and the delayed-JOL effect. *Memory and Cognition*, **20**, 373–380.

Efklides, A. (2001). Metacognitive experiences in problem solving: Metacognition, motivation, and self-regulation. In A. Efklides, J. Kuhl, & R. M. Sorrentino (Eds.), *Trends and prospects in motivation research* (pp. 297–323). Dordrecht, The Netherlands: Kluwer.

(2002a). Feelings as subjective evaluations of cognitive processing: How reliable are they? *Psychology: The Journal of the Hellenic Psychological Society*, **9**, 163–184.

(2002b). The systemic nature of metacognitive experiences: Feelings, judgments, and their interrelations. In M. Izaute, P. Chambres, & P.-J. Marescaux (Eds.), *Metacognition: Process, function, and use* (pp. 19–34). Dordrecht, The Netherlands: Kluwer.

(2006). Metacognition and affect: What can metacognitive experiences tell us about the learning process? *Educational Research Review*, **1**, 3–14.

(2007). Effort and its conceptualization: Task difficulty, capacity, allocation policy, and regulation. In P. Kordoutis, Z. Papaligoura, & E. Masoura (Eds.), *Scientific Annals of the Faculty of Philosophy, School of Psychology, Aristotle University of Thessaloniki* (Vol. 7, pp. 325–353). Thessaloniki, Greece: Aristotle University Press/Art of Text.

(2008). Metacognition: Defining its facets and levels of functioning in relation to self- and co-regulation. *European Psychologist*, **13**, 277–287.

(2011). Interactions of metacognition with motivation and affect in self-regulated learning: The MASRL model. *Educational Psychologist*, **46***(1)*, 6–25.

Efklides, A., & Dina, F. (2004). Feedback from one's self and from the others: Their effect on affect. *Hellenic Journal of Psychology*, **1**, 179–202.

(2007). Is mastery orientation always beneficial for learning? In F. Salili & R. Hoosain (Eds.), *Culture, motivation and learning: A multicultural perspective* (pp. 131–167). Greenwich, CT: Information Age Publishing.

Efklides, A., Kourkoulou, A., Mitsiou, F., & Ziliaskopoulou, D. (2006). Effort regulation, effort perceptions, mood, and metacognitive experiences: What determines the estimate of effort expenditure? *Metacognition and Learning*, **1**, 33–49.

Efklides, A., Papadaki, M., Papantoniou, G., & Kiosseoglou, G. (1997). The effects of cognitive ability and affect on school mathematics performance and feelings of difficulty. *American Journal of Psychology*, **110***(2)*, 225–258.

(1998). Individual differences in feelings of difficulty: The case of school mathematics. *European Journal of Psychology of Education*, **XIII***(2)*, 207–226.

Efklides, A., & Petkaki, C. (2005). Effects of mood on students' metacognitive experiences. *Learning and Instruction*, **15**, 415–431.

Efklides, A., Samara, A., & Petropoulou, M. (1999). Feeling of difficulty: An aspect of monitoring that influences control. *European Journal of Psychology of Education*, **XIV***(4)*, 461–476.

Efklides, A., & Tsiora, A. (2002). Metacognitive experiences, self-concept, and self-regulation. *Psychologia: An International Journal of Psychology in the Orient*, **45**, 222–236.

Ellis, H. C., Ottaway, S. A., Varner, L. L., Becker, A. S., & Moore, B. A. (1997). Emotion, motivation, and text comprehension: The detection of contradictions in passages. *Journal of Experimental Psychology: General*, **126**, 131–146.

Erber, R., & Erber, W. M. (1994). Beyond mood and social judgment: Mood incongruent recall and mood regulation. *European Journal of Social Psychology*, **24**, 79–88.

Fabricius, W. V., & Schwanenflugel, P. J. (1994). The older child's theory of mind. In A. Demetriou & A. Efklides (Eds.), *Intelligence, mind, and reasoning Structure and development* (pp. 111–132). Amsterdam: Elsevier.

Fernandez-Duque, D., Baird, J. A., & Posner, M. I. (2000). Executive attention and metacognitive regulation. *Consciousness and Cognition*, **9**, 288–307.

Flavell, J. H. (1979). Metacognition and cognitive monitoring: A new area of cognitive developmental inquiry. *American Psychologist*, **34**, 906–911.

Fredrickson, B. L. (2001). The role of positive emotions in positive psychology. *American Psychologist*, **56**, 218–226.

Gendolla, G. H. E., & Brinkmann, K. (2005). The role of mood states in self-regulation: Effects on action preferences and resource mobilization. *European Psychologist*, **10**, 187–198.

Harter, S. (1986). Processes underlying the formation, maintenance, and enhancement of the self-concept. In J. Suls & A. Greenwald (Eds.), *Psychological perspectives on the self* (Vol. 3, pp. 137–181). New York: Wiley.

Hidi, S. (2006). Interest: A unique motivational variable. *Educational Research Review*, **1**, 69–82.

Hidi, S., & Renninger, A. K. (2006). The four-phase model of interest development. *Educational Psychologist*, **41***(2)*, 111–127.

Hubbard, J. A. (2001). Emotion expression processes in children's peer interaction: The role of peer rejection, aggression, and gender. *Child Development*, **72**, 1426–1438.

Iiskala, T., Vauras, M., & Lehtinen, E. (2004). Socially-shared metacognition in peer learning? *Hellenic Journal of Psychology*, **1**, 147–178.

Jacobs, J. E., Lanza, S., Osgood, W. D., Eccles, J. S., & Wigfield, A. (2002). Changes in children's self-competence and values: Gender and domain differences across Grades one to twelve. *Child Development*, **73**, 509–527.

Kahneman, D. (1973). *Attention and effort.* Englewood Cliffs, NJ: Prentice-Hall.

Kitchener, K. S. (1983). Cognition, metacognition, and epistemic cognition: A three-level model of cognitive processing. *Human Development*, **26**, 222–232.

Koriat, A. (1997). Monitoring one's own knowledge during study: A cue-utilization approach to judgments of learning. *Journal of Experimental Psychology: General*, **126**, 349–370.

(2007). Metacognition and consciousness. In P. D. Zelazo, M. Moscovitch, & E. Thompson (Eds.), *The Cambridge handbook of consciousness* (pp. 289–325). Cambridge, UK: Cambridge University Press.

Koriat, A., & Levy-Sadot, R. (1999). Processes underlying metacognitive judgments: Information-based and experience-based monitoring of one's own knowledge. In S. Chaiken & Y. Trope (Eds.), *Dual-process theories in social psychology* (pp. 483–502). New York: Guilford.

Kruger, J., & Dunning, D. (1999). Unskilled and unaware of it: How difficulties in recognizing one's own incompetencies lead to inflated self-assessments. *Journal of Personality and Social Psychology*, *77(6)*, 121–134.

Kuhl, J. (1985). Volitional mediators of cognitive behavior consistency: Self-regulatory processes and action versus state orientation. In J. Kuhl & J. Beckman (Eds.), *Action control* (pp. 101–128). New York: Springer.

(2001). A functional approach to motivation: The role of goal enactment and self-regulation in current research on approach and avoidance. In A. Efklides, J. Kuhl, & R. M. Sorrentino (Eds.), *Trends and prospects in motivation research* (pp. 239–268). Dordrecht, The Netherlands: Kluwer.

Kuhl, J., & Fuhrmann, A. (1998). Decomposing self-regulation and self-control: The Volitional Component Inventory. In J. Heckhausen & C. S. Dweck (Eds.), *Motivation and self-regulation across life span* (pp. 15–49). Cambridge, UK: Cambridge University Press.

Kuhn, D. (2000). Theory of mind, metacognition, and reasoning: A life-span perspective. In P. Mitchell & K. J. Riggs (Eds.), *Children's reasoning and the mind* (pp. 301–326). Hove, UK: Psychology Press.

Lockl, K., & Schneider, W. (2007). Knowledge about the mind: Links between theory of mind and later metamemory. *Child Development*, **78**, 148–167.

Lories, G., Dardenne, B., & Yzerbyt, V. Y. (1998). From social cognition to metacognition. In V. Y. Yzerbyt, G. Lories, & B. Dardenne (Eds.), *Metacognition: Cognitive and social dimensions* (pp. 1–15). London: Sage.

Martin, L. L., & Davies, B. (1998). Beyond hedonism and associationism: A configural view of the role of affect in evaluation, processing, and self-regulation. *Motivation and Emotion*, **22**, 33–51.

Metallidou, P., & Efklides, A. (2001). The effects of general success-related beliefs and specific metacognitive experiences on causal attributions. In A. Efklides, J. Kuhl, & R. M. Sorrentino (Eds.), *Trends and prospects in motivation research* (pp. 325–347). Dordrecht, The Netherlands: Kluwer.

Mor, N., & Winquist, J. (2002). Self-focused attention and negative affect: A meta-analysis. *Psychological Bulletin*, **128**, 638–662.

Nelson, T. O. (1996). Consciousness and metacognition. *American Psychologist*, **51**, 102–116.

Nelson, T. O., Kruglanski, A. W., & Jost, J. T. (1998). Knowing thyself and others: Progress in metacognitive social psychology. In V. Y. Yzerbyt, G. Lories, & B. Dardenne (Eds.), *Metacognition: Cognitive and social dimensions* (pp. 69–89). London: Sage.

Nelson, T. O., & Narens, L. (1994). Why investigate metacognition? In J. Metcalfe & A. Shimamura (Eds.), *Metacognition: Knowing about knowing* (pp. 1–25). Cambridge, MA: The MIT Press.

Newell, A. (1990). *Unified theories of cognition*. Cambridge, MA: Harvard University Press.

Nicholls, J. G. (1984). Achievement motivation: Conceptions of ability, subjective experience, task choice, and performance. *Psychological Review*, **91**, 328–346.

Paris, S. G. (2002). When is metacognition helpful, debilitating, or benign? In M. Izaute, P. Chambres, & P.-J. Marescaux (Eds.), *Metacognition: Process, function, and use* (pp. 105–120). Dordrecht, The Netherlands: Kluwer.

Paris, S. G., & Paris, A. H. (2001). Classroom applications of research on self-regulated learning. *Educational Psychologist*, **36***(2)*, 89–101.

Pekrun, R., Elliot, A. J., & Maier, M. A. (2006). Achievement goals and discrete achievement emotions: A theoretical model and prospective test. *Journal of Educational Psychology*, **98**, 583–597.

Pekrun, R., Goetz, T., Titz, W., & Perry, R. P. (2002). Academic emotions in students' self-regulated learning and achievement: A program of qualitative and quantitative research. *Educational Psychologist*, **37**, 91–105.

Pomerantz, E. M., & Rudolph, K. D. (2003). What ensues from emotional distress? Implications for competence estimation. *Child Development*, **74**, 329–345.

Reder, L. M., & Schunn, C. D. (1996). Metacognition does not apply: Strategy choice is governed by implicit learning and memory. In L. M. Reder (Ed.), *Implicit memory and metacognition* (pp. 45–78). Hillsdale, NJ: Erlbaum.

Renninger, K. A., Sansone, C., & Smith, J. L. (2004). Love of learning. In C. Peterson & M. E. P. Seligman (Eds.), *Character strengths and virtues: A handbook and classification* (pp. 161–179). Washington, DC: American Psychological Association.

Rudolph, K. D., Caldwell, M. S., & Conley, C. S. (2005). Need for approval and children's well-being. *Child Development*, **76**, 309–323.

Ryan, R. M., & Deci, E. L. (2000). Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being. *American Psychologist*, **55**, 68–78.

Salonen, P., Vauras, M., & Efklides, A. (2005). Social interaction: What can it tell us about metacognition and co-regulation in learning? *European Psychologist*, **10**, 199–208.

Sansone, C., & Thoman, D. B. (2005). Interest as the missing motivator in self-regulation. *European Psychologist*, **10**, 175–186.

Skinner, E. A. (1995). *Perceived control, motivation, and coping*. Thousand Oaks, CA: Sage.

Spielberger, C. D. (1980). *Manual for the State-Trait Anxiety Inventory*. Palo Alto, CA: Consulting Psychologists Press.

Thrash, T. M., & Elliot, A. J. (2001). Delimiting and integrating achievement motive and goal constructs. In A. Efklides, J. Kuhl, & R. M. Sorrentino (Eds.), *Trends and prospects in motivation research* (pp. 3–21). Dordrecht, The Netherlands: Kluwer.

Touroutoglou, A., & Efklides, A. (2010). Cognitive interruption as an object of metacognitive monitoring: Feeling of difficulty and surprise. In A. Efklides & P. Misailidi (Eds.), *Trends and prospects in metacognition research* (pp. 171–208). New York: Springer.

Trope, Y., Hassin, R., & Gervey, B. (2001). Overcoming defensive feedback seeking. In A. Efklides, J. Kuhl, & R. M. Sorrentino (Eds.), *Trends and prospects in motivation research* (pp. 207–220). Dordrecht, The Netherlands: Kluwer.

van Veen, V., & Carter, C. S. (2002). The timing of action-monitoring process in the anterior cingulate cortex. *Journal of Cognitive Neuroscience*, **14***(4)*, 593–602.

Veenman, M. V. J., & Elshout, J. J. (1999). Changes in the relation between cognitive and metacognitive skills during the acquisition of expertise. *European Journal of Psychology of Education*, **XIV**, 509–523.

Weiner, B. (1985). *Human motivation*. New York: Springer.

Wigfield, A., & Eccles, J. S. (2000). Expectancy-value theory of achievement motivation. *Contemporary Educational Psychology*, **25**, 68–81.

Winkielman, P., & Cacioppo, J. T. (2001). Mind at ease puts a smile on the face: Psychophysiological evidence that processing facilitation leads to positive affect. *Journal of Personality and Social Psychology*, **81**, 989–1000.

Winne, P. H. (2004). Students' calibration of knowledge and learning processes: Implications for designing powerful software learning environments. *Educational Research*, **41**, 466–488.

Zimmerman, B. J. (1998). Developing self-fulfilling cycles of academic regulation: An analysis of exemplary instructional models. In D. H. Schunk & B. J. Zimmerman (Eds.), *Self-regulated learning: From teaching to self-reflective practice* (pp. 1–19). New York: Guilford.

19

Motivation in Language

Klaus-Uwe Panther

Introduction

Whether natural language is *motivated* by extralinguistic (e.g., cognitive) factors has been a controversial topic since antiquity; it is much older than the emergence of linguistics as a scientific discipline in the nineteenth century. In Plato's dialogue *Cratylus*, Socrates is asked by Hermogenes and Cratylus to act as an umpire on the problem of "truth" or "correctness" in "names", where the last category is rather vague, including proper names, common names, and adjectives (Sedley, 2003, p. 4). Cratylus's position is usually referred to as "naturalism", in contrast to Hermogenes's "conventionalism" (Sedley, 2003, p. 4). Hermogenes describes Cratylus's view, as opposed to his own, in the following terms:

> I should explain to you, Socrates, that our friend Cratylus has been arguing about names; he says that they are natural and not conventional; not a portion of the human voice which men agree to use; but that there is a truth or correctness in them, which is the same for Hellenes as for barbarians.... I have often talked over this matter, both with Cratylus and others, and cannot convince myself that there is any principle of correctness in names other than convention and agreement. (Hamilton & Cairns, 1961, p. 422)

In modern linguistic terminology, the apparently opposing conceptions of the nature of linguistic signs can be rephrased as follows: Naturalists maintain that the relation between the form of linguistic signs and their content is motivated, whereas conventionalists contend that this relation is purely conventional and arbitrary.[1]

The term "arbitrary" as a property of linguistic signs was probably first coined, or at least widely spread, by the Swiss linguist Ferdinand de Saussure, who is credited with being the founder of structuralist linguistics in Europe. Saussure regards the linguistic sign as a mental entity (*entité psychique*) linking a content (*signifié* or "signified") with an "acoustic image" (*signifiant* or "signifier") (Saussure, 1995, p. 99). The relation between signifier (form) and signified (content) is considered to be arbitrary (ibid., p. 100). The term *arbitraire* is somewhat misleading because it suggests that language users are free to select any signifier for any signified they intend to express. What Saussure really has in mind can be illustrated with a simple example from his *Cours de linguistique générale*: the association of the content "female sibling" with the linguistic form *sœur* is a convention of the French language, just as it is an arbitrary convention to express the same concept as "sister" in English and *sorella* in Italian. The term "arbitrary" (*arbitraire)* is thus understood as the opposite of "motivated" (*motivé).*

The principle of arbitrariness is certainly part and parcel of Saussure's semiotic theory, but it does not represent everything that the Swiss linguist had to say about the nature of linguistic signs. Importantly, Saussure differentiates explicitly between various degrees of arbitrariness/motivation. That is, he recognizes that language can and even must be "relatively motivated":

> *Le principe fondamental de l'arbitraire du signe n'empêche pas de distinguer dans chaque langue ce qui est radicalement arbitraire, c'est-à-dire immotivé, de ce qui ne l'est que relativement. Une partie seulement des signes est absolument arbitraire; chez d'autres intervient un phénomène qui permet de reconnaître des degrés dans l'arbitraire sans le supprimer : le signe peut être relativement motivé.* (Saussure, 1995, pp. 181–182)

Which translated means: "The fundamental principle of the arbitrariness of the sign does not prevent our singling out in each language what is radically arbitrary, i.e., unmotivated, and what is only relatively arbitrary. Some signs are absolutely arbitrary: in others we note, not its complete absence, but the presence of degrees of arbitrariness: the sign may be relatively motivated" (Saussure, 1968, p. 131; translated by Wade Baskin).

Saussure realizes that the notion of (relative) motivation is relevant in the formal and conceptual analysis of complex linguistic expressions (see Radden & Panther, 2004, pp. 1–2). He observes, for example, that the French words for the cardinal numbers "ten" and "nine" – *dix* and *neuf*, respectively – are both arbitrary and conventional. Furthermore, the French language conventionally codes the number concept "nineteen" as *dix-neuf* (literally, "ten-nine"). In German, the same concept is expressed as *neunzehn* (literally, "nine-ten"). Although it is not predictable from the concept nineteen how it should be coded in natural language, both codings – ten-nine and nine-ten – are motivated. *Dix-neuf* and *neunzehn* are thus partially arbitrary, because the individual words in the compound expression are arbitrary; but they are

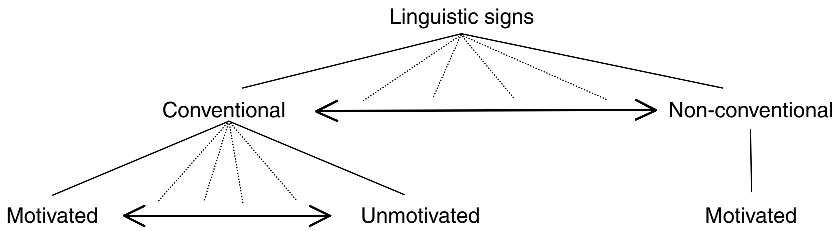

FIGURE 19.1. The conventionality and motivation scales (adapted from Panther, 2008, p. 8).

also partially motivated because it is "natural" to represent the concept nineteen by means of the concatenation of the words for nine and ten. Finally, there is again some language-specific arbitrariness in how the elementary meaning-bearing building blocks (morphemes) nine and ten are ordered. French chooses the order double digit + single digit, whereas German selects the reverse order. This example demonstrates that there exist degrees of arbitrariness/motivation (i.e., the contrast between arbitrariness and motivation is polar, rather than binary).

In this chapter, I take a theoretical perspective that integrates Saussure's insights with an aim to demonstrate that grammatical structure is (relatively) motivated. In what follows, I assume that linguistic signs are distinguished along two dimensions: conventionality and motivation. Conventional signs (simple and complex) range from unmotivated to motivated, but non-conventionally used signs must always be motivated to some extent; otherwise they would be uninterpretable. Figure 19.1 diagrams the relationship between motivation and conventionality.

The assumption that grammar is motivated is called into question in formalist theories of language (e.g., generative grammar). In this framework, it is commonly held that grammatical generalizations are purely formal; they are not shaped in any way by conceptual content, communicative function, economy of coding, and so forth (see Borsley & Newmeyer, 2009; Newmeyer, 1983, 2000).[2] However, functionalist and cognitive linguists have accumulated an impressive array of data in support of the claim that grammar is at least partially motivated. Nevertheless, some principled explanation must be given why, as Saussure already observed, not every grammatical structure is motivated. In the conclusion to this chapter, an attempt is made to provide a provisional solution to this problem.

The remainder of this chapter is organized as follows: A working definition of motivation is proposed, followed by an interlude about the theoretical status of motivation as an explanatory concept in linguistics. The section concludes with a brief characterization of extralinguistic factors that arguably have an impact on the form and/or content of linguistic signs. Next, I consider basic semiotic relations and language-independent parameters that constitute motivating factors. Then, a classical example of a motivated relation between content and form (iconicity) is presented. The section that constitutes the core of this chapter is concerned with motivation in grammar. I focus on a typical phenomenon of English, the meaning and distribution of question tags, showing that these tags are sanctioned and constrained by a variety of language-independent factors. The final section reflects on why grammar is not fully but only partially motivated.

MOTIVATION IN CONTEMPORARY LINGUISTICS

The notion of linguistic motivation assumed in this chapter is based on the one proposed in Radden and Panther (2004, p. 4) and Panther (2008, p. 6):

(1) i. Motivation is an unidirectional relation between a *linguistic source* and a *linguistic target*.
ii. A linguistic target is motivated if and only if at least some its properties are caused by the linguistic source, i.e. its form and/or content) and *language-independent factors* (see also Heine, 1997, p. 3).

Henceforth, I use the terms "form" and "content" instead of Saussure's terms "signifier" and "signified," respectively. I understand "content" in a rather broad sense as covering both conceptual (semantic) content and pragmatic (communicative) function. The term "form" is, for my purposes, a convenient blend of components that are usually kept apart in linguistics: syntax (i.e., rules and principles of sentence construction), morphology (i.e., the syntax of words), and phonology (i.e., sound and prosodic structure).[3] The semiotic relation between content and form can be diagrammed as in Figure 19.2.

The term "language-independent factors" in (1ii) is meant to express the assumption that the kinds of motivating forces that shape linguistic signs are found not only in language but in other semiotic and communicative systems such as gestures, traffic signs, the visual arts, and so forth, as well. In this sense, these motivating factors are not specifically linguistic, and might be called *translinguistic*. Such translinguistic motivational parameters include perceptual factors, such as iconicity, economy of coding, and cognitive factors, such as creative thinking, reasoning (e.g., conceptual metaphor, metonymy, and non-monotonic inferencing) (see Radden & Panther, 2004 for extensive discussion).

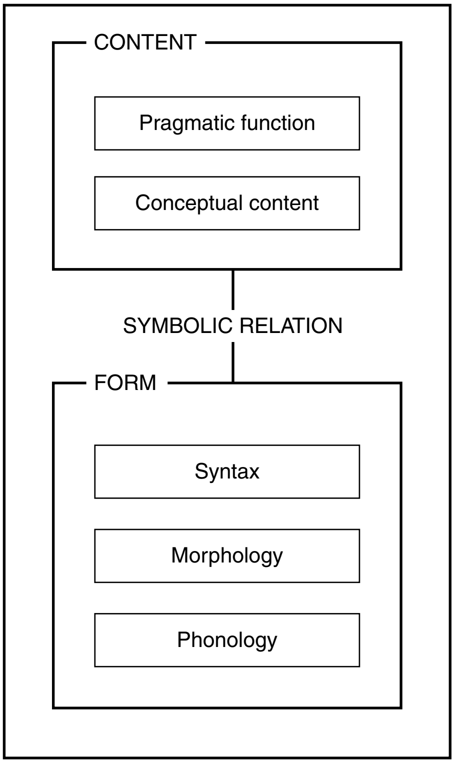

FIGURE 19.2. The symbolic relation between content and form of the linguistic sign.

Possibly under the influence of a partial misunderstanding of Saussure's conception of the linguistic sign, but especially with the advent of the formalist framework of generative grammar, the idea of motivation as an explanatory concept has been met with skepticism if not outright dismissal (e.g., Newmeyer, 1983, 2000).

One reason for the skepticism that motivational explanations have faced is that they have no *predictive* power. This is readily admitted, or at least implicitly assumed, by many functionalist and cognitive linguists (e.g., Haiman, 1985; Heine, 1997; Lakoff, 1987; Langacker, 2008). For example, with regard to the form and meaning of grammatical constructions, Goldberg (2006, p. 217) emphasizes that the motivation of some aspect of the form or content of a construction does not imply that "the construction *must* exist." The motivational link between a linguistic source and a target is "contingent, not deterministic". Goldberg emphasizes that this situation is not uncommon in other sciences (e.g., in evolutionary biology). In the humanities, including for example historical linguistics, non-predictive explanations of linguistic change are common.

For the reason given above, generative linguists have qualms about motivation as an *explanatory* concept; that which counts as an explanation in linguistics is, however, highly theory-dependent. According to generative grammar, humans are equipped with a genetically implemented language faculty, metaphorically called a Universal Grammar (UG), which is considered a precondition for the acquisition of a human language. One important goal of generative grammar is to uncover the properties of the presumed UG and seek *explanatory adequacy* by answering the question: "*Why* do natural languages have the properties they do?" (Radford, 1997, p. 5). One of the universal properties of grammar, in particular of syntax, is its putative autonomy. Thus, Radford (1988, p. 31), among others, stipulates that syntactic rules "cannot make reference to pragmatic, phonological, or semantic information".

With regard to the supposed autonomy and non-motivated nature of syntax, the cognitive linguist George Lakoff and philosopher Mark Johnson (Lakoff & Johnson, 1999, p. 481) make an important point. For them syntax is "the study of generalizations over the distributions of … syntactic elements." Despite this somewhat unfortunate (circular) characterization of syntax, the authors have a good point in arguing that it is "an empirical question whether semantic and pragmatic considerations enter into … distributional generalizations" (p. 482). In other words, the autonomy or non-autonomy of syntax cannot be stipulated by fiat. To date, a large number of grammatical (e.g., syntactic) phenomena have been discovered, some of which have been analyzed insightfully by Lakoff (1987) and Lakoff and Johnson (1999). Their case studies and those of many other functionalist and cognitive linguists (e.g., Goldberg, 2006, 2009; Haiman, 1985; Langacker, 2008) strongly suggest that syntactic generalizations often can be formulated adequately only if conceptual and pragmatic information is incorporated into their descriptions.

Since the nineteenth century, in historical linguistics, motivational explanations have proved their worth in unraveling tendencies of linguistic change. Consider the well-documented development of grammatical morphemes/words from lexical units, a subtype of the historical process known as *grammaticalization*. For example, in their *World Lexicon of Grammaticalization*, Heine and Kuteva (2002, pp. 149–157) list myriad grammatical markers that have evolved from lexical concepts. A telling example is the grammaticalization of the concept of "giving" in various languages. Give has developed grammatical functions (e.g., affixes, prepositions, conjunctions, complementizers) with meanings, such as "benefactive" (e.g., Thai, Mandarin Chinese), "causative" (e.g., Vietnamese, Khmer), "concern" (e.g., Zande), "dative" (e.g., Ewe), and "purpose" (e.g., Acholi).

At least for some of these changes, a motivational explanation is natural. Consider the conceptual link between the concept of giving and the grammatical category benefactive.[4] The action of giving implies a giver and a recipient, the latter usually benefiting from the action. It is this semantic aspect of "give" that becomes part of the grammar in a number of languages. A similar analysis applies to the development of the dative case from verbs of giving. The dative typically coincides with the recipient of an action and wears the etymological motivation of its name on its sleeve (*dative* "case of giving"). In Southeast Asian languages such as Vietnamese and Khmer, the verb denoting give has developed a causative meaning. One might add here that the verb *give* in present-day English is also attested with a causative meaning: in sentences such as "This constant noise gives me a headache," the original meaning of transfer has "bleached" into a meaning that is more abstract (i.e., more grammatical than the basic sense).

The above-mentioned linguistic changes do not occur by necessity; it is not possible to prognosticate that every language that has a verb with the meaning "give" in its lexicon will develop a grammatical category "dative". However, for those languages where the route of grammaticalization from "give" to "dative", for example, has been taken, an "explanation" in terms of conceptual motivation seems natural. In conclusion, despite the non-predictability of grammaticalization processes and other types of semantic and formal change, it is hard to imagine how language change could be accounted for without some notion of motivation.

Grammaticalizations and other types of motivated linguistic change may extend beyond the lifespan of language users, so that they are often unaware of what has initially motivated shifts from lexical to more grammatical functions of linguistic units. However, motivated signs and sign complexes are also recognizable on the synchronic level, where they very well may be internalized as part of the linguistic competence of native speakers.[5] I turn to this topic in the following section.

THE MANY FACETS OF MOTIVATION

There are four basic combinatorial possibilities of how the content and form of signs may be motivationally related, which are diagrammed in Figure 19.3b–e. These are the elementary building blocks from which more complex motivational relations are assembled (see Radden & Panther, 2004, p. 15). The

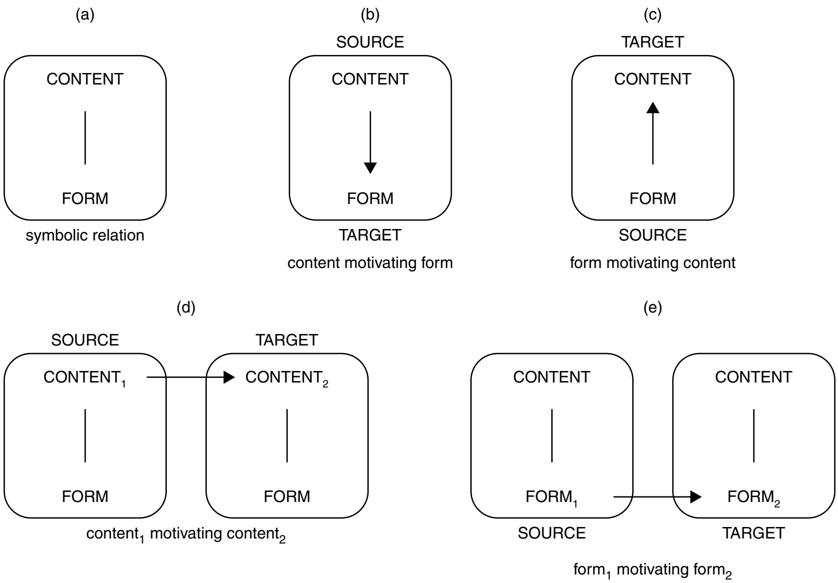

FIGURE 19.3. Basic semiotic relations (adapted from Radden & Panther, 2004, p. 15).

directionality of the motivation is indicated by means of an arrow. A simple line connecting content and form, as in Figure 19.3a, notates an unmarked symbolic relation (i.e., there is no specification as to whether it is motivated or not). Linguistic phenomena usually exhibit combinations of motivated *and* unmotivated semiotic relations.

Figure 19.4 provides a (non-exhaustive) list of motivating factors that, together with an adequate linguistic source, might trigger a motivated process. Recall that these factors operate not only in language but in other semiotic systems, as well, which is why I have termed them *translinguistic*. In Figure 19.4, motivating factors already mentioned and to be discussed in this chapter appear in bold.

In the following two sections some motivating factors are illustrated and discussed in more detail. I begin with a relatively straightforward example of motivation from content to form (i.e., iconicity – similarity of content and form), and then move on to more complex examples of interacting motivating factors such as economy, communicative motivation, metonymy, and inference.

ONOMATOPOEIC WORDS

A reasonable assumption – in line with Saussure's semiotics[6] – is that *simple signs* (i.e., signs that [roughly] cannot be analyzed into smaller meaning-bearing units [morphemes]) are typically unmotivated in the sense

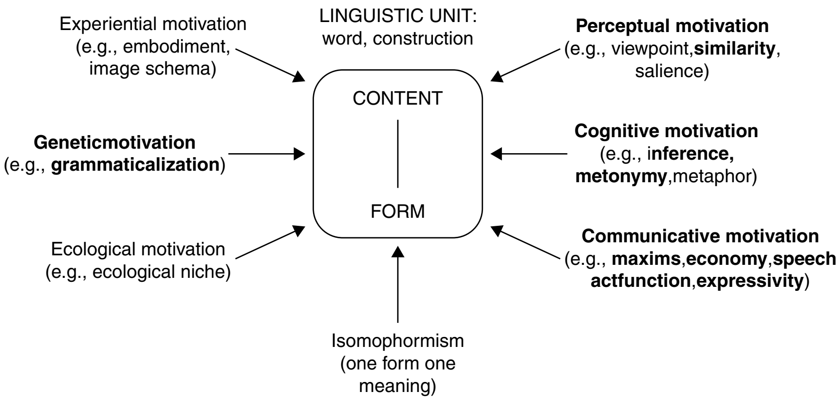

FIGURE 19.4. Types of motivating factors (adapted from Radden & Panther, 2004, p. 24).

that no natural connection between content and form can be established. There are, however, some notable exceptions where the form of simple signs seems to be at least relatively motivated by their denotata. One such case is briefly presented below.

This phenomenon has been known for a long time as *onomatopoeia*, words that are a subclass of *iconic* signs. Such words exemplify *perceptual motivation* (see Figure 19.4). Onomatopoeia is the (more or less) accurate linguistic imitation of sounds and noises in the extralinguistic world. Examples are English verbs such as *neigh*, *meow*, *moo*, *roar*, *crack*, *clang*, *swish*, *whoosh*, *gurgle*, and *plop*. Strictly speaking, these words are not perfect replicas of the natural sounds and noises that they denote. Cows do not really go "moo" (see Katamba 2005: 45), nor do cats go "meow," (i.e., these animals do not pronounce the initial sound [m] followed by the respective vowels and diphthongs of "moo" and "meow"). These words represent the animal sounds by means of the phonological (and graphemic) system available in a particular human language (here English). Despite this "alienation" from the original acoustic shape, there is sufficient resemblance between the original and reproduction: it is certainly more adequate to represent the sounds produced by cows as "moo," rather than, for example, "tick-tock." There is, however, some cross-linguistic variation in how natural sounds are coded, as Table 19.1 illustrates for the verbs with the meaning "meow" as well as the conventional interjections that imitate laughter, in 10 European languages:

Table 19.1 illustrates the point made above that the language-specific phonological and graphemic systems play a role in how natural sounds are coded. This is clearly the case with verbs denoting meowing, where one finds some formal variation across the 10 languages. There is more uniformity in how the interjection that imitates laughter is coded, but again some language-

TABLE 19.1. *Graphemic coding of the act of meowing and the interjection for laughter in ten European languages*

English	German	Dutch	French	Spanish	Italian	Portuguese	Swedish	Finnish	Polish
meow miaow	miauen	miauwen	miauler	Maullar	miagolare	miar	jama	naukua	miaucze
ha! ha!	haha!	Ha! ha!	ah! ah! ha! ha!	Ja	ah! ah!	ah! ah!	haha!	ha ha	Ha! Ha!

Source: Online multilingual dictionary *Mot 3.1*.

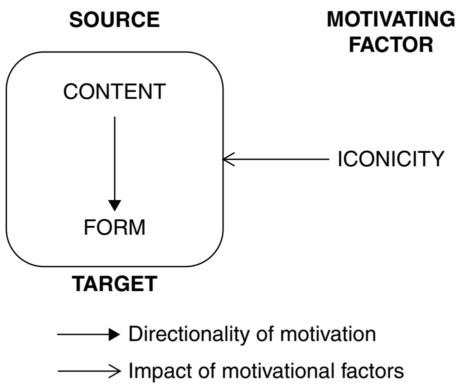

FIGURE 19.5. Onomatopoeic signs.

specific idiosyncrasies are noticeable. In Germanic languages such as English, German, Dutch, and Swedish, the letter <h> is articulated as [h], but in the Romance languages such as French and Italian, this letter is not pronounced, as these languages lack the phoneme /h/. The motivational structure of onomatopoeic words is diagrammed in Figure 19.5.

A CASE OF MOTIVATED GRAMMAR

As pointed out in Section 4, motivation on the level of elementary linguistic signs exists and is not in dispute. More intriguing and challenging are cases of motivation on abstract levels of linguistic organization, such as grammatical form.

Motivated Grammar: Question-Tagged Declarative and Imperative Sentences

Two case studies on question tags in declarative and imperative sentences are presented to provide evidence for the following claims[7]:

(2) i. The content/function and form of question tags in declaratives and imperatives are motivated by factors, such as economy of coding, metonymy, inference, and speech act function.

ii. Idiosyncrasies (i.e., unmotivated distributional patterns) occur, but they are relatively rare.

Question tags are, I contend, an excellent testing ground for the Saussurean thesis that grammar is relatively motivated. Sentences 3 and 4 are typical instances of the phenomena to be analyzed:

(3) Mary left, *didn't she*?

(4) Hand me that book, *will you*?

Henceforth, I refer to the declarative and the imperative clauses proper as the *host clause*, and to the italicized constituents in 3 and 4 as the *tag*. Tags have a variety of communicative functions in English, and Bolinger (1989, p. 115) notes that their use is "a typically English device" (quoted in Wong 2008, p. 89). I will not try to develop a detailed taxonomy of the different communicative functions of individual tags (see Huddleston & Pullum, 2002, pp. 851–945, 942–943). I also neglect the (crucial) role of intonation in the interpretation of question tags. My aim is more modest: I intend to show how tags are related to and motivated by the conceptual content and pragmatic function of the host clause. I also address the important question of why some expressions that are functionally and semantically compatible with the host do not appear as tags.

I begin with some possible and impossible tagged declaratives and imperatives that an adequate account in terms of motivation has to come to grips with (unacceptable tags and only marginally acceptable ones are marked with an asterisk and a superscripted question mark, respectively):

(5) Gore won the Nobel Prize,
 a. did(n't) he?
 b. right?
 c. or?
 d. *do(n't) I believe it?

(6) You are fired,
 a. *are(n't) you?
 b. *right?

(7) Pour me some wine,
 a. *do(n't) you?
 b. would you?
 c. why don't you?
 d. *why do you?
 f. shouldn't you?
 e. *must you?

The first observation about tags is that they are relatively short. This property appears to be motivated by considerations of economy or brevity (see Figure 19.3).[8] The same kind of communicative effect as with a question tag could, in principle, be achieved by means of a full interrogative clause attached to the host sentence. However, it would be highly uneconomical to render, for example, 3 as 8:

(8) ?Mary left; didn't Mary/she leave?

Analogously, the maxim of brevity will bar 4 from being rendered as 9:

(9) ?Hand me the book; will you hand me the book/hand it to me?

Brevity, is however only one feature of acceptable tags. A glance at sentences 5–7 reveals that certain tags do not pair very well with their respective host clauses. The solution to the question of why certain tags appear and others are blocked is found in the conceptual content and pragmatic function of their respective host clauses. The conceptual content and standard pragmatic function of declaratives and imperatives can be described by *speech acts scenarios* (for this notion, see, for example, Panther & Thornburg, 1998, 1999, 2003, 2007; Thornburg & Panther, 1997). The scenarios for declaratives and imperatives are presented in the following two sections.

Tagged Declaratives

Before delving into the semantics and pragmatics of tagged declarative sentences, it is crucial to review the *formal* properties of what one could call "canonical tags," as exemplified by "Mary left, didn't she?" in sentence 3 above:

(11) i. There is referential identity between the host clause subject and the tag subject, realized as an anaphoric pronoun: *Mary* is coreferential with *she*.
ii. The host clause predicate (verb phrase) is anaphorically resumed in the tag by an auxiliary verb: *left* is resumed by *didn't*.
iii. The positions of the tag subject and the auxiliary are inverted: the auxiliary verb *didn't* is positioned before the subject *she*.
iv. The polarity of the host clause is typically reversed from affirmative to negative, or negative to affirmative, as the case may be: in 3, the host clause is positive, the tag is negative.
v. The host clause and the tag are tightly linked: the tag functions as a "sentence clitic."

vi. The tag is short.
vii. The tag is "unclause-like."

Tags such as "right?" and "or?" come very close to canonical tags. They fulfill the requirement of being short, but they are syntactically less tightly linked to the host clause than "do"-tags described in 11. In the case of "right?", the content expressed by the host clause is *ellipted*, but easily recoverable. In the case of "or?", alternatives to what is asserted in the host clause are evoked, but there are no elements in the tag that are coreferential with elements in the host clause.

The standard communicative function of declaratives is to perform *assertive* speech acts, or more technically, assertive *illocutionary* acts.[9] The semantics and pragmatics of illocutionary acts can be represented by means of *conceptual frames*. The notion of conceptual frame is based on the idea that the meaning of a word "can only be properly understood and described against the background of a particular body of knowledge and assumptions" (Cruse, 2006, pp. 66–67). I assume that the frame semantic approach can be applied to the analysis of speech acts, as well, and henceforth I refer to the conceptual frames for speech acts as "scenarios." A speech-act scenario includes information about the context in which a speech act is felicitously performed (in the sense of Austin, 1962, and Searle, 1969). In Figure 19.6, a scenario for assertive speech acts is proposed.

In Figure 19.6, the assertive speech act itself is referred to as "core" (shaded in grey), the background conditions for its felicitous performance as "before," and the consequences of the performance of the speech act as "result" and "after." The lines connecting conceptual components symbolize what Linda Thornburg and I term (potential) *metonymic* links. These connections can be called metonymic because one component in a speech-act scenario may evoke other components or the whole scenario.

Depending on the components selected by the speaker, an assertive speech act can be performed more or less *directly* or *indirectly* (see Searle, 1975 for the notions of direct and indirect speech act):

(12) a. I claim that Auster wrote *The Brooklyn Follies*. (direct: sentence addresses core)
b. I believe Auster wrote *The Brooklyn Follies*. (indirect: addresses a before component)
c. Did you know that Auster wrote *The Brooklyn Follies*? (indirect: addresses a before (component)
d. Do you now believe me that Auster wrote *The Brooklyn Follies*? (indirect: addresses the after)

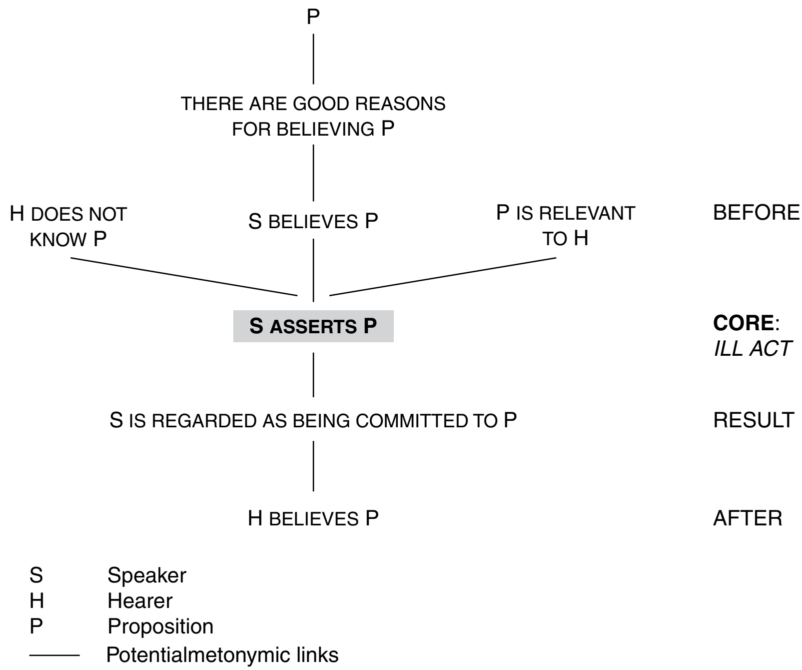

FIGURE 19.6. Scenario for assertive speech acts.

Question tags, exactly as the full sentences in 12, address components of speech-act scenarios, but they do so in a shorthand and hence economical way. The main purpose of a declarative sentence is to represent a proposition P as true. Intuitively, one would thus expect *truth*-related tags to be attached to declaratives, given that the corresponding speech acts, assertives, are essentially about what the world is like. It does therefore not come as a surprise that in utterances (5a, 5b), repeated here as (13a, 13b), the tag explicitly addresses the truthfulness of the before component P:

(13) a. Gore won the Novel Prize, didn't/did he?
b. Gore won the Nobel Prize, right/or?

However, it is also possible to address some other components of the speech-act scenario; for example, the knowledge state of the hearer:

(14) a. Gore won the Nobel, doncha know?
b. Gore won the Nobel Peace Prize, did you hear? [*hear* stands metonymically for "know"]

Note that in this case, the tags that refer to the hearer's knowledge are formally not as tightly integrated into the host clause as in the case of tags that address the veracity of the proposition P. The verbs in the tags of (14a, 14b), "know" and "hear," are not verbatim resumptions of the host clause verbs; nevertheless, they address an important before component of the assertive scenario and their appearance is thus motivated.

Much longer and less felicitous are tags that evoke the relevance of the asserted proposition for the hearer:

(15) a. ?Gore won the Nobel Peace Prize, do you care?
b. ?Gore won the Nobel Peace Prize, are you interested?
c. Gore won the Nobel Peace Prize, if you're interested.

The appended expressions in 15 are increasingly clause-like (in comparison with 13 and 14). Moreover, in 15c, the tag is conditional, not interrogative. Conditionality is conceptually related to interrogativity (English *if*, which is a cognate form of German *ob,* "whether," can be used in indirect questions), but the conditional clause in 15c does certainly not constitute a canonical tag. Finally, the tag expressions in 15 are also syntactically less tightly connected to their host clauses than in the canonical cases in 13. There are no anaphoric ties at all between the host clause subject and predicate and the elements in the tag.

The acceptability and canonicity of tags decreases even more drastically when the before component "S believes P" and "there are good reasons for believing P," and the core component "S asserts P," the result component "S is regarded as being committed to P (as an effect of asserting P)," and the after component "H believes P" are addressed. The tags become both longer and more clause-like, and most of them are downright unacceptable.

(16) a. *Gore won the Nobel, do(n't) I believe/think/assume so?
b. *Gore won the Nobel, are there good reasons for this claim?
c. *Gore won the Nobel, do(n't) I claim/assert/say so?
d. *Gore won the Nobel, aren't/am I committed to the truth of this?
e. Gore won the Nobel, (or) don't you believe me?

There are good reasons for the unacceptability of 16a–d. Utterance 16a is communicatively (although not logically) inconsistent. Speakers are supposed to have privileged access to their beliefs; to seek confirmation for what one believes to be true is therefore pragmatically odd. As to 16b, there is a communicative principle that requires people to assert only propositions whose truth they can back up with good arguments. To pose the question in the tag whether such good reasons exist undermines the communicative function of the host clause. Utterance 16c is unacceptable because it is pragmatically paradoxical to assert something and at the same time question whether one's own act of assertion has actually been performed. Similarly, the utterance of 16d is infelicitous because the assertion of the content of the host clause creates the effect that the speaker is seriously committed to the truth of the asserted proposition, but it is exactly this pragmatic effect that is challenged in the tag. The only tag that is acceptable refers to the after component of the speech act. The speaker's goal in asserting something is usually to make the hearer believe that the asserted proposition is true. This aim is, however, not always achieved, and it is therefore quite natural for speakers to address the after component. Nevertheless, despite the acceptability of 16e, the tag is formally not canonical. First, it is rather long (clause-like), and, second, it is not anaphorically linked to the preceding host; neither the subject of the tag nor its verb anaphorically resumes formal elements of the host clause.

To conclude this section, a set of sentences is worth mentioning that seems to behave erratically in not admitting canonical declarative question tags:

(17) a. *I promise to be on time, don't I?
b. *I apologize for keeping you waiting, don't I?
c. *Passengers are requested to board immediately, aren't they? (request to board a plane)
d. *I pronounce you man and wife, don't I? (priest performing marriage ceremony)
e. *You're fired, aren't you? (speaker fires hearer from job)
f. ?I believe Gore won the Nobel Prize, don't I?
e. *I am glad you came to my party, aren't I?

In grammatical terms, all of the above utterances are declarative sentences, but they do not allow a tag that addresses the truth value of the proposition expressed in the host clause. The host clauses in 17a–d typically serve as what Austin (1962) terms "explicit performative utterances." The verb in the superordinate clause self-referentially describes the speech act that the speaker actually performs in uttering the sentence. In these cases, the host clauses are not to be categorized in terms of truth but in terms of felicity (see Austin, 1962). The utterances 17a–c constitute a promise, an apology, and a request, respectively; the speaker cannot, in the same breath, question the performance of these explicitly named illocutionary acts.

Utterances 17d and 17e are examples of linguistic acts that are grounded in institutions. Institutionally legitimized speakers create new social, judicial, and religious "facts" as a result of performing them. The utterance of the correct words, in the right circumstances, by the right speaker has the effect that proposition P becomes "reality." It is this feature that distinguishes what Searle (1976) calls "declarations" from ordinary assertive declarative sentences, which are descriptively either true or false. Similarly, explicit performative utterances are conventionalized social practices in a speech community. The act named by the performative verb becomes a noncontestable fact; therefore, its reality status cannot be mitigated or hedged by question tags. It therefore makes pragmatic sense that declarative tags are barred from appearing in performative utterances and declarations.

Finally, there are good reasons why tags are not felicitously used with host clauses that refer to the speaker's mental or emotional attitude, as in 17f and 17g, respectively. Speakers have privileged access to their own mental states and emotions. Therefore, it is strange to question or seek confirmation of the existence of those mind states from others.

Tagged imperatives

The number of tags that can be attached felicitously to imperative sentences is much larger than those that co-occur with declarative clauses. Tagged imperatives have the canonical structure *Modal Auxiliary (n't) + you*. Here are some examples:

(18) a. Hand me that book, will/won't/would you?
b. Open that door for me, can/can't/could you?

The imperative tags in 18 are syntactically not as tightly linked with their host clauses as canonical declarative tags are with their hosts. First, the subject of an imperative tag (*you*) has no explicitly named antecedent in the host clause, although it refers back to an understood addressee of the imperative sentence. Second, imperative tags are not "pro-forms" for the verb phrase in the host clause in the sense that the auxiliaries *do/did* are "pro-verb" forms for the predicates in declaratives are. However, despite their looser syntactic ties to the host clause, the appearance of modals such as *can*, *could*, *will*, and *would* is, as argued below, are highly motivated by conceptual factors.

The standard function of imperative sentences is to perform *directive* speech acts (i.e., they are used to perform orders, instructions, requests, recommendations, etc.). In order to understand what licenses or constrains the appearance of imperative tags, it is necessary to consider the scenario for directive speech acts. I consider a subtype of this scenario (viz. a conceptual frame that represents requests for the transfer of an object from the hearer to the speaker) (see Figure 19.7).

A glance at Figure 19.7 reveals that the tags in sentences 18a and 18b index components of the directive speech-act scenario. Tagged imperatives combine a *direct speech act* (the host clause) with a compacted *indirect speech act* (the tag). For example, "can you?" in 18b is a condensed form of the

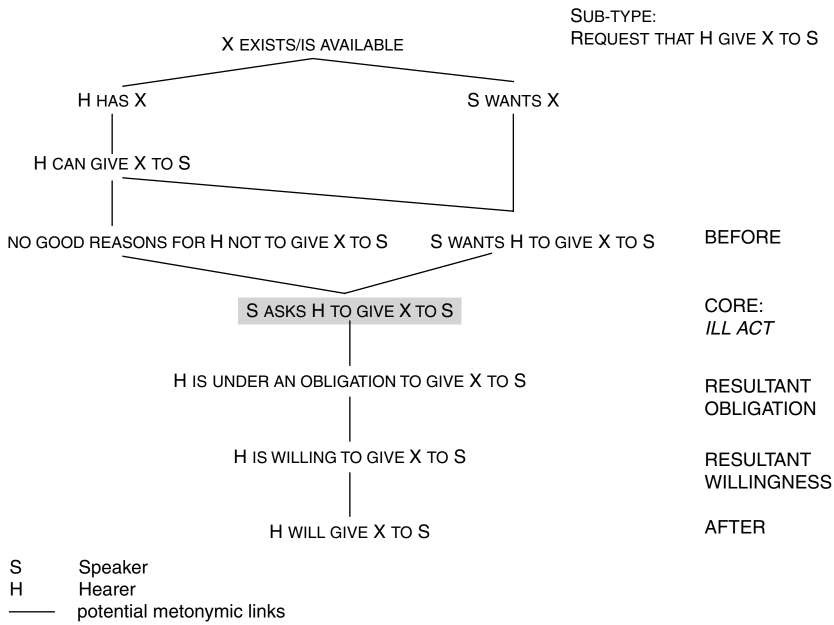

FIGURE 19.7. Scenario for directive speech acts.

full-fledged indirect request "Can you open that door for me?" The latter is called indirect because it can be used to achieve the same purpose as the corresponding direct request "Open that door for me." A second important feature of well-formed imperative tags is that they are *metonymically* linked in a part-whole relationship to the directive speech-act scenario. The tag selects one aspect (component) of the speech-act scenario, which then metonymically evokes other parts of the speech-act scenario or the whole scenario. It has often been observed that indirect speech acts are politer than direct speech acts (Brown & Levinson, 1987; Searle, 1975), and many of the imperative tags (although not all) serve the purpose of mitigating the impositive force of the host clause.

The task remains to check which parts of the scenario can be verbalized as imperative tags and why.

Before: availability, possession of x

(19) a. ?Pour me some Rioja, is there any?
b. ?Pour me some Rioja, do you have any?

The components "availability of x" and "possession of x" are not exploitable as "ideal" tags because they are clause-like (i.e., similar to interrogative sentences). Furthermore, questioning the availability of Rioja in the tag is pragmatically not consistent with the assumption conveyed in the host clause that Rioja is available.

Before: H can give X to S
(20) a. Pour me some Rioja, can/can't you?
b. Pour me some Rioja, could/couldn't you?
c. *Pour me some Rioja, are you able to/do you have the ability to?

The addressee's ability to perform the requested action is a central condition of felicitous requests. Asking someone to pour some Rioja is pointless if, for some reason, the hearer is unable to carry out this action. Conveniently, in English, a short modal – *can* – is available so that the tag can be economically coded. There is an interesting pragmatic difference between the affirmative and the negative form of the tag, the latter having a more demanding and aggressive effect. The interpretation of negative tags requires some pragmatic inferencing on the part of the hearer. The tag "can't you?" like the corresponding full-fledged sentence "Can't you pour me some Rioja?" is typically used in situations in which it is crystal clear that the hearer *can* carry out the requested action; hence, the challenging overtone of "Pour me some Rioja, can't you?" The puzzling occurrence of negated *can* is thus highly motivated, a kind of motivation that might be called *inferential motivation*. The term "inferential" is not supposed to suggest that inferential work has to be carried out every time a hearer encounters a negative modal tag. It means that the original motivation of the negative tag is inferential even though the interpretation of such tags is spontaneous and effortless for the native speaker.

My last observation in connection with the ability component concerns the impossibility of using tags such as "are you able to?" or "do you have the ability to?" which are rough paraphrases of "can you?" Why they do not occur is readily explained by the economy principle or the Gricean maxim of manner "Be brief."[10]

Before: no good reasons for H not to give X to S
(21) a. Pour me some Rioja, why don't you?
b. *Pour me some Rioja, why do you?

The tag "why don't you?" in 21a is perfectly good, although it is longer and more clause-like than canonical tags. The tag is appropriate in a context where it is clear to the speaker that there are in fact no reasons why the request should not be complied with. It is thus not expected (and pragmatically odd) for the hearer to come up with negative reasons why she cannot carry out the desired action. In contrast to "why don't you?" the tag "why do you?" is very bizarre, given the goal of the speaker (compliance with the request). For communicative reasons, such a tag is completely unmotivated and will therefore not appear.

Before: S wants H to give X to S
(22) *Pour me some Rioja, do I want you to/would I like you to?

The tags in 22 refer to what in speech act theory is known as a sincerity condition. To question this component is pragmatically odd because speakers should know their own wishes. An analogous constraint holds for assertive tags that question the speaker's belief in the proposition P (see Section 5.2).

Core: S asks H to give X to S
(23) *Pour me some Rioja, do(n't) I ask you to?

As in the case of assertive tags (see Section 5.2), the illocutionary act, more precisely, reference to the speaker and act of asking, cannot be compacted into a well-formed tag. The reason is clear: such a tag creates an illocutionary paradox because the speech act is accomplished in uttering the host clause, and at the same time, questioned in the tag.

Resultant obligation: H is under an obligation to give X to S
(24) a. *Pour me some Rioja, must you?
b. *Pour me some Rioja, should you?
c. *Pour me some Rioja, mustn't you?
d. Pour me some Rioja, shouldn't you?

The positive tags in 24a and 24b are pragmatically odd because they create – similar to the illocutionary tag in 23 – a paradoxical situation. In uttering the host clause, the speaker introduces an obligation for the hearer, but the immediately adjacent tag suspends this obligation. In contrast, utterance 24d is felicitous. Here, the negative tag pragmatically implies the existence of a host's normally willingly undertaken social commitment (cf. "Shouldn't you pour me some Rioja" [as you're the host]?). The negative form of the tag is thus inferentially motivated. Yet 24c, with the negative tag "mustn't you?" seems less felicitous, if not infelicitous. The reason might be that, unlike *should*, *must* often implies an externally imposed obligation complied with only reluctantly, if not unwillingly.

Resultant willingness: H is willing to give X to S
(25) Pour me some Rioja, would you like to/be willing to/mind?

The tags in 25 are acceptable (but not canonical) because they are more clause-like and thus do not abide by the principle of economical coding.

After: H will give X to S

(26) Pour me some Rioja, will/won't/would/wouldn't you?

The tags in 26 are perfect in all respects. They are conveniently short, they are tightly linked to the host clause (cf. the tags referring the hearer's ability in 20a and 20b), and they metonymically access a central aspect of the directive scenario: the compliance with the request. As noted above, there are inferentially derived pragmatic effects associated with negative tags. The tag "won't you?" just as its full-fledged counterpart, "Won't you pour me some Rioja," evokes a context in which the corresponding affirmative proposition "You will pour me some Rioja" is already established. Hence, as in the case of "can't you?" a connotation of aggressiveness is conveyed.

In summary, the functions of imperative tags are as follows:

(27) i. Imperative tags usually serve the function of mitigating the impositive force of the host.
ii. They achieve this mitigating function in metonymically accessing components of the directive scenario to perform condensed indirect speech acts.
iii. The most systematically exploited imperative tags are those that refer to the hearer's ability to carry out the desired action (before) and those that refer to the performance of the requested action (after).

Among the constraints on the use of imperative tags, the following appear to be the most significant:

(28) i. Tags that are pragmatically incompatible with the meaning of the host clause are avoided.
ii. Speaker-referring tags are avoided.
iii. Hearer-addressed tags are preferred.

These results are tabulated in Table 19.2, which ranks the conceptual components of directive speech-act scenarios according to their suitability to be coded as tags. In addition, the components are classified as to whether they are speaker-oriented, hearer-oriented, or exhibit no specific orientation.

The Motivated Structure of Tagged Declaratives and Imperatives

The overall results of the two case studies on tagged declarative and imperative sentences are diagrammed in Figure 19.8.

The content and form of question tags involve content-to-content and form-to-form motivation. The translinguistic factors that guide these processes include speech act function, metonymy, inferences, and economy of

TABLE 19.2. *Availability and acceptability of components in directive speech-act scenarios for tag formation*

Directive Scenario COMPONENT	ORIENTATION	TAG
H can give X to S	H-oriented	+++
H will give X to S	H-oriented	+++
No good reasons for H not to give X to S	H-oriented	++
H is under obligation to give X to S	H-oriented	++
H is willing to give X to S	H-oriented	++
X exists/is available	neutral	+
H has X	H-oriented	+
S wants H to give X to S	S-oriented	*
S asks H to give X to S	S-oriented	*

+++ fully acceptable and natural.
++ acceptable.
+ barely acceptability.
* unacceptable.

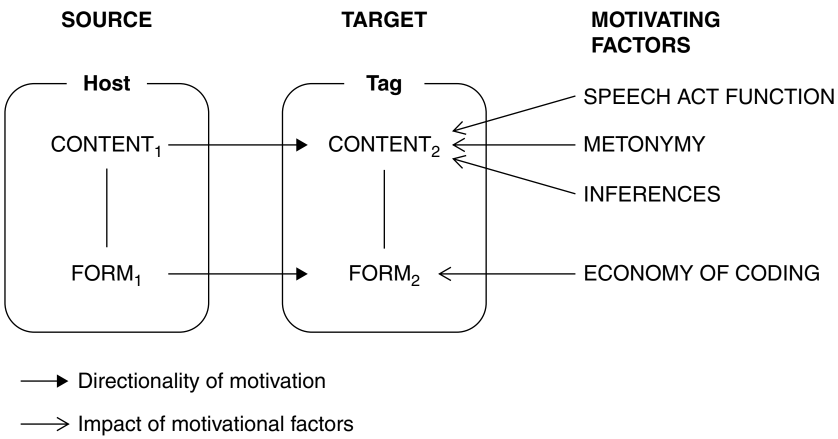

FIGURE 19.8. Motivated structure of tagged declaratives and imperatives.

coding.[11] The content of the host clause has an impact on the content of the tag in that the tag metonymically selects one suitable conceptual component from the speech-act scenario of the preceding host. The tag functions as a condensed indirect speech act in imperative tags, and it focuses on the truth of the proposition in declarative tags. Routinized inferential processes are involved in the interpretation of, for example, negative tags such as "can't you?" and "won't you?" The tags are preferably coded as economically as possible.

CONCLUSIONS

In this chapter, I hope to have made the case for motivation as a key concept in linguistic theorizing. In particular, I have tried to substantiate Saussure's claim that although elementary linguistic signs are – with notable exceptions – arbitrary, language as an instrument of expressing thoughts and performing communicative acts must, to a certain extent, be motivated. I have shown that grammatical phenomena – question tags attached to declarative and imperative sentences – are licensed and constrained by a variety of motivating factors. Tags are found in many other languages, but what kinds of tags appear in a specific language cannot be predicted. It is a fact about English that it has motivated canonical tags such as "did she?" "can you?" or "will your?" and their negated counterparts. It is also a fact that German and French lack literal equivalents of these English tags.

A final problem remains to be addressed very briefly. Why are linguistic structures often only partially, or in Saussurean terms, relatively motivated? Ariel (2008, p. 123) proposes an interesting answer. She points out that motivation is, in logical terms, not a transitive relation. If some source *x* motivates a target *y*, and *y* serves in turn as a source for motivating *z*, the result of this chaining is not necessarily a recognizable motivational relationship between *x* and *z*. Motivated chains of this sort are very common in the history of languages, and the results of such diachronic processes often, from a synchronic perspective, appear to be unmotivated linguistic phenomena.

Notes

1. The conventionalist theory of linguistic signs is also propounded by Aristotle in his treatise *De Interpretatione*. Aristotle holds that the relation between a linguistic expression and its content is conventional; that is, "no name exists by nature, but only by becoming a symbol" (quoted in Crystal, 1997, p. 408).
2. For example, in a recent discussion of Adele Goldberg's book *Constructions at Work* (2006), which explicitly embraces the thesis that grammatical constructions are partially motivated, Borsley and Newmeyer (2009) argue that purely formal syntactic generalizations exist, one of them being the rule of "Auxiliary–Subject Inversion." The authors argue that the constructions that undergo this rule are semantically heterogeneous (e.g., interrogatives, exclamative sentences, counterfactual conditionals) but they all fall formally under the same generalization (i.e., the auxiliary is placed before the subject).
3. Langacker (e.g., 2008), the leading figure in the branch of cognitive linguistics referred to as Cognitive Grammar, assumes throughout his work that linguistic signs (simple and complex) exhibit a symbolic relationship between the semantic pole and the phonological pole. Syntax and morphology are not considered to be independent levels of linguistic organization.

4. Radden and Panther (2004, p. 10) suggest that the use of "give" as a grammatical category "benefactive" in Ewe can be accounted for as the result of abductive reasoning.
5. The Saussurean term *synchronic* refers to the linguistic system "at one point in time" and is opposed to *diachronic* – "the evolution of language through time."
6. Throughout the *Cours de linguistique générale* Saussure uses the term *sémiologie,* whereas in English the term *semiotics* (introduced by the American philosopher C. S. Peirce) is preferred.
7. Parts of this section originated in talks that were prepared and delivered with Linda Thornburg at conferences at Josip Strossmayer University in Osijek, Croatia, and the University of Bielsko-Biała, Poland, in September 2007 and October 2008, respectively. My sincere thanks go to Professors Mario Brdar and Bogusław Bierwiaczonek for their kind invitations and hospitality. Suggestions and constructive criticism from the audiences at these conferences are gratefully acknowledged.
8. Grice (1975) lists "Be brief" as one of the conversational maxims subsumed under the Cooperative Principle that guides rational communication.
9. The term "illocutionary act" (what is done "in speaking") was coined by the Oxford philosopher John L. Austin in the 1960s, and further developed by the American philosopher John Searle (1969). It is the latter's notion of illocutionary act that is assumed here. In what follows, I use the terms "speech act" and "illocutionary act" interchangeably.
10. See Panther and Thornburg (2006) for the motivated behavior of manner scales such as <*can, be able to, have the ability*>.
11. On the role of metonymy as a motivating factor of grammar, see the collection of articles in Panther, Thornburg, and Barcelona (2009).

References

Ariel, M. (2008). *Pragmatics and grammar.* Cambridge: Cambridge University Press.

Austin, J. L. (1962). *How to do things with words*. Cambridge, MA: Harvard University Press.

Bolinger, D. (1989). *Intonation and its uses*. Stanford, CA: Stanford University Press.

Borsley, R. D., & Newmeyer, F. J. (2009). On subject-auxiliary inversion and the notion "purely formal generalization." *Cognitive Linguistics*, **20**, 135–145.

Brown, P., & Levinson, S. C. (1987). *Politeness: Some universals in language use*. Cambridge: Cambridge University Press.

Cruse, A. (2006). *A glossary of semantics and pragmatics*. Edinburgh: Edinburgh University Press.

Crystal, D. (1997). *The Cambridge encyclopedia of language*. Cambridge: Cambridge University Press.

Goldberg, A. (2006). *Constructions at work*. Oxford, NY: Oxford University Press.

(2009). The nature of generalization in language. *Cognitive Linguistics*, **20**, 93–127.

Grice, H. P. (1975). Logic and conversation. In P. Cole & J. L. Morgan (Eds.), *Speech acts* (Syntax and Semantics 3) (pp. 41–58). New York: Academic Press.

Haiman, J. (1985). *Natural syntax: Iconicity and erosion*. Cambridge: Cambridge University Press.

Hamilton, E., & Cairns, H. (Eds.), (1961). *The collected dialogues of Plato including the letters*. Princeton, NJ: Princeton University Press.

Heine, B. (1997). *Cognitive foundations of grammar*. Oxford: Oxford University Press.

Heine, B., & Kuteva, T. (2002). *World lexicon of grammaticalization*. Cambridge: Cambridge University Press.

Huddleston, R., & Pullum, G. K. (2002). *The Cambridge grammar of the English language*. Cambridge: Cambridge University Press.

Katamba, F. (2005). *English words*. London: Routledge.

Lakoff, G. (1987). *Women, fire, and dangerous things: What categories reveal about the mind*. Chicago and London: The University of Chicago Press.

Lakoff, G., & Johnson, M. (1999). *Philosophy in the flesh: The embodied mind and its challenge to Western thought*. New York: Basic Books.

Langacker, R. (2008). *Cognitive grammar: A basic introduction*. Oxford: Oxford University Press.

Newmeyer, F. J. (1983). *Grammatical theory: Its limits and its possibilities*. Chicago, IL: The University of Chicago Press.

(2000). *Language form and language function*. Cambridge, MA: MIT Press.

Panther, K.-U. (2008). Conceptual and pragmatic motivation as an explanatory concept in linguistics. *Journal of Foreign Languages*, **315**, 2–19.

Panther, K.-U., & Thornburg, L. L. (1998). A cognitive approach to inferencing in conversation. *Journal of Pragmatics*, **30**, 755–769.

(1999). The potentiality for actuality metonymy in English and Hungarian. In K.-U. Panther & G. Radden (Eds.), *Metonymy in language and thought* (Human Cognitive Processing 4) (pp. 333–357). Amsterdam & Philadelphia: Benjamins.

(2003). Metonymies as natural inference and activation schemas: The case of dependent clauses as independent speech acts. In K.-U. Panther, & L. L. Thornburg (Eds.), *Metonymy and pragmatic inferencing* (Pragmatics & Beyond New Series 113) (pp. 127–147). Amsterdam and Philadelphia: Benjamins.

(2006). Metonymy and the way we speak. In R. Benczes & S. Csábi (Eds.), *The metaphors of sixty: Papers presented on the occasion of the 60th birthday of Zoltán Kövecses* (pp. 183–195). Budapest: Eötvös Loránd University, Department of American Studies.

(2007). Metonymy. In Geeraerts, Dirk, and Hubert Cuyckens, (Eds.), *Handbook of Cognitive Linguistics* (pp. 236–263). Oxford: Oxford University Press.

Panther, K.-U., Thornburg, L. L., & Barcelona, A. (Eds.), (2009). *Metonymy and metaphor in grammar* (Human Cognitive Processing 25). Amsterdam and Philadelphia: Benjamins.

Radden, G., & Panther, K.-U. (2004). Introduction: Reflections on motivation. In G. Radden, & K.-U. Panther (Eds.), *Studies in linguistic motivation* (Cognitive Linguistics Research 28) (pp. 1–46). Berlin and New York: Mouton de Gruyter.

Radford, A. (1988). *Transformational grammar: A first course*. Cambridge: Cambridge University Press.

(1997). *Syntax: A minimalist introduction*. Cambridge: Cambridge University Press.

Saussure, F. de. (1968). *Course in general linguistics*. New York: McGraw-Hill.

Saussure, F. de. (1995). *Cours de linguistique générale*. Paris: Payot.

Searle, J. R. (1969). *Speech acts: An essay in the philosophy of language*. Cambridge: Cambridge University Press.

(1975). Indirect speech acts. In P. Cole & J. L. Morgan (Eds.), *Speech acts* (Syntax and Semantics 3) (pp. 59–82). New York: Academic Press.
(1976). A classification of illocutionary acts. *Language in Society*, **5**, 1–23.
Sedley, D. (2003). *Plato's Cratylus*. Cambridge: Cambridge University Press.
Thornburg, L. L., & Panther, K.-U. (1997). Speech act metonymies. In W.-A. Liebert, G. Redeker, & L. Waugh (Eds.), *Discourse and perspective in cognitive linguistics* (pp. 205–219). Amsterdam and Philadelphia: Benjamins.
Wong, J. (2008). Anglo English and Singapore English tags: Their meanings and cultural significance. *Pragmatics and Cognition*, **16**, 88–117.

20

Intelligence and Cognitive Exceptionality

The Motivational Perspective

Edward F. Zigler

INTELLIGENCE – ITS NATURE AND ASSESSMENT

There is no commonly accepted definition of intelligence. However, there is some kind of prevalent agreement that intelligence refers to a set of cognitive abilities that are related to success in the prevailing academic and social frameworks. The list often includes problem solving, memory, learning ability, induction, deduction, mathematics, and other similar skills. Many of these skills are assessed by the so-called intelligence tests, of which the IQ is the outcome score. However, although the IQ measure provides an easy operational definition of intelligence, its application has been accompanied by uneasiness for a long time. Some of the reasons are its lack of sensitivity to ethnic and cultural differences and the fact that it is not grounded in any theory. There have been several attempts to ground intelligence in some kind of theory, such as information processing, neurological, or genetic. So far none has led to definite results that could account at least for the selection of cognitive skills that supposedly make up intelligence.

Thus, although the arguments about the nature and meaning of intelligence still go on, let us recall the criterion that has originally directed the selection of cognitive skills to be considered as intelligence: successful performance in accepted social frameworks, such as school or work. It becomes immediately clear that regardless of how one conceptualizes and measures intelligence, the performance of individuals, young or older, could not be a function only of how intelligent they are. Many other factors contribute to the performance and behavior that are usually erroneously attributed exclusively to the level or amount of intellect (Zigler, 1986). This is what this chapter is all about.

This chapter focuses on individuals manifesting cognitive exceptionality. In terms of IQ measures, there are two such groups, each at one of the extremes of the normal curve of IQ distribution. Terms often used in the past or present for referring to individuals at the lower end include "mental retardation," "mental deficiency," "mental challenge," "intellectual disability," "developmental disability," or "developmental delay." Terms of this kind represent the attempt to describe a phenomenon without falling into the trap of using pejorative descriptors. Currently, mental retardation is defined as intelligence test performance two or more standard deviations below the mean, namely, below the score of 70, accompanied by limitations in adaptive functioning (Robinson, Zigler, & Gallagher, 2000), with onset prior to the age of 18 years (APA, 1980). Thus, IQ in the range of 50–69 is sometimes viewed as mild mental retardation, IQ in the range of 35–49 as moderate mental retardation, and lower than 35 as severe. It should, however, be evident that mental retardation is largely a matter of definition. The arbitrary nature of the diagnostic criteria is clear from the fact that in recent years the cutoff IQ score for mental retardation has fluctuated between 85 (APA, 1966) and 70 (APA, 1980). Furthermore, as emphasized by Zigler (1986), the important point may not be the precise IQ but the divergence between the chronological age and the mental age, whereby in the retarded the former is higher than the latter. Whatever the cutoff point of the IQ is, it disregards another highly important distinction among individuals in this domain of disability, which is that between cultural-familial (nonorganic) etiologies and organic etiologies that has been emphasized and studied by Zigler and his students (Burack, 1990).

The situation is not much simpler in regard to the higher end of the IQ curve. Usual terms that are used include "giftedness," "talent," "high ability," "excellence in performance," or "high levels of accomplishment when compared with others of their age, experience or environment" (Ross, 1993, p. 26). Here again there do not exist any accepted definitions or consensual IQ cutoff points. Common distinctions refer to children scoring 115–129 as bright, those scoring 130–144 as moderately gifted, 145–159 as highly gifted, 160–174 as exceptionally gifted, and those scoring above 175 as profoundly gifted (Gross, 2004, p. 7; Newman, 2008). However, it is widely accepted that most IQ tests are not very sensitive in distinguishing between degrees of giftedness at the higher levels (Pfeiffer & Blei, 2008). Furthermore, similar to the asynchrony between age and mental age in the retarded, in the gifted there is a parallel "asynchrony gap" between the chronological age and the mental age, whereby the former is lower than the latter. In fact, giftedness has been defined as "asynchronous development" resulting in advanced cognitive abilities coupled with performance and inner experiences and awareness that are qualitatively different from the norm characterizing the chronological age (Morelock, 1992).

Here again the general undifferentiated approach to high ability as such competes with the differentiated approach that emphasizes superior intellectual ability (e.g., two standard deviations above the mean of IQ) plus creativity or evidence for specific talent in particular domains, such as mathematics or the arts (Gagné, 1991; Renzulli, 1978).

FACTORS INFLUENCING PERFORMANCE AT THE LOWER END OF THE IQ CURVE

A large body of data accumulated over the last half century by Zigler and his students has demonstrated the impact of extra-intelligence factors on cognitive performance. The evidence supporting this view has been continuously increasing, starting with the first study (Zigler, 1958). The bulk of the evidence focuses on motivational factors that have been shown to have a significant impact on the functioning of mentally retarded individuals. Because this material has been widely published and often summarized (e.g., Hodapp, Burack, & Zigler, 1990; Zigler & Bennett-Gates, 1999), the present review will focus on the major concepts and highlights, organized around three foci: the external environmental factors, personality and behavioral factors, amplified by cognitive motivational factors.

This organization of the material is based on several assumptions. The first is that environmental factors external to the retarded individual contribute to the shaping of specific personality tendencies and behavioral traits in the child. A second assumption is that the specific tendencies and traits constitute a motivational disposition depressing the performance of the children. The environmental variables could be considered as distal factors separate from the personality and behavioral tendencies that would be considered as the proximal factors determining motivation. A third assumption is that the environmental factors in concert with the behavioral and personality tendencies generate in the children a set of beliefs that enhance the personality and behavioral tendencies, thus perpetuating their low level of performance. Hence, a cycle of self-confirming prophesy is formed wherein the cognitive-motivational beliefs function as the motor and rationale for low performance, inhibiting any change, even if the environmental circumstances or other factors change.

External environmental factors. Major environmental factors that contribute to the shaping of the personality and impact the performance of low-ability children are social deprivation, amplified by parenting style and environmental stimulation. Social deprivation is defined as including the following factors: “lack of continuity of care by parents or caretakers, an excessive desire by parents to separate from or institutionalize their child, impoverished economic circumstances, and/or a family history of marital discord, mental illness, abuse, or neglect" (Merighi, Edison, & Zigler, 1990, p. 16). This complex of variables, assessed by the Social Deprivation Scale (Butterfield & Zigler, 1970), has been shown to adversely affect the behavior of retarded children; for example, their dependence and wariness (Balla, Butterfield, & Zigler, 1974; Zigler & Hodapp, 1986). It should be noted that adverse social experiences may also occur outside the family, in institutions and other frameworks for the mentally retarded (Zigler, 1971).

In addition, a negative effect on motivation can be attributed to the increased frequency of failures that retarded children experience (Raber & Weisz, 1981). It may enhance their readiness to anticipate failure and promote the conception that failure is due to low ability, as a stable and uncontrollable cause (Dweck et al., 1978). An affiliated factor is exposure to the "mentally retarded" label that was shown to promote frustration and helplessness in low-ability children (Bromfield, Weisz, & Messer, 1986; Weisz, 1981a). Maternal directiveness is a further environmental factor with a potentially broad range of effects. It is considered as an overly didactic, pressuring, and intrusive style of parenting that focuses on solving the child's problems and improving the child's intellectual performance at the expense of attaining other goals (Hodapp & Fidler, 1999).

Finally, the extent of environmental stimulation may also be an important issue. Clinical experience and developmental research reveal the importance of environmental stimulation on children's social, emotional, physical, and cognitive development (Shonkoff & Phillips, 2000). There is evidence that extremely low levels of stimulation (e.g., children raised in orphanages) negatively impact the rate and extent of development. Inadequate stimulation may have adverse effects, for example, on verbal behavior (Schlanger, 1954). However, Hodapp and Fidler (1999, p. 231) note that "children with mental retardation may have difficulties in handling too much stimulation." For these children, the line between satisfying stimulation and overstimulation can be thin, requiring particular consideration of type, pace, timing, and nature of provided stimulation, so as to avoid reactions such as withdrawal or loss of control on the part of the children (Zigler & Hodapp, 1986).

Personality and behavioral factors. A large body of data accumulated over four decades has resulted in identifying a set of behaviors and personality tendencies in retarded individuals that was shown to adversely impact their level of performance. Although each of these tendencies may also appear in individuals who are not retarded, it is characteristic of retarded children that they mostly have all or most of these tendencies, and each of them to a heightened degree. Hence, these tendencies may be considered as constituting the motivational disposition of retarded individuals.

The set of personality tendencies include first and foremost the following: (a) the *positive reaction tendency*, which is manifested in an enhanced motivation to interact with and be dependent on an adult providing support (Balla & Zigler, 1975; Harter, 1967); (b) the *negative reaction tendency*, which is manifested in wariness and withdrawal shown initially by the children when they are expected to interact with unfamiliar adults (Zigler, Balla, & Butterfield, 1968); (c) *low expectancy of success* manifested by the children when confronted with a new task, amplified by a high expectancy of failure, low-degree of risk taking, and weak tendency to delay gratification (Bennett-Gates & Kreitler, 1999; Kreitler & Zigler, 1990); (d) *outerdirectedness*, defined as the tendency to look to others for solutions and guidelines in regard to cognitive tasks that seem difficult or ambiguous (Bybee & Zigler, 1999); and (e) *low effectance motivation* that entails the tendency not to derive any pleasure from coping with difficult problems (Bennett-Gates & Zigler, 1999).

This set of tendencies is amplified by further tendencies, most of which are related to the mentioned ones or represent their variants: (g) *rigidity* or the tendency to persevere in manifesting the same responses even when they are wrong or difficulty in switching to other responses (Kounin, 1941a, 1941b); (h) *learned helplessness*, defined as deficits in response initiation and perseverance due to the feeling that one has no control over certain outcomes (Reynolds & Miller, 1985; Weisz, 1981b); (i) *task-extrinsic motivation* – that is, motivation to do a task that depends on external rewards or circumstances rather than on characteristics inherent to the task itself, such as creativity or challenge (Switzky, 1997); (j) the *reinforcer hierarchy*, which designates the child's degree of responsiveness or interest in rewards of different kinds, whereby retarded children are more responsive to tangible rewards (e.g., candy) than to intangible ones (e.g., praise for being correct) (Harter & Zigler, 1974; Zigler & Unell, 1962); (k) *low self-image or self-concept*, which particularly reflects a sense of inferiority, lower readiness to rely on oneself, and only small disparity between the images of the self and the ideal self (Glick, 1999).

Each of the mentioned personality tendencies was shown to be manifested to an increased degree in retarded individuals and to account for cognitively lower-level performance. These personality tendencies account for a significant portion of the variance differentiating between retarded and non-retarded children, especially in regard to mentally retarded children of the cultural-familial etiology and those diagnosed with only mild retardation.

Cognitive-motivational factors. The cognitive performance of retarded children was shown to depend in varying degrees on personality and behavioral tendencies that could be accounted for largely by the environmental circumstances characteristic for these children. In addition, there is evidence – based on studies done in the framework of the cognitive orientation theory (Kreitler & Kreitler, 1988) – that the personality and behavioral tendencies are also supported by motivationally relevant cognitions. The cognitions that have a motivational function in regard to behavior are characterized in terms of form and contents (Kreitler, 2004). From the point of view of form, the cognitions are of four types of beliefs: (a) beliefs about self that refer to informations and other facts about oneself in the present or past (e.g., I am lazy, I am not intelligent, I hate being ordered around); (b) general beliefs that refer to informations and other facts about others and reality (e.g., trying hard can sometimes help, some teachers help you when you ask them); (c) norm beliefs that refer to rules and standards concerning ethical, social, behavioral, and other acts or events (e.g., at school one should do what the teacher says, if asked a question one ought to answer); and (d) goal beliefs that refer to goals and wishes in different domains (e.g., I want to have many friends, I wish to be loved by everyone).

From the point of view of contents, the beliefs that play a role in regard to motivation represent underlying meanings relevant for the behavior in question, detected in a series of pretest interviews. The cognitive orientation questionnaires for the retarded children were constructed so that each kind of studied behavior was represented by a focal situation, and the child was asked questions about different meanings related to that behavior that referred separately to the four belief types. The studied behaviors were rigidity, responsiveness to tangible and intangible rewards, and responses to success and failure (increase or decrease in performance after each). For example, questions concerning rigidity referred to fear of punishment, limited possibilities for doing things, trying harder when a task gets difficult, and keeping track of one's responses. A low score in the cognitive orientation of rigidity was given to a child whose responses showed that he/she believed that there was no need to be afraid of punishment, that there were many different ways of doing things, that trying harder could be helpful when a task gets difficult, and that it is necessary to keep track of one's previous responses in order to be able to comply with the instructions for a task.

The results showed that the cognitive orientation scores significantly predicted the children's behaviors in the studied domains. This indicates that the children's performance in different cognitive tasks matched the beliefs that reflect specific motivational orientations. Hence, for example, rigidity of retarded children in cognitive tasks is as much a function of motivational tendencies as a cognitive behavior. The same holds in regard to the other studied behaviors.

Thus, the motivational tendencies that affect the retarded children's cognitive performance are manifested both on the behavioral level and on the cognitive level. This indicates that the motivational tendencies are indeed deeply ingrained. On the other hand, it also provides a venue for affecting the children's behavior by changing their motivationally orienting beliefs. In some cases, changing beliefs may be a more straightforward and simpler way of changing the children's behaviors than changing them by means of rewards and training or by changing the long-term environmental conditions responsible for many of these behaviors. Changing, in playful discussions, the children's beliefs about the themes relevant for rigidity brought about a significant decline in the children's behavioral rigidity (Kreitler & Kreitler, 1988, pp. 109–111).

Concluding remarks. A large body of data shows that motivation plays an important role in determining the cognitive performance of children at the lower end of the IQ curve. The motivational factors are manifest in the behavior of the children, in their personality, and in the motivationally orienting beliefs they have. The evidence about the impact of motivation is of great importance in regard to the interactions of cognition and motivation, especially because of the nature of the studied population. As it is obvious that in retarded children the etiology, including sometimes the genetic background, plays a definite role, the evidence that motivation is a factor of such great importance in determining cognitive performance indicates that considering cognition without motivation is not the advisable or productive approach.

FACTORS INFLUENCING PERFORMANCE AT THE HIGHER END OF THE IQ CURVE

Robinson et al. (2000) argue that gifted individuals should be considered in terms of parameters similar to those applied in regard to retarded individuals, although the precise concepts and results will differ. Thus, for example, the mismatch between chronological age and mental age is evident at both ends of the IQ curve as well as divergence from the norm and possible difficulties of functioning in standard academic frameworks, although for different reasons.

Notably, "the differentiated model of giftedness and talent" (Gagné, 2000), which is one of the better-known approaches in this field, lists six components that need to be considered in handling giftedness: the natural abilities (giftedness as such), chance, the environmental catalyst, the intrapersonal catalyst, learning or practice, and talent, considered as outcome. Natural abilities may be considered as paralleling the etiology and learning/training are the behaviors that enable cognitive performance, while chance as well as the environmental and intrapersonal catalysts are the environmental and personality factors that can facilitate or hinder the learning or training necessary for becoming talented. This approach clearly reflects the conception that the manifestation of giftedness is a function of multiple factors, including motivation. This assumption is shared by most investigators in the field. According to Renzulli (1978), gifted behavior consists of behaviors that reflect an interaction among three basic clusters of human traits – above-average ability, high levels of task commitment, and high levels of creativity. Sternberg and Davidson (1986), in their review of conceptions of giftedness, have shown that most investigators define giftedness in terms of multiple qualities. In addition to IQ scores, they include qualities that are not intellectual – mainly motivation, high self-concept, and creativity. These examples provide the theoretical justification in the present chapter for discussing giftedness or high ability in terms of the same three headings used for the individuals at the lower end of the curve.

External environmental factors. Important environmental factors in regard to giftedness include the socioeconomic circumstances, family atmosphere, support provided by the family, schooling, and the treatment of the child as “divergent” by the community at school as well as at large. A major determinant of the development of talent in the gifted is the opportunities for learning and training that the gifted individual can get. The environment plays a major role in the nurturance of higher intelligence or giftedness (Lens & Rand, 2008; Tannenbaum, 1986). Giftedness and talent require a special environment, just as lower intelligence does. The environment must be enriching and encouraging, considerate of the extra-high developmental levels of the children (Sakar-DeLeeuw, 1999). Adequate educational frameworks are a necessity in order to enable an appropriate cognitive development as well as to prevent boredom and frustration and take care of the so-called asynchrony gap that may lead gifted children to the extreme of unconsciously developing deficits (Grobman, 2006). Educational opportunities may vary in appropriateness, the stimulation they provide, and the degree and nature of achievement for the student that they enable. Runco (2007, pp. 177–212) has reviewed a broad set of studies showing what teaching and adequate classroom organization can do for promoting creativity or inversely depressing it. Educational programs geared for the gifted have not always existed in most countries or schools, and even nowadays are not a commodity that may be expected to exist in most educational frameworks. Furthermore, the educational means should be available continuously from the initial level of preschool through elementary school and secondary schools to the university. Often, education for the gifted exists only up to a certain level, say, the end of elementary school, leaving the gifted individual stranded after that (Feldhusen, 1985).

Another important factor in providing good educational opportunities for the gifted are the socioeconomic circumstances of the parents and the support they can or are ready to provide. Sometimes parents are not aware of the giftedness of their child or of their role in promoting the child's development. Beyond that, parents may be too engrossed in economic difficulties or family problems to be able to devote enough attention to the gifted child at home and mobilize the financial and emotional resources necessary for promoting the child's development (Olszewski-Kubilius, 2008). Thus, the educational development of the gifted individuals depends, on the one hand, on the availability and accessibility of the adequate educational programs and, on the other hand, on family status and support (Gagné, 1991; Tannenbaum, 1986).

In addition, the fact that gifted individuals are exceptional and may often differ from others in many characteristics may also create a problem that is not dissimilar from that of labeling in regard to the mentally retarded. Plucker and Levy (2001, p. 75) have noted that, "in this culture, there appears to be a great pressure for people to be 'normal' with a considerable stigma associated with giftedness or talent." As a consequence, gifted individuals tend to suffer from isolation, especially those with no social network of gifted peers. In order to gain popularity, they may try to hide their abilities, for example, by means of underachievement or the use of less sophisticated vocabulary (Swiatek, 1995). Notably, isolation may be eased by being able to function in social frameworks with similarly gifted children.

In sum, environmental conditions, including adequate educational frameworks and social settings, are of prime importance for promoting the full manifestation of the cognitive abilities of gifted children. However, environment plays a role in regard to giftedness beyond educational possibilities. In the workplace, the prevailing atmosphere and available incentives play an important role in determining the extent of original and creative outputs of the gifted individuals. Studies show that the performance of the gifted in the workplace depends largely on factors, such as challenge, autonomy in choosing means for attaining goals, matching people with the right assignments, sufficient resources, supportive teams where members share the excitement and readiness to help and recognize each other's talents, information sharing, readiness to accept new ideas, collaboration, and organizational encouragement in the form of praise and rewards (Amabile, 1998; Dorst & Cross, 2001; Nonaka, 1991; Sullivan & Harper, 2009).

Personality and behavioral factors. A large body of data presents information about personality tendencies and behaviors characteristic of the gifted. We will briefly describe some of the major ones, mentioned in multiple studies, grouped into clusters (Coleman & Cross, 2008; Friedman-Nimz & Skyba, 2009; Jackson, Moyle, & Piechowski, 2009; Lens & Rand, 2008; Sekowski, Siekanska, & Klinkosz, 2009).

(a) curiosity, inquisitiveness, childlike sense of wonder, desire to know, openness to experience and a broad range of interests; perceptiveness, good sense of observation, sensitivity to small changes in the environment, awareness of things that others do not perceive, and perceiving the world differently than others; heightened sensory awareness that may take the form of overexcitabilities or supersensitivities in one or more of the following domains: psychomotor, sensual, emotional, intellectual, and imaginational;
(b) tolerance for ambiguity and complexity, considering situations from many points of view;
(c) independence, nonconformity, autonomy, questioning rules or authority;
(d) perfectionism, setting high standards for self and others, high achievement drive, being critical of oneself;
(e) feeling different from others, sometimes out of step with others, but compassionate and interested in others and their problems;.
(f) passionate, having intense feelings;
(g) tendency for risk-taking;
(h) need sometimes to withdraw, need for solitude and periods of contemplation;
(i) having high moral standards, being disturbed by inequity, exploitation, corruption, and needless human suffering.

This list, even though it is partial, shows that the personality tendencies characteristic for the gifted serve to enhance the likelihood of exceptional products by the gifted. Their curiosity, attentiveness to the environment, achievement motivation, independence, and moral standards are guarantees that the giftedness will be manifested in original, creative, and useful outputs.

However, it has been noted that some of the personality tendencies of the gifted may be manifested in forms that will not be conducive to excellence or may even hinder it. For example, the broad range of interests may lead to losing focus and dealing with too many projects; the nonconformism may lead to stubbornness, rejection of authority, poor collaboration with others, and difficulties of functioning in social frameworks; the tendency for overexcitabilities may lead to overload of stimulation and withdrawal from others; the high achievement drive coupled with perfectionism and exaggerated self-criticism may result in withdrawing from action and giving up too soon when the high standards set for oneself cannot be attained (Reis & McCoach, 2002; Schuler, 2002).

Some of the personality tendencies seem likely to create problems in the domain of interacting with others. For example, feeling different and sensing one's intellectual superiority may lead to a feeling of isolation, of not being understood, and of general frustration. One result could be underachievement (Rimm, 2008). Some investigators noted more extreme manifestations in the gifted that appear to be similar to symptoms of hyperactivity, bipolar disorder, ADHD, autism spectrum conditions, and other psychological disorders that undoubtedly depress intellectual performance (Friedman-Nimz & Skyba, 2009; Jackson et al., 2009). Hence, in the gifted, personality and behavioral tendencies were shown to function either for promoting cognitive performance or hindering it.

Cognitive-motivational factors. As in the case of individuals at the lower end of the IQ curve, at the higher end of the curve there are also correlates of motivation on the cognitive level. In terms of the cognitive orientation theory, the cognitive-motivational correlates of creativity consist of beliefs in the form of four belief types (about oneself, reality and others, rules and norms, and goals and wishes) referring to the following 11 groupings of themes: 1. Self-development (investing, promoting, and guarding oneself); 2. emphasis on the inner world (identifying, knowing, developing, and expressing one's thinking, feeling, and imagination); 3. inner-directedness (emphasis on one's desires, will, and decision, self-confidence in one's ability to succeed); 4. contribution to society (concern with contributing something meaningful to the community or society even if it does not involve personal advancement); 5. awareness of one's own uniqueness as an individual (emphasis on oneself as an individual unique in one's talents and way of perceiving, behaving, and being, not necessarily due to nonconformity); 6. freedom in acting (need to act in line with rules and regulations set by oneself rather than by others); 7. restricted openness to the environment (readiness and need to absorb from the environment knowledge and inspiration coupled with resistance to being overwhelmed and harmed by too much openness); 8. acting under conditions of uncertainty (readiness to act under conditions of uncertainty concerning the results, with no control over the circumstances, a tendency which may resemble risk-taking); 9. demanding from oneself (demanding from oneself effort, perseverance, giving up comfort and readiness for total investment despite difficulties and even failures); 10. self-expression (concern with using one's talents and expressing oneself with authenticity and characteristically); 11. nonfunctionality (readiness to act even if functionality is not clearly evident from the start).

These groupings form two factors, in line with the results of confirmatory factor analysis. The first and main factor is saturated mainly on the following groupings: self-development; emphasizing one's uniqueness; self-expression as well as demanding from oneself; contributing to society; and emphasis on one's inner world. The emphasis seems to be mainly on the self – its uniqueness, development, and expression. The second factor is saturated mainly on the following groupings: freedom in functioning; being receptive to the environment; absorbing from the environment; functioning under conditions of uncertainty; nonfunctionality; as well as inner directedness. The different groupings deal with the relations between the self and the environment, whereby, on the one hand, there is emphasis on receptiveness and absorption from the environment and, on the other hand, there is emphasis on keeping inner directness and freedom from potential restrictions such as uncertainty and functionality. Hence, the second factor was labeled as maintaining openness to the environment without endangering inner directness.

The questionnaire scores of the cognitive orientation of creativity were related to manifestations of creativity in various domains, including teaching, designing, and engineering, assessed by a variety of objective measures (Casakin & Kreitler, 2008, 2010; Kreitler & Casakin, 2009; Kreitler & Kreitler, 1990; Margaliot, 2005; Richter, 2003). Notably, the same two factors of the cognitive orientation of creativity were identified in different samples. This confirms the validity and structure of the cognitive orientation questionnaire. The questionnaire is also being applied for identifying differences in cognitive-motivational correlates of creativity in different samples. For example, in engineers the second factor is loaded on pro-functionality and is stronger than the first (Casakin & Kreitler, 2010, 2011; Kreitler & Casakin, 2009).

Concluding remarks. The findings of studies in regard to the gifted demonstrate the important role that motivational factors play in regard to the manifestations and flourishing of giftedness. Environmental circumstances, personality tendencies, and cognitive-motivational correlates need to be considered in order to understand why, in the case of a certain gifted individual, the high ability and intellect became manifested and led to extraordinary outputs but in the case of other similarly endowed individuals the outputs were at best mediocre.

GENERAL CONCLUSIONS

This chapter dealt with the effects of motivation on cognitive functioning in two groups of individuals extreme in regard to intellectual ability. The reason for focusing on these two groups is the common assumption that in view of the evident status of intelligence in the retarded and in the gifted, motivation appears to be of little consequence, if at all. The evidence provided in this chapter about the role of motivation precisely in regard to these two groups provides a strong argument in support of the dependence of cognitive functioning on motivation.

Notably, the factors that were reviewed as impacting motivation were of three kinds: environmental circumstances, personality tendencies, and cognitive-motivational correlates. It was found that the same groups of factors influence cognitive performance in the two groups of individuals. Furthermore, in some cases, it became evident that motivational factors depressing performance in the retarded or promoting it in the gifted were contrasts, such as outerdirectedness in the former and innerdirectedness in the latter group.

Observations of this kind indicate that one of the next steps in the study of the interactions of cognition and motivation could be the development of a theory of motivation that would be comprehensive both in its structure – including environmental, personality, and cognitive factors – and its application – to individuals at all levels of ability.

References

Amabile, T. M. (1998). How to kill creativity: Keep doing what you're doing. Or, if you want to spark innovation, rethink how you motivate, reward, and assign work to people. *Harvard Business Review* (September–October), 77–87.

American Psychiatric Association (APA) (1966). *Diagnostic and statistical manual* (2nd ed.). Washington, DC.

(1980). *Diagnostic and statistical manual* (3nd ed.). Washington, DC.

Balla, D., Butterfield, E., & Zigler, E. (1974). Effects of institutionalization on retarded children: A longitudinal, cross-institutional investigation. *American Journal of Mental Deficiency*, **78**, 530–549.

Balla, D., & Zigler, E. (1975). Preinstitutional social deprivation and IQ changes among institutionalized retarded children. *Journal of Abnormal Psychology*, **75**, 83–89.

Bennett-Gates, D., & Kreitler, S. (1999). Expectancy of success in individuals with mental retardation. In E. Zigler & D. Bennett-Gates (Eds.), *Personality development in individuals with mental retardation* (pp. 130–144). NY: Cambridge University Press.

Bennett-Gates, D., & Zigler, E. (1999). Effectance motivation and the performance of individuals with mental retardation. In E. Zigler & D. Bennett-Gates (Eds.), *Personality development in individuals with mental retardation* (pp. 145–164). NY: Cambridge University Press.

Bromfield, R., Weisz, J. R., & Messer, T. (1986). Children's judgments and attributions in response to the "mentally retarded" label: A developmental approach. *Journal of Abnormal Psychology*, **95**, 81–87.

Burack, J. A. (1990). Differentiating mental retardation: The two-group approach and beyond. In R. M. Hodapp, J. A. Burack, & E. Zigler (Eds.), *Issues in the developmental approach to mental retardation* (pp. 27–48). NY: Cambridge University Press.

Butterfield, E., & Zigler, E. (1970). Preinstitutional social deprivation and IQ changes among institutionalized mentally retarded. *American Journal of Mental Deficiency*, **70**, 48–56.

Bybee, J., & Zigler, E. (1999). Outerdirectedness in individuals with and without mental retardation: A review. In E. Zigler & D. Bennett-Gates (Eds.), *Personality development in individuals with mental retardation* (pp. 165–205). NY: Cambridge University Press.

Casakin, H., & Kreitler, S. (2008). Place attachment as a function of meaning assignment. *The Open Environmental Journal*, **2**, 93–100.

(2010). Motivation for creativity in architectural design: Differences between architects and engineers. *International Journal of Technology and Design Education*, **20**, 477–493.

(2011). The cognitive profile of creativity in design. *Thinking Skills and Creativity*, **6**, 159–168.

Coleman, L. J., & Cross, T. L. (2008). Social-emotional development and the personal experience of giftedness. In S. I. Feiffer (Ed.), *Handbook of giftedness in children* (pp.203–213). New York: Elsevier.

Dorst, K., & Cross, N. (2001). Creativity in the design process: co-evolution of problem solution. *Design Studies*, **22**, 425–437.

Dweck, C. S., Davidson, W., Nelson, S., & Enna, B. (1978). Sex differences in learned helplessness: II. The contingencies of evaluative feedback in the classroom. III. An experimental analysis. *Developmental Psychology*, **14**, 268–274.

Feldhusen, J. (1985). Education for the gifted, talented- charting its growth and development. *NASSP Bulletin*, **69**, 1–11.

Friedman-Nimz, R., & Skyba, O. (2009). Personality qualities that help or hinder gifted and talented individuals. In L. Shavinina, R. Persson, L. Kreger-Silverman, S. M. Reis, D. K. Simonton, N. Colangelo, & J. VanTassel-Baska (Eds.), *International handbook on giftedness* (pp. 421–435). New York: Springer.

Gagné, F. (1991). Toward a differentiated model of giftedness and talent. In N. Colangelo & G. A. Davis (Eds.), *Handbook of gifted education* (pp. 65–80). Boston: Allyn and Bacon.

Glick, M. (1999). Developmental and experiential variables in the self-images of people with mild mental retardation. In E. Zigler & D. Bennett-Gates (Eds.), *Personality development in individuals with mental retardation* (pp. 47–69). NY: Cambridge University Press.

Grobman, J. (2006). Underachievement in exceptionally gifted adolescents and young adults: a psychiatrist's view. *Journal of Secondary Gifted Education*, **17**, 199–210.

Gross, M. U. M. (2004). *Exceptionally gifted children*. New York: RoutledgeFalmer.

Harter, S. (1967). Mental age, IQ, and motivational factors in the discrimination learning set performance of normal and retarded children. *Journal of Experimental Child Psychology*, **5**, 123–141.

Harter, S., & Zigler, E. (1974). The assessment of effectance motivation in normal and retarded children. *Developmental Psychology*, **10**, 169–180.

Hodapp, R. M., Burack, J. A., & Zigler, E. (1990). *Issues in the developmental approach to mental retardation*. New York: Cambridge University Press.

Hodapp, R. M., & Fidler, D. J. (1999). Parenting, etiology, and personality-motivational functioning in children with mental retardation. In E. Zigler & D. Bennett-Gates (Eds.), *Personality development in individuals with mental retardation* (pp. 226–248). NY: Cambridge University Press.

Jackson, P. S., Moyle, V. F., & Piechowski, M. M. (2009). Emotional life and psychotherapy of the gifted in light of Dabrowski's theory. In L. Shavinina, R. Persson, L. Kreger-Silverman, S. M. Reis, D. K. Simonton, N. Colangelo, & J. VanTassel-Baska (Eds.), *International handbook on giftedness* (pp. 437–465). New York: Springer.

Kounin, J. (1941a). Experimental studies of rigidity: I. The measurement of rigidity in normal and feeble-minded persons. *Character and Personality*, **9**, 251–272.

(1941b). The explanatory power of the concept of rigidity as applied in feeblemindedness. *Character and Personality*, **9**, 273–282.

Kreitler, S. (2004). The cognitive guidance of behavior. In J. T. Jost, M. R. Banaji, & P. A. Prentice (Eds.), *Perspectivism in social psychology: The Yin and Yang of scientific progress* (pp. 113–126).Washington, DC: American Psychological Association.

Kreitler, S., & Casakin, H. (2009). Motivation for creativity in design students. *Creativity Research Journal*, **21**, 282–293.

Kreitler, S., & Kreitler, H. (1988). The cognitive approach to motivation in retarded individuals. In N. W. Bray (Ed.), *International review of research in mental retardation* (Vol. 15, pp. 81–123). San Diego, CA: Academic Press.

(1990). *The cognitive foundations of personality traits*. New York: Plenum.

Kreitler, S., & Zigler, E. (1990). Motivational determinants of children's probability learning. *Journal of Genetic Psychology*, **151**, 301–316.

Lens, W., & Rand, P. (2008). Motivation and cognition: Their role in the development of giftedness. In S. I. Feiffer (Ed.), *Handbook of giftedness in children* (pp. 199–202). New York: Elsevier.

Margaliot, A. (2005). *A model for teaching the cognitive skill of melioration to pre-service science teachers in a college for teachers*. Unpublished doctoral dissertation, Bar-Ilan University, Ramat Gan, Israel.

Merighi, J., Edison, M., & Zigler, E. (1990). The role of motivational factors in the functioning of mentally retarded individuals. In R. M. Hodapp, J. A. Burack, & E. Zigler (Eds.), *Issues in the developmental approach to mental retardation* (pp. 114–134). NY: Cambridge University Press.

Morelock, M. (1992). Giftedness: The view from within. *Understanding Our Gifted*, **1**, 11–15.

Newman, T. M. (2008). Assessment of giftedness in school-age children using measures of intelligence or cognitive abilities. In S. I. Feiffer (Ed.), *Handbook of giftedness in children: Psychoeducational theory, research and best practices* (pp. 161–176). New York: Springer.

Nonaka, I. (1991). The knowledge creating company. *Harvard Business Review*, **69**, 96–104.

Olszewski-Kubilius, P. (2008). The role of the family in talent development. In S. I. Feiffer (Ed.), *Handbook of giftedness in children: Psychoeducational theory, research and best practices* (pp.53–70). New York: Springer.

Pfeiffer, S. I., & Blei, S. (2008). Gifted identification beyond the IQ test: Rating scales and other assessment procedures. In S. I. Feiffer (Ed.), *Handbook of giftedness in children: Psychoeducational theory, research and best practices* (pp. 177–198). New York: Springer.

Plucker, J. A., & Levy, J. J. (2001). The Downside of Being Talented (Electronic version). *American Psychologist*, **56**, 75–76.

Raber, S. M., & Weisz, J. R. (1981). Teacher feedback to mentally retarded and nonretarded children. *American Journal of Mental Deficiency*, **86**, 148–156.

Reis, S. M., & McCoach, D. B. (2002). Underachievement in gifted students. In M. Neihart, S. M. Reis, N. M. Robinson, & S. M. Moon (Eds.), *The social and emotional development of gifted children* (pp. 81–91). Waco, Texas: Prufrock Press.

Renzulli, J. (1978). What makes giftedness: Reexamining a definition. *Phi Delta Kappan*, **60**, 180–184.

Reynolds, W. M., & Miller, K. L. (1985). Depression and learned helplessness in mentally retarded and nonmentally retarded adolescents: An initial investigation. *Applied Research in Mental Retardation*, **6**, 295–306.

Richter, R. (2003). *Cognitive orientation when creatively solving engineering and business problems*. Unpublished master's thesis in Industrial Engineering, Tel Aviv University, Tel-Aviv, Israel.

Rimm, S. (2008). Underachievement syndrome: A psychological defensive pattern. In S. I. Feiffer (Ed.), *Handbook of giftedness in children: Psychoeducational theory, research and best practices* (pp. 139–160). New York: Springer.

Robinson, N. M., Zigler, E., & Gallagher, J. J. (2000). Two tails of the normal curve: Similarities and differences in the study of mental retardation and giftedness. *American Psychologist*, **55**, 1413–1424.

Ross, P. O. (1993). *National excellence: A case for developing America's talent*. Washington, DC: US Department of Education, Office of Educational Research and Improvement.

Runco, M. A. (2007). *Creativity: Theories and themes: Research, development and practice*. NY: Elsevier

Sakar-DeLeeuw, N., (1999). Gifted preschoolers: Parent and teacher views on identification, early admission and programming. *US: Roeper School Article Review*, **21**, 174–179.

Schlanger, B. B. (1954). Environmental influences on the verbal output of mentally retarded children. *Journal of Speech and Hearing Disorders*, **19**, 339–343.

Schuler, P. (2002). Perfectionism in gifted children and adolescents. In M. Neihart, S. M. Reis, N. M. Robinson, & S. M. Moon (Eds.), *The social and emotional development of gifted children* (pp. 71–79). Waco, Texas: Prufrock Press.

Sekowski, A., Siekanska, M., & Klinkosz, W. (2009). On individual differences in giftedness. In L. Shavinina, R. Persson, L. Kreger-Silverman, S. M. Reis, D. K. Simonton, N. Colangelo, & J. VanTassel-Baska (Eds.), *International handbook on giftedness* (pp. 467–485). New York: Springer.

Shonkoff, J. P., & Phillips, D. A. (Eds.) (2000). *From neurons to neighborhoods: The science of early childhood development*. National Research Council and Institute of Medicine – Committee on Integrating the Science of Early Childhood Development Board on Children, Youth, and Families, Commission on Behavioral and Social Sciences and Education. Washington, D.C.: National Academy Press.

Sternberg, R. J., & Davidson, J. E. (1986). Conceptions of giftedness: A map of the terrain. In R. J. Sternberg & J. E. Janet (Eds.), *Conceptions of giftedness* (pp. 3–20). NY: Cambridge University Press.

Sullivan, C., & Harper, G. (Eds.) (2009). *Authors at work: The creative environment Essays and Studies Collection*, Vol. 62, The English Association, UK/DS Cambridge: Brewer.

Swiatek, M. A. (1995). An empirical investigation of the social coping strategies used by gifted adolescents. *Gifted Child Quarterly*, **39**, 154–160.

Switzky, H. N. (1997). Individual differences in personality and motivational systems in persons with mental retardation. In W. E. MacLean, Jr. (Ed.), *Ellis'handbook of mental deficiency, psychological theory and research*, 3rd ed. (pp. 343–377). Mahwah, NJ: Erlbaum.

Tannenbaum, A. J. (1986). Giftedness: A psychosocial approach. In R. J. Sternberg & J. E. Janet (Eds.), *Conceptions of giftedness* (pp. 21–52). NY: Cambridge University Press.

Weisz, J. R. (1981a). Effects of the "mentally retarded" label on adult judgments about child failure. *Journal of Abnormal Behavior*, **90**, 371–374.

(1981b). Learned helplessness in black and white children identified by their schools as retarded and nonretarded: Performance deterioration in response to failure. *Developmental Psychology*, **17**, 499–508.

Zigler, E. (1958). *Social deprivation and rigidity in the performance of feeble-minded children*. Unpublished doctoral dissertation, University of Texas.

(1971). The retarded child as a whole person. In H. E. Adams & W. K. Boardman (Eds.), *Advances in experimental clinical psychology* (pp. 47–121). New York: Pergamon.

(1982). MA, IQ and the developmental-difference controversy. In E. Zigler & D. Balla (Eds.), *Mental retardation: The developmental-difference controversy* (pp. 207–211). Hillsdale, NJ: Erlbaum.

(1986). Intelligence: A developmental approach. In R. J. Sternberg & D. K. Detterman (Eds.), *What is intelligence?* (pp. 149–152). Norwood, NJ: Ablex Publishing Co.

Zigler, E., Balla, D., & Butterfield, E. C. (1968). A longitudinal investigation of the relationship between preinstitutional social deprivation and social motivation in institutionalized retardates. *Journal of Personality and Social Psychology*, **10**, 437–445.

Zigler, E., & Bennett-Gates, D. (Eds.) (1999). *Personality development in individuals with mental retardation*. New York: Cambridge University Press.

Zigler, E., & Hodapp, R. M. (1986). *Understanding mental retardation*. New York: Cambridge University Press.

Zigler, E., & Unell, E. (1962). Concept-switching in normal and feeble-minded children as a function of reinforcement. *American Journal of Mental Deficiency*, **66**, 651–657.

21

How Conscious Thought, Imagination, and Fantasy May Relate to Cognition and Motivation

Jerome L. Singer & Dorothy G. Singer

When William James laid out a vast agenda for a scientific discipline in his grand two-volume *Principles of Psychology* of 1890 (James, 1950), he placed chapters on consciousness and the self (Decartes's *je pense* and *je suis*) toward the very beginning of this work. Since then there have been several waves of influence that have tended to cast consciousness or direct experience of selfhood somewhat in the shadows. Freud and his clinical followers in psychoanalysis brought unconsciousness or thought and motivation without awareness to the fore. Behaviorism, through developing highly sophisticated experimental procedures for assessing learning and observable action sequences, in effect ostracized consciousness and imagery for half a century (Holt, 1964). Attention to consciousness began to re-emerge with the "cognitive revolution" of the 1960s and opened avenues to studying human awareness, ongoing thought, and private cognitive processing. The qualia of experience now intrigue philosophers of the mind as well as behavioral scientists and neurophysiologists (Buckner, Andrews-Hanna, & Schacter, 2008; Ciba Foundation Symposium, 1993; J. L. Singer & Salovey, 1999; J. L. Singer & Bonanno, 1990). Although new research in social cognition has also opened the way for studying out-of-awareness attitude phenomena (Hassin, Uleman, & Bargh, 2005), the importance of research on conscious thought is no longer denied.

DEFINING CONSCIOUSNESS AND IMAGINATION

What are the phenomena that characterize consciousness and the forms taken by our human imagination? We greet them earliest in the biblical accounts of dreams or waking fantasies of Jacob, Joseph, and Ezekiel. Later, we experience a shock of recognition in the imaginative narrations of Socrates and Aristophanes in Plato's *Symposium,* in the powerful interior monologues and visions of the characters presented so effectively in Shakespeare's plays, and in the past century, in the stream-of-consciousness novels of Virginia Woolf, James Joyce, and Saul Bellow, among many others. In the cinema and on television, the combination of visual imagery and "voice-over" interior monologues capture our experiences of ongoing consciousness most tellingly.

However compelling these literary examples may be, we need to move beyond intuitive anecdotal accounts of private experience to formulate scientific models of the processes and functions of consciousness (Baars, 1997; J. L. Singer & Salovey, 1999). We propose first that consciousness is reflected along three major dimensions.

1. Physical Consciousness versus Unconsciousness

Here we refer to the situation of loss of sensory awareness of one's environment or one's memories or thoughts as the result of a gross physical impact (a knock-out punch) or a psychological trauma (a terrible fright). Sleep, of course, is our more normal instance, but, as Hamlet anticipated in "To Sleep, perchance to dream /Aye, there's the rub," we know now from laboratory studies that dreaming occurs regularly to us all through these nightly periods of somnolence. For our purposes, the sheer physical manifestation of consciousness, however important for brain research and definitions of life and bodily health, is not central to our chapter.

2. Perceptual and Information Processing Consciousness

This form of consciousness is perhaps the one most extensively studied now by neurophysiologists and philosophers of the mind as well as by psychologists interested in attention; perception; the encoding, retention, and retrieval of properties of memory; and effortful learning. Although it is clearly the basis for the processes of ongoing thought and imagination, it is dealt with more extensively elsewhere in this volume, more generally in studies of cognition and information processing.

3. Reflective Thought and Self-Sware, Self-Directed Consciousness

Attentive, perceptual cognitive processes establish one's orientation in the physical environment and, to some extent, the social milieu, but we can identify a third dimension of consciousness designated by Johnson (1997) in her analysis of memory as "reflective processing," and even earlier by H. Kreitler and S. Kreitler (1976) as "cognitive orientation and the assignment of meaning." As Johnson notes, "Reflection allows one to go beyond the immediate consequences (both direct and associative) of stimulus-evoked activation … [in contrast with perception] reflection is endogenously generated cognition" (Johnson 1997, p. 137). The Kreitlers' cognitive orientation system may begin operation in pure perceptual consciousness. The "noting, refreshing and reaction" and the "discovering, retrieving and rehearsing" features of Johnson's levels of reflective processing open the way for more complex meaning assignments that we experience as self-directed control and awareness of our memories, intentions, and wishes. It is this third level of consciousness that we will emphasize here.

Baars (1997) has provided a detailed model of the domain of consciousness we are addressing. He terms it a "theater model," in which "working memory" (comparable to reflective processes) is like the stage on which anything from rehearsing memories to repeating and reshaping our life narratives can occur. This working memory is manifest through "inner speech" and "visual imagery." There is a kind of competition between which "actors" or different memories, wishes, intentions, or reconstructions of life experiences can compete for the limited access to the "stage of consciousness." We say limited access because, considering the vast accumulation of information we are storing and reprocessing, consciousness – like a stage or, in an earlier metaphor of Baars, a computer workspace – has a restricted channel capacity.

We are inclined to modify Baars's focus on external stimulation by adding to his use of "outer senses" a person's awareness of "body mechanism operation" such as stomach gurglings, aches and pains, or muscles twitches. For his reference to "inner sense" we would add other imagery modalities besides the visual. As Spurgeon's (1961) research on Shakespeare has shown, the Bard's great range of references to smell, touch, taste, and auditory images distinguishes him from his contemporary poets and playwrights. These rich images very likely resonate so well with our own recollections of sensory experience that we are more strongly attracted to his poetry, prose, and vivid characterizations.

We propose, in contrast with psychoanalytic theorizing, that a great deal of what may seem unconscious may have been "on stage" from time to time as part of the nearly endless rehearsing and retrieving that characterizes our stream of consciousness. Unless we participate in thought-sampling methods, we often do not notice how many times we have remembered past events, anticipated future events, or playfully created a range of fantasies (Singer, 2006). What may seem to be intuitive discoveries, surprising unintended thoughts, or the smoothly run off organized mental structures such as schemas and scripts may well be automatized, overlearned materials that were often consciously rehearsed (Singer & Salovey, 1991).

Imagination may best be regarded as a facet of ongoing consciousness that reflects what Bruner (1986) has called "narrative thought" in contrast to "paradigmatic thought," and what Epstein (1999) designated the "experiential" side of his Cognitive-Experiential Self-Theory. The experiential mode, as Epstein stresses, is more closely linked to emotionality. The rational form of thought in Bruner and Epstein's systems is characterized by deliberateness and greater effort. It operates through abstraction and verbal or mathematical thought. As Bruner suggests, it strives for "truth," correct, convergent answers. The narrative or experiential mode involves the more spontaneous accumulation of concrete experiences or what cognitive researchers called "episodic memories" aiming toward what Bruner calls "verisimilitude" or the elaboration of story-like, emotionally laden skeins of conscious sequences. Both forms of thought are potentially adaptive and may work in concert as a feature of creative work in the sciences as well as in business or the arts.

COGNITION, EMOTION, AND MOTIVATION

Let us now attempt to set our human imaginative processes within an integrated framework linking cognition to emotion and motivation. We propose that the overarching motivational structure for our genus is cognitive. We seek from birth to organize and give meaning to experience (H. Kreitler & S. Kreitler, 1976). This cognitive striving incorporates the range from bodily needs of satisfying hunger, thirst, sexual arousal, and pain avoidance to more global motives of *attachment* and *affiliation*, ("community"), as against *autonomy* and *self-realization* ("agency") (Bakan, 1966), or in Blatt's (2008) recent massive research review, *relationship and self- representation*. The labeling, encoding, and periodic mental rehearsal or anticipation of our motives make up a considerable proportion of the variability of our stream of consciousness, as Klinger (1999) has shown in his research on "current concerns."

In our processing of information, we must not only organize it into logical structures but also examine the alternative and future possibilities or even consider the darker alternatives that appear in any new human experience. Indeed, we store information, as is increasingly clear in memory research, by organized verbal schemas, on the one hand, and narrative episodes or possibilities in the form of fantasies and daydreams on the other (Singer, 1985; Singer & Salovey, 1991). Narrative thought and subjunctive structure reflect the human capacity for what the great neurologist Kurt Goldstein (1940) called "taking an attitude toward the possible." He believed this capacity reflected the optimal functioning of a healthy and intact brain. Through this orientation to the possible, one becomes capable of potential futures or – in effect – a virtual relit of traveling through time and space to a different or "better" childhood or maturity.

This capacity for reconstructing one's past or for planning for one's daily activities through mental rehearsal or simply daydreaming about future vacations, sexual opportunities, or fantastic space adventures also serves a broader function. Our imagination liberates us from the tyranny of *this* place, of *these* particular duties and obligations, of *these* particular people in our social milieu. We accomplish these metamorphoses not only through the abstraction of high-level logical or mathematical processes but through our capacity for creating narrative and using our skills at imagery to provide us with alternative temporary environments that we can manipulate for self-help and ultimately put into service of orderly living or simply sustaining hope and effort (Singer, 1974a; Singer, 2006; Singer & Bonnano, 1990; Taylor, 1989).

We can now conceive a new model of the human being. Even babies and children are information-seeking organisms striving to organize and integrate novelty and complexity. They are curious and exploratory, but also more likely to feel comfortable and smile once they can experience control over novelty and assimilate new information into prior concepts and scripts about the sequence of events. The signs of positive emotion (smiling and laughter associated with familiarity in adults) suggest that although cognition and emotion may be different systems in terms of bodily structure, they are closely related in actual human response (Demos, 1995; Izard, 1977; H. Kreitler & S. Kreitler, 1976; Mandler, 1984; Tomkins, 1962).

Theoretical analyses initiated by Silvan Tomkins have contributed greatly to the paradigm shift toward the cognitive-affective view of the human organism. Tomkins's work has succeeded in putting emotions back at the center of active research in personality and social psychology. The fact that human beings are continuously assigning meaning and organizing their experience in schemas and scripts does not preclude a significant motivational role for affect or emotion. With the support of increasing empirical research carried out both on children and adults by investigators such as Carroll Izard (1977), Paul Ekman (1973), Ekman, Friesen, and Ellsworth (1982), and many others, we can now regard human beings as showing differentiated emotional response patterns that are closely intertwined with responses to the novelty, complexity, and other structural properties of information confronted from moment to moment (Demos, 1995; Shapiro & Emde, 1992; Singer & Singer, 2005).

The cognitive-affective perspective broadens our conception of human motivation considerably. Rather than reducing all human motivation to some symbolic reflection of infantile sexuality or aggression, one can propose that the basic emotions that have now been shown to exist across human species in the research of Ekman and Izard are motivating human beings in dozens of different situations independent of presumed drive pressures. Human beings seek – as Tomkins has proposed – to reconstruct, in overt action or in thought, situations that evoke the positive emotions of interest-excitement or joy. They seek to avoid in action or thought those situations that have evoked specific negative emotions of anger, fear-terror, sadness-distress (weeping), or the complexes of shame-humiliation-guilt. Human beings are further "wired-up" to express emotions as fully as possible and finally to control emotional expression where social experience suggests such control is necessary, either for safety or to avoid humiliation. Situations that permit experience and expression of positive emotions or that allow appropriate control of negative emotion are intrinsically positively reinforcing. Those situations that are more likely to evoke negative emotions – such as fear, anger, distress, or shame – or that have blocked the expression of socially adaptive control of emotions may be experienced as inherently punishing or negatively reinforcing (Singer, 1974b; Tomkins, 1962, 1981).

Memory and anticipation become central features related to emotional experience. Identifying, labeling, and gradually organizing new information into mental representations that are technically labeled as schemas accomplishes this. These structures include schemas about persons or physical objects, schemas about self and others, and scripts about action sequence or prototypes that become means for encapsulating a variety of common features of situations and persons into one fuzzy concept (Mandler, 1984; Mandler, 1988; J. L. Singer & Salovey, 1991).

The avoidance of negative affects, seeking to maximize the positive effects of joy and excitement-curiosity, expressing of emotions and yet also managing to control emotions may reflect the overarching link of affects to cognition. We must, however, also call attention to the two major human polarities of community and agency because these, in varied expressions, form much of the content of our conscious thought. A wide range of research of psychopathology, healthy behaviors, and interpersonal interactions support the notion that humans throughout life are seeking a balance between personal intimacy and group affiliation, on the one hand, and autonomy or self-actualized individuality, on the other (Blatt, 2008; Bonanno & Singer, 1990). Whether expressed as memories (Singer & Salovey 1993), intrusive thoughts about self and others (Singer, 2006), or current concerns and wishes (Klinger 1999, Singer, 2002), our conscious mentation largely represents content involving our affiliative or agency needs.

THE EMERGENCE OF CONSCIOUS THOUGHT FROM CHILDREN'S PLAY

We propose that the major foundation for the development of a complex and relatively self-directed consciousness is laid in the period between two and six years of age, when the child initiates and elaborates make-believe or pretend play. Such play is characterized by the child's mimicking adult behavior by feeding herself with an empty coffee cup, then moving on to the more advanced concept of feeding a toy animal or doll with an empty cup and admonishing her plaything to "Drink it all up!" Soon, a few blocks can become a pretend village, peopled with toy figures or even invisible ones in which, as the child grows older, a relatively lengthy narrative may unfold.

Consider the cognitive-affective dilemma of the preschool child. He or she must make sense of a complex world by gradually assimilating the bigness and strangeness of people, animals, and objects such as cars, airplanes, or trucks into a limited range of schemas and scripts. A child may react with fear when first faced with extreme novelty that cannot at once be assimilated into established structures. The child may respond with a smile of pleasure once a match can be made between new information and some well-known schema, and the novelty or ambiguity of the environmental situation can be assimilated. When the new situation is only moderately complex and some overriding schema is still available, the child may move to explore the novelty in the situation, and this evokes the positive affects of interest and excitement. Children and adults live in a situation of perennially delicate balance between the potential for fear or anxiety evoked by new situations and the excitement of exploring such situations. By such exploration, one can assimilate incongruity into established schemas, enrich such schemas, or start to form new ones. The persistence over time of large amounts of unexpected or ambiguous information evokes the negative effects of anger or distress and sadness (Singer & Singer, 2005; Tomkins, 1962). We all learn to bring sets of expectations of what may occur to each new situation. We practice such expectations through brief anticipatory fantasies, some more realistic than others depending on our maturity, the complexity of our schema structure, and our social development. Our task in each new situation is to examine new information and determine whether it confirms or disconfirms some of our anticipations.

What seems to be the intrinsic unmotivated character of play to an adult represents the child's continuing effort to create new meaning structures and provide itself with a sense of control and power by reducing large-scale settings, persons, or social interactions to meaningful structures that can be assimilated into the as-yet limited number of schemas the child has at its command. The startle responses or terror evoked in a toddler by the size and noise of a huge passing truck may be gradually transformed into curiosity and interest as the child attempts to reproduce the noises and movements of the truck through creating its own sound effects and manipulating blocks or toy trucks. Imaginative play may thus be understood as a means by which the uncontrollable qualities and complexity of one's physical and social environment can be gradually miniaturized and manipulated. In effect, we can see that much of human thought involves a similar effort to create, at least temporarily, a world one can control through replaying memories or anticipation and fantasy. Indeed, it can be argued that the very act of rehearsal and anticipation or even of elaborating possible future events in somewhat more bizarre fantasies may gradually approximate possible situations we do encounter. Such mental rehearsal may leave us better prepared to handle these, or at least be less frightened by them when they do occur (Singer & Singer, 2005).

With the conceptual framework of the agency-autonomy or Blatt's relational versus self-representation dialectic, the child's make-believe world is one that represents a continuous working out of the tension between the need for closeness and affiliation and the need for privacy with its concomitant experience of personal power and individuality. Indeed, the very act of beginning to form individualized images, memories, and anticipatory fantasies becomes, in our crowded and sensory-bombarded world, the last refuge for an experience of individuality and personal privacy. For the developing child seeking the "story line," it can simulate sustained relationships with parents and others. It can also create private games by floor play or enacting a relationship with a personally possessed stuffed animal or even an invisible playmate, thus establishing that experience of individuation that also seems so necessary in our human condition.

In view of this persistent human attachment-individuation tension, the emergence of an increasingly complex imaginative dimension subject to reasonable control (a kind of cognitive skill in itself) sustains the need for self-definition, a sense of uniqueness, and private power. The child must learn gradually to establish priorities in the direction of attention, whether toward the environment or material recurring from memory or forming itself into fantasies. Our practical survival may well demand that we assign a somewhat higher priority to the processing of externally generated stimulation. Our affective development must also involve reflection, introspection, the capacity to enjoy private experiences, gradually shape and direct them, to plan and also create stories, and mentally to manipulate the range of future possibilities. For young children with limited motor and linguistic capacities and a smaller and less differentiated range of stored schemas and scripts, the balancing of such priorities may be reflected in the varying amounts of physical, rule-oriented, or social and imaginative play in which they engage.

Of special importance is the conception of transformation or the emergence through play of what Alan Leslie (1987) in a fine paper has called a *metarepresentational mode of thought*. Leslie's argument is that a major step in development involves the "decoupling" of the direct representations we sustain of objects, persons, or situations from their perceptual images into a new set of metarepresentations that are symbolic or mental representations of the same original set of objects, but now treated as part of an entire system of thought that one can modify, manipulate, analogize, or transform to metaphor. With the help to some extent of adults, but also on the basis of an inherent capacity in the child, the ability merges to create a frame in which otherwise very stable objects can be transformed into representations that bear only a tenuous link with their original shapes.

Leslie's conception of the theory of mind implies that human beings have available a domain of metarepresentations they can manipulate to make inferences about causes, predictions about future events, recognize the consequences of ignorance, distinguish reality from fantasy, acquire a language of words and phrases depicting mental experiences or states, and infer motivations. As Leslie puts it, "Pretend play is thus one of the earliest manifestations of the ability to characterize and manipulate one's own and other's cognitive relations to information" (Leslie, 1987, p. 422).

It may well be the case that preschool children practicing imaginative play may also be more likely to move naturally into adopting a metarepresentational orientation. They may show an ability to demonstrate a "theory of mind"; that is, an ability to be aware of their own thoughts as distinct from others. In a series of studies under our direction (Rosen, Schwebel, & Singer, 1997; Schwebel, Rosen, & Singer, 1999), it has been demonstrated that preschool children who play more imaginatively (on observation by raters on several occasions) may actually perform better on the reality-fantasy and false-belief measures used as estimates of theory of mind. As a matter of fact, even when age and other factors are taken out in multiple regression analyses, the scores on make-believe play still predict theory of mind results.

What we are proposing, then, is that imaginative play in childhood emerges almost necessarily as the child's cognitive capacities unfold through heightened brain development and inevitable social experiences. At the same time, this metarepresentational mode makes it possible for increasing complexity of play to occur. Such play provides pleasures for the children by allowing them to miniaturize complex events and objects as well as to seem to gain power over the objects and people around them through manipulating them in original story lines.

During the "high season of make-believe play," children basically talk aloud their thoughts. At the earlier ages, they may engage in collective monologues, each child, even when side by side with another, simply describing a unique plot. Later, as our research shows, the children who engage in a great deal of such behavior are often leaders in groups, and they interact in role-playing and directing others (Singer & Singer, 1990). By ages six and seven, however, we see a transition toward internalizing play and its verbal concomitants. Just exactly how this happens is still something of a mystery. We have as yet no detailed, systematic experimental or longitudinal studies to demonstrate how overt play becomes covert and is transformed into private thought and the self-reflective consciousness of our definition. It does appear to be the case, from follow-up research, that preschool children who engage in more pretend play are likely to show more signs of general imaginativeness and creativity by middle childhood (Root-Bernstein, 2009; Russ, 2004; Singer & Singer, 1990; Taylor, 1999). How exactly this occurs for the average child is uncertain.

In summary, it is evident that conscious thought may well take its origin in the symbolic floor play of preschoolers. It seems very likely that such play is adaptive and that it enhances verbal fluency, imagery, empathy, self-control, and the capacity for self-entertainment, as research demonstrates (Singer & Singer, 2005). The ability of preschoolers to miniaturize the big, confusing world around them and thereby gain some sense of power and control is carried over into our adult thought. We can privately relive memories on the "small stage" of our own mind's eyes or ears and also anticipate a range of possible futures or even create the novel scenarios we call fantasies.

BRAIN-IMAGING RESEARCH ON MIND WANDERING AND STIMULUS-INDEPENDENT THOUGHT

Our earlier work using electroencephalography (EEG) and other psychophysiological measurements had suggested ways that daydreaming and forms of stimulus-independent thoughts (SITs) or Task-Unrelated Images and Thoughts (TUITs) were linked to brain activities when active sensory or motor responses to external stimulation were not demanded by some tasks. We, however, lacked the tools for intensive systematic brain research. The past two decades have provided the methods of positron emission tomography (PET) scanning or functional magnetic resonance imaging (fMRI), which can locate specific brain areas that become active when a person's attention shifts from looking or listening to environmental signals toward reminiscing about past events of one's experience or thinking about one's own personal goals or activities.

A fine summary of a large body of research on mind wandering by Smallwood and Schooler (2006) has shown how such shifts of attention can actually have goal-driven, executive functions even when they are diversions from focusing on an ongoing chore. The experimental studies of Mason et al. (2007) using new imaging techniques have shown that mind wandering and stimulus independent thought can indeed be tied to a specific brain system that becomes active when the brain is presumably "at rest." This system has been identified as the Brain Default Network, and it "lights up" on fMRI or PET scans in situations, as their studies show, during passive sensory processing, but it is "attenuated" when persons confront a demanding, novel task. Thought-sampling supported this finding, and individual differences in participants' prior self-reports on our daydreaming questionnaire also related to greater engagement of Default Network brain regions along with more verbal reports of stimulus independent thoughts.

The most recent and extensive review presentation of the anatomy and functional role of this cerebral system has further supported the important executive or goal-related significance of the Brain Default Network (Buckner et al., 2008). These authors review the anatomical features of the network in both monkeys and humans. They conclude that the default network is indeed likely to become activated when individuals are focusing their attention on personal memories, attempts at adopting the perspectives of other people (a form of theory of mind or empathic thought), and when anticipating or presumably daydreaming about future events or interactions.

Their review of the anatomical and brain-functional evidence from imaging research leads them to the description of the Default Network as involving two systems, with the medial temporal lobe serving as the provider of the memories and associative connections upon which imagery and related mental constructions of events lead to a sort of replay of situations. They found that then the medial prefrontal subsystem is active to facilitate the dynamic and flexible use of this information during the construction of mental simulations, in particular when these are self-relevant. They trace how the two subsystems converge on various "hubs" such as the posterior cingulate cortex that serve as integrating centers. In the course of their review, they also point to developmental evidence that the interactions between default network areas are first seen in toddlers and older children, the same period as the emergence of imaginative play just discussed above. Such processes may often be disrupted in advanced aging. Buckner, Andrews-Hanna, and

Schacter go on to insightful speculations about links of deficits, disruptions, or even over-activities of the brain's default system in pathological conditions such as autism, schizophrenia, and Alzheimer's.

If we now review these brain findings in relation to the research on daydreaming and the stream of thought described above, we find considerable convergence. One of the first findings from the questionnaire studies was that most people reported that their daydreaming was most frequent just before falling asleep at bedtime, when eyes were closed and when one was presumably attempting to shut out external stimulation. The experimental studies of signal detection provide extensive evidence that daydreams or reminiscences occur most often when the cognitive demands of the task or the stimulus novelty from the immediate environmental surround is relatively reduced. The studies directed by Antrobus on dreams or mentation during the sleep cycle show that the more frequent accounts and seemingly more elaborate dreams in the EEG-Stage 1 and REM sleep phases occur because there is a convergence of motor paralysis, reduced external awareness, and greater brain activation in contrast with what occurs during Sleep EEG Stages 2, 3, or 4 (Antrobus, 1993, 1999).

The identification by Buckner, Andrews-Hanna, and Schacter of a link to self-focus and the brain default network regions is also found in behavioral studies of self-defining memories and self-relevant material in thought-sampling and emotionality (Garfinkle, 1994; Hart et al., 1997; S. Kreitler & Singer, 1991; Singer & Salovey, 1993; J. A. Singer, 2005; J. L. Singer, 2006). The research on the beginnings of brain default network functioning in toddler-aged and older children (Fransson et al., 2007) meshes with studies of the beginnings of pretend play in childhood and the relation of such play to theory of mind, reality-fantasy distinction, and other perspective-taking (D. G. Singer & J. L. Singer, 1990, 2005; Schwebel et al., 1999). It is exciting to think that we may be entering a period in which we can begin to integrate phenomenal private experiences and experimentally or psychometrically assessed behaviors in a systematic fashion with the voiceless, nonverbal electrochemical activation of neuronal networks in the brain.

Consciousness and Motivation

What specific role does conscious thought play in human motivation? We mentioned early on the waves of influence that led to an underplaying conscious mentation in favor of strong unconscious influences on human motives and actions. The power of psychoanalytic models of out-of-awareness drives and thought processes has been greatly eroded in recent decades because of dubious evidence and relative untestability. At the same time, cognitive science has provided support for the present view that much of our information processing and our uses of schemas, scripts, prototypes, or attitudes operates relatively automatically or without conscious awareness (Banaji, 2001; Hassin et al., 2005; Kihlstrom, 1987; J. L. Singer & Salovey, 1991). Is the theater of consciousness simply an epiphenomenon or does it contribute a special potency to our intentions toward action?

The position we are proposing is that the brain (except when traumatically disabled as in our first definition of consciousness) is almost continuously active. Materials from long-term memory recur sometimes almost randomly (as may be especially the case in night dreaming), but also as a function of recurrent, unfinished tasks, unfulfilled intentions, or current concerns (Klinger, 1999). These current concerns may be aroused by associations to environmental signals such as pictures of food, odors from food vendor's stands, or erotic images on TV and in magazines. Antrobus (1999) has outlined with precision these circumstances from controlled research that identify the likely awareness of TUITS (Giambra, 1995). Recent brain imaging (MRI) research seems consistent with the laboratory evidence that during those intervals when individuals are not processing externally generated task information (with parietal and occipital areas activated), they revert to frontal-lobe activity, which may well reflect recurrent working memory or future-oriented mentation (Antrobus, 1993, 1999; Courtney, 1997). As Klinger summarizes recent research, "It is now clear that up to perhaps one half of waking thought takes one form or another of daydreaming … thoughts are, like more overt behavior, organized entities that … pertain to the goals to which people commit themselves and are steered by emotional response to goal related cues" (Klinger, 1999, p. 46). We concur with Klinger's conclusion that such mentation may well play a role in all cognitive processing from simpler stimulus responses (see Johnson, 1997) to more complex forms of problem-solving and creative thinking. Our human ability to project images, self-representations, or even to carry on internal monologues or imagined dialogues establishes a meaningful (S. Kreitler, 1999) stage or workspace (Baars, 1997) that often motivates us to action much in the same manner as sight or smell from the food vendor's stand.

The research support for our position derives from a variety of experimental, psychometric, and clinical sources (J. L. Singer & Bonanno, 1990; J. A. Singer & Salovey, 1999). For example, direct inquiry through questionnaires makes clear the ubiquity of daydreaming and related ongoing conscious activities and their extensive personality correlates. Laboratory research, in which participants engaging in vigilance or signal-detection tasks are periodically interrupted to report on the occurrence of TUITs, point to the frequency of such processes and their current concerns or motivational role. More naturalistic research of thought-sampling by the use of paging devices that interrupt people during their daily activities extend the laboratory findings further. Such research also indicates how self-representations and images of ideal or socially desirable self-roles may actually moderate emotions or ongoing mood states (J. L. Singer, 2006). Clinical uses of imagery and daydream-like procedures in therapies as diverse as psychoanalysis, waking dream therapies, and cognitive-behavioral treatments (J. L. Singer & Pope, 1978; J. L. Singer, 2006) also exemplify the affect-arousing and motivational role of conscious processing.

Self-Representation

An awareness of self as reflected in interior monologues (Hamlet's "O what a rogue and peasant slave am I") or images of oneself in future interactions (Hamlet's "The play's the thing/wherein I'll catch the conscience of the king!") is a recurrent feature of ongoing conscious thought. Beliefs about oneself in relation to significant others such as parents and authorities or about one's "actual self" as compared to one's "ideal," "ought," or "dreaded self" have increasingly been carefully and extensively studied (Higgins, 1987; Hart et al., 1997; J. L. Singer, 2006).

The valuable work by Higgins and his various collaborators has outlined with strong experimental evidence how discrepancies between Actual and Ideal or Actual and Ought self-beliefs may be associated with depressive or agitated-anxious moods, respectively. We have carried this work further to show that such self-beliefs are related not only to self-esteem measures and mood or emotional states but are reflected in participants' ongoing thought as sampled by pager interruptions seven times a day over a week's time. Arousing participants' awareness of actual-ideal or actual-ought discrepancies increased conscious recurrence of self-thought and heightened negative affects (J. L. Singer, 2006). The examination of samples of ongoing waking thought about self may be a fruitful field, not only for further research but also for clinical application.

In summary, we have sought to show that although a great deal of human information may well run off out-of-awareness, there remains a narrower but vivid stage of conscious thought, on which we re-enact memories, reshape schemas, play out scripts for alternative futures, and even try out relatively bizarre or fantastic adventures. Recent research on the Brain's Default System supports the findings from purely psychological studies to suggest that when attention shifts away from processing external, sensory-focused tasks, areas of cortical activity drawing on long-term memories, unfulfilled current concerns, and future plans become active. Such conscious experience has its own stimulus value that forges motivational possibilities as well as contributing to information processing. In its more playful or "abandoned" forms, our conscious imagery may not only entertain but lead us on to creative experience and expression.

References

Antrobus, J. A. (1993). Thinking away and ahead. In H. Morowitz & J. L. Singer, (Eds.), *The mind, the brain, and complex adaptive systems* (pp. 155–174). New York: Addison–Wesley.

(1999). Towards a neurocognitive processing model of imaginal thought. In J. A. Singer & P. A. Salovey (Eds.), *At play in the fields of consciousness* (pp. 3–28). Mahwah, New Jersey: Lawrence Erlbaum Associates.

Baars, B. (1997). *A cognitive theory of consciousness.* Cambridge, England: Cambridge University Press.

Bakan, D. (1966). *The duality of human existence.* Chicago: Rand McNally.

Banaji, Mahzarin R. (2001). Implicit attitudes can be measured. In H. L. Roediger III, J. S. Nairne, I. Neath, & A. M. Surprenant (Eds.), *The nature of remembering: Essays in honor of Robert G. Crowder* (pp. 117–150). Washington, DC: APA.

Blatt, S. J. (2008). *Polarities of experience: Relatedness and self-definition in personality development, psychopathology, and therapeutic process.* Washington, DC: American Psychological Association.

Bonanno, G. A., & Singer, J. L. (1990). Repressive personality style: Theoretical and methodological implications for health and pathology. In J. L. Singer (Ed.), *Repression and dissociation* (pp. 435–470). Chicago: University of Chicago Press.

Bruner, J. (1986). *Actual minds, possible worlds.* Cambridge, MA: Harvard University Press.

Buckner, R., Andrews-Hanna. J., & Schacter, D. (2008). The brain's default network: Anatomy, function and relevance to disease. *Annals of the New York Academy of Sciences*, **1124***(1)*, 1–38.

Ciba Foundation Symposium 174. (1993). *Experimental and theoretical studies of consciousness.* Chichester, England: Wiley.

Courtney, S. (1997, February). Functional MRI studies of visual perception and working memory. Paper presented at the 22nd Annual Interdisciplinary Conference, Jackson Hole, Wyoming.

Demos, E.V. (Ed.) (1995). *Exploring affect: The selected writings of Silvan S. Tomkins.* New York: Cambridge University Press.

Ekman, P. (1973). *Darwin and facial expressions: A century of research in reviews.* New York: Academic Press.

Ekman, P., Friesen, W. V., Ellsworth, P. C. (1982). *Emotion in the human face: Guidelines for research and an integration of findings.* Rev ed. Cambridge, MA: Cambridge University Press.

Epstein, S. (1999). The interpretation of dreams from the perspective of cognitive-experiential self-theory. In J. A. Singer & P. Salovey (Eds.), *At play in the fields of consciousness* (pp. 51–82). Mahwah, NJ: Erlbaum.

Fransson, P., Skiold, B., Horch, S., Nordell, A., Blennow, M. et al. (2007). Resting-state networks in the infant brain. *Proceedings National Academy Sciences, USA*, **104**:15531–15536.

Garfinkle, J. (1994). *Discrepant representations of self and relations to personality, emotion, and continuous mood.* Unpublished doctoral dissertation, Yale University, New Haven, CT.

Giambra, L. M. (1995). A laboratory method for investigating influences on switching attention task-unrelated imagery and thought. *Consciousness and Cognition*, **4**, 1–21.

Goldstein, K. (1940). *Human nature in the light of psychopathology.* Cambridge, MA: Harvard University Press.

Hart, D., Field, N., Singer, J. L., & Garfinkle, J. (1997). Representations of self and others: A semantic space model. *Journal of Personality*, **65**, 77–105.

Hassin, R. R., Uleman, J. S., & Bargh, J. A. (Eds.) (2005). *The new unconscious*. Oxford and New York: Oxford University Press.

Higgins, E. T. (1987). Self-discrepancy: A theory of relating self and affect. *Psychological Reviews*, **94**, 319–340.

Holt, R. (1964). Imagery: The return of the ostracized. *American Psychologist*, **19**, 254–264.

Izard, C.E. (1977). *Human emotions.* New York, Plenum Press.

James, W. (1950). *The principles of psychology.* New York: Holt. (Original work published 1890).

Johnson, M. (1997). Identifying the origin of mental experience, In M. S. Myslobodsky (Ed.), *The mythomaniacs: The nature of deception and self-deception* (pp. 133–180). Mahwah, NJ: Erlbaum.

Kihlstrom, J. F. (1987). The cognitive unconscious. *Science*, **237**, 1445–1452.

Klinger, E. (1999). Thought flow: Properties and mechanisms underlying shifts in content. In J. A. Singer & P. Salovey (Eds.), *At play in the fields of consciousness (*pp. 29–50). Mahwah, NJ: Erlbaum.

Kreitler, H., & Kreitler, S. (1976). *Cognitive orientation and behavior.* New York: Springer.

Kreitler, S. (1999). Conciousness and meaning In J. A. Singer & P. Salovey (Eds.), *At play in the fields of consciousness (*pp. 175–206). Mahwah, NJ: Erlbaum.

Kreitler, S., & Singer, J. L. (1991). The self-relevance effect in incidental memory: Elaboration, organization, rehearsal and self-complexity. *Imagination, Cognition and Personality*, **10**, 167–194.

Leslie, A. M. (1987). Pretense and representation: The origins of "Theory of Mind." *Psychological Review*, **94**, 412–426.

Mandler, G. (1984). *Mind and body.* New York: Norton.

Mandler, J. (1998). *Stories, scripts and scenes: Aspects of schema theory.* Hillsdale, NJ: Erlbaum.

Mason, M. F., Norton, M. I., Van Horn, J. D., Wegner, D. M., Grafton, S. T., & Macrae, C. H. (2007). Wandering minds: The default network and stimulus-independent thought. *Science*, **335(***5810)*, 393–395.

Root-Bernstein, M. (2009). Imaginary worldplay as an indicator of creative giftedness. In L. Shavinina (Ed.), *The international handbook of giftedness* (pp. 599–616). New York: Springer Science.

Root-Bernstein, M., & Root-Bernstein, R. (2006). Imaginary worldplay in childhood and maturity and its impact on adult creativity. *Creativity Research Journal*, **18***(4)*, 405–425.

Rosen, C. S., Schwebel, D. C., & Singer, J. L. (1997). Preschooler's attributions of mental states in pretence. *Child Development*, **68**, 1133–1142.

Russ, S. W. (2004). *Play in child development and psychotherapy*. Mahwah, NJ: Earlbaum.

Schwebel, D. C., Rosen, C. S., Singer, J. L. (1999). Preschoolers' pretend play and theory of mind: The role of jointly constructed pretence. *British Journal of Developmental Psychology*, **17**, 333–348.

Shapiro, T., & Emde, R. (1992). *Affect: Psychoanalytic perspectives.* New York: International University Press.

Singer, D. G., & Singer, J. L. (1990). *The house of make-believe: Children's play and the developing imagination.* Cambridge, MA: Harvard University Press.

(2005). *Imagination and play in the electronic age.* Cambridge, MA: Harvard University Press.

Singer, J. A. (2005). Evacuees cut loose from touchstones of memory. *Hartford Courant*, C4.

(1993). *The remembered self: Emotion and memory in personality.* New York: Free Press.

Singer, J. A., & Salovey, P. (Eds.) (1999). *At Play in the fields of consciousness.* Mahwah, NJ: Lawrence Erlbaum Associates.

Singer, J. L. (1974a). Daydreaming and stream of thought. *American Scientist*, **62**, 417–425.

(1974b). *Imagery and daydream methods in psychotherapy and behavior modification*. New York: Academic Press.

(1985).Transference and the human condition: A cognitive-affective perspective. *Psychoanalytic Psychology* **2**, 189–219.

(2002). Cognitive and affective implications of imaginative play in childhood. In M. Lewis (Ed.), *Child and adolescent pyschiatry* (pp. 252–262). Philadelphia, PA: Lippincott Williams & Wilkins.

(2006). *Imagery in psychotherapy*. Washington, DC: American Psychological Association.

Singer, J. L., & Bonanno, G. (1990). Personality and private experience: Individual variations in consciousness and in attention to subjective phenomena. In L. Pervin (Ed.), *Handbook of personality* (pp. 419–444). New York: Guilford Press.

Singer, J. L., & Pope, K. S. (Eds.) (1978). *The power of the human imagination.* New York: Plenum.

Singer, J. L., & Salovey, P. (1991). Organized knowledge structures and personality: Person schemas, self-schemas, prototypes and scripts. In M. J. Horowitz (Ed.), *Person schemas and recurrent maladaptive interpersonal patterns* (pp. 33–79). Chicago: University of Chicago Press.

Smallwood, J., & Schooler, J. W. (2006). The restless mind. *Psychological Bulletin*, **132**, 946–958.

Spurgeon, C. (1961). *Shakespeare's imagery.* New York and London: Cambridge University Press.

Taylor, M. (1999). *Imaginary companions and the children who create them.* New York: Oxford University Press.

Taylor, S. (1989). *Positive delusions: Creative self-deceptions and the healthy mind.* New York: Basic Books.

Tomkins, S. S. (1962). *Affect, imagery and consciousness.* Vol. 1. New York: Springer.

(1981). The quest for primary motives: Biography and autobiography of an idea. *Journal of Personality and Social Psychology*, **41**, 306–329.

22

Creativity and Motivation

Mark A. Runco & David J. McGarva

THEORIES OF CREATIVITY AND MOTIVATION

For Freud (1966), creative behavior was one way of sublimating libidinal energy. Creativity was rooted in wish fulfillment; writers, for example, would create worlds of their own, taking the result very seriously and expending a great deal of emotion on it. Although Freud's theory is no longer given universal respect, in part because so little of it can be tested empirically, the view that creativity is tied to disturbance and sometimes even psychopathology is widely held. Indeed, research frequently supports the link between creativity and psychological illness. Richards (1999) described how that link may assume different forms: pathology may lead directly or indirectly to creative behavior; creativity may be a direct or indirect cause of illness; or both may result from some third factor. Motivational tendencies may account for that third factor.

Barron (1972, 1995) found that in a group of 66 writers (56 professionals and 10 students), the average writer was in the upper 15 percent of the general population on every measure of psychopathology in the Minnesota Multiphasic Personality Inventory. However, the creative writers also scored significantly above average on a test of ego strength, which is more usually negatively correlated with psychopathology. Barron suggested that writers "are much more troubled psychologically, but they also have far greater resources to deal with their troubles" (1961, p. II-8).

Ludwig (1995) statistically analyzed biographical data from 1,028 individuals. Writers and other creative workers showed significantly more psychopathology – including depression, anxiety, and psychosis – than other groups. Fiction writers were significantly more likely than most groups to undergo psychotherapy or voluntary hospitalization.

Andreasen (1997) interviewed 30 eminent creative writers and determined that 80 percent had histories of major mood disorders. This was considerably higher than her figure of 30 percent for a matched control group from other occupations. The finding is so remarkable that it is important to note that Andreasen's diagnostic methods were more rigorous than in any previous study.

Jamison (1997) questioned 47 award-winning British, Irish, or Commonwealth writers. Thirty-eight percent reported having sought treatment for mood disorders, as compared to 6 percent in the general population.

Piirto (1998) examined the lives of 80 women writers using questionnaires and published material. She found one of the themes was the incidence of self-destructive acts and depression. The exact prevalence of this characteristic is not clear; presumably, it was observed mostly in the confidential questionnaires because Piirto recorded only six writers for whom it was identified by literature analysis.

Rivers-Norton (2002) noted that although studies of eminent writers emphasized their distress, dysfunction, and mood disorders, they did not focus primarily on the effects of childhood abuse. Analyzing autobiographical and biographical material as well as literary narratives by four randomly selected eminent writers who had reported such abuse, she evaluated inter alia whether these writers created narratives to acknowledge, engage, integrate, and transcend their lived experiencing of this abuse. In all cases, she found that early abuse led to existential crises that were reflected in literary content and form.

Kaufman and Baer (2002) pointed out that most studies in this area have focused predominantly, or even exclusively, on male writers, and that this may limit the generalizability of the findings. There is, however, evidence that mental illness is prevalent among successful women writers. In a historiometric study of 1,629 writers, Kaufman (2001) found that female poets were significantly more likely to suffer mental illness than female fiction writers or male writers of any type. A subsequent study of 520 eminent American women found that poets were more likely to have mental illnesses and to experience personal tragedy than journalists, visual artists, politicians, and actresses (Kaufman, 2001).

The relationship between creativity and psychopathology may reflect the fact that disturbances can be motivating. That is one way to interpret Freud's theory. Simplifying some, an individual may have a problem and use creative work to explore or even relieve the disturbance. An alternative is suggested by the findings of an association of creativity with alcohol and other substance use. Ludwig's (1995) study, mentioned previously, showed that creative writers were more likely than members of less creative professions to have alcohol and drug problems. One explanation for this was offered by the novelist John

Cheever. He suggested that his capacity to tap uncensored material led him to drink – and gave him creative insight.

HUMANISTIC VIEWS

The motive to creative does not always originate in disturbance. This is especially clear in the framework of what is often labeled the Humanistic perspective. It posits that creativity can be motivated by the drive for self-actualization and the fulfillment of potential. Note here that creativity can therefore be tied to psychological health and well-being. Rogers (1961), for instance, felt that creativity can flourish only when motivation comes from within the creator and not when there is an expectation of being evaluated. Maslow (1968) viewed creative behavior as part of self-actualization, and therefore placed it at the top of his hierarchy of needs, to be addressed only when the more basic needs were met. A questionnaire-based study has confirmed the relationship between creativity and self-actualization (Runco, Ebersole, & Mraz, 1997).

Maslow (1968) acknowledged that self-actualizing creativity (which he distinguished from special-talent creativity), rather than conforming fully to the hierarchical model, might be observed in innately creative people even when they were unsatisfied, unhappy, or hungry. Rhodes (1961) pointed out that creative behavior may result from either "deficiency" or "being" needs, in the same way in which Maslow (1968) described two kinds of love: "D-love" and "B-love." When creative behavior is successful as a response to deficiencies in one's basic needs in an emotionally repressive or deprived environment, it may allow subsequent access to higher levels of creativity. The deliberate and conscious working through of underlying conflicts has also been shown to have health benefits (Pennebaker, Kiecolt-Glaser, & Glaser, 1997).

One interesting part of the Humanistic perspective is the claim that creativity originates from within the individual. This is interesting because a parallel view is very apparent in creative studies. We are referring to the emphasis placed on intrinsic motivation in studies of creativity (Amabile, 1990; Eisenberger & Shanock, 2003; Runco, 1993). Intrinsic motivation was tied to creative talent in some of the very first empirical investigations reported at the *Institute for Personality Assessment and Research* (IPAR) (Barron, 1963, 1972; MacKinnon, 1965, 1970, 1983). Intrinsic motivation was, at that point, a core characteristic and viewed much more as a general tendency, much as a personality trait. Other core characteristics included wide interests (which is itself a reflection of motivation), unconventionality, and, of course, originality.

More recent work on intrinsic motivation has become highly rigorous. This research has also included a very wide range of subjects, whereas earlier studies at IPAR mostly tested unambiguously creative groups (e.g., architects and writers). Dudek and Hall (1991) have published a follow-up of the IPAR architects' studies.

Amabile (1990) defined *intrinsic motivation* as "the motivation to do an activity for its' own sake, because it was intrinsically interesting, enjoyable, or satisfying. In contrast, extrinsic motivation was defined as the motivation to do an activity primarily to achieve some extrinsic goal, such as a reward" (p. 62). In one experimental study of intrinsic motivation, Amabile (1983) asked a group of female psychology students to make collages. Those who were led to expect that their work would not be evaluated performed more creatively (as assessed by a panel of experienced art students) than others. This was true whether or not they were instructed to be creative. Thus, Amabile showed that a salient extrinsic constraint leads, in general, to lower creativity. Many subsequent studies have confirmed this finding (summarized in Amabile, 1990). In one study, Amabile asked 72 self-identified creative writers to write two Haiku-style poems. Between the two poems, one group completed a questionnaire on reasons for writing, designed to draw their attention to the intrinsic reasons; a second group completed a questionnaire focused on extrinsic reasons; and a control group completed no questionnaire. The poems subsequently written by the first group were significantly more creative (as rated by poets) than the others. Amabile suggested that people who generally approach their work with an intrinsic orientation may be more consistently creative.

One simple view is that intrinsic motivation is sometimes conducive to creativity and that extrinsic motivation is detrimental. This simple view is consistent with a number of observations and with the idea that sometimes creative efforts are stopped because the person is squelched (Davis, 1999). Squelchers may be interpersonal. They may take the form of evaluation and criticism offered by parents, teachers, or supervisors at work.

Yet it is not as simple as "intrinsic motives are good, extrinsic are bad." Eisenberger and Shanock (2003) pointed out that there are underlying factors, including self-determination, and that these are critical determinants of behavior. Rubenson and Runco (1992, 1995) also looked beneath the simple intrinsic-extrinsic dichotomy and outlined a psychoeconomic explanation using the ideas of costs and benefits. One of the interesting implications of psychoeconomic theory is that sometimes, people are motivated to do things that then preclude originality and creativity. This is especially clear in the case of large investments, which have the possibility of depreciation.

> Individuals who have invested a large amount into one style or perspective (e.g., a scientist who has spent years developing one theory or model) will be motivated to justify its usage. If his or her pet model was replaced, the scientist's investment (temporal and psychic) would depreciate. Note that it is essentially linear: the more of an investment, the higher the motivation to avoid depreciation. Experts would thus be highly motivated in a particular fashion, as would anyone who has devoted years to a topic or model or perspective. (Runco, 2003)

Amabile (1996) described how extrinsic motivation can have a positive influence if it is *synergistic* – informational or enabling – rather than controlling. The positive effect is especially likely when high intrinsic motivation is already present. Thus, her theory allows for internal and external motivations to co-occur. To test this, Ruscio, Whitney, and Amabile (1998) asked 151 university students to write Haiku meeting stated requirements of form and content. They had previously tested the participants' stable, domain-specific motivation. The poems were rated for creativity and other qualities by English graduate students. Stable intrinsic motivation significantly predicted creativity.

In a collage experiment with elementary school students in the United States and Saudi Arabia, Hennessey (2000) found that, as usual, subsequent reported interest in the task was undermined by the promise of a reward. However, the Saudi children showed a smaller, in fact insignificant, effect. Explaining this in terms of cultural differences, she went on to suggest that Deci and Ryan's (1995) self-determination theory may be of wider application than a simplistic intrinsic motivation principle.

Heinzen (1994) has also divided creative behaviors into the intrinsically and extrinsically motivated, associating the former with positive affect and spreading cognitive activation, in which multiple ideas, consequences, and benefits are quickly surveyed and assessed. This theoretical approach accounts for the superior creativity of intrinsically motivated behaviors. Clearly, speed is not essential to creativity. Another effect of personal interest in a project may be that the creator is willing to work on it over a longer period, and it may be allowed to mature in an unconscious "incubation" (Wallas, 1926) phase where unexpected associations can occur. More exactly, it may be that equally good associations are made both consciously and unconsciously, but that the latter are more accessible when needed later (Zhong, Dijksterhuis, & Galinsky, 2008).

Ochse (1990) argued that the intrinsic motivation principle may apply better in the laboratory than in the real world. Extrinsic rewards offered by experimenters are merely short-term satisfactions such as praise and privileges, and the subjects are usually unexceptional people who engage in the research for extrinsic reasons. Ochse cautions that one should be wary of using the conclusions to explain the stubborn labor of habitual creators.

Csikszentmihalyi (1996) recognized the role of both intrinsic and extrinsic factors. He described "exotelic" and "autotelic" creative activities in terms that clearly identified them with extrinsic and intrinsic motivation. "Most things in life are exotelic. We do them not because we enjoy them but in order to get at some later goal" (1996, p. 113). *Autotelic* activities are those performed for their own sake, and are characteristic of the "flow" state. Some activities can be both exotelic and autotelic, such as the behavior of people who earn their living by activities they can perform in flow. Some creative workers report achieving the flow state frequently (Csikszentmihalyi, 1996; Perry, 1999).

Keller and Bless (2008) proposed that flow is a subclass of the "regulatory compatibility" experience. A balance between personal characteristics (such as, skill and habitual goal orientation) and structural and environmental influences (such as, task demands, incentives, and availability of distinct means) results in regulatory compatibility. This is an enjoyable experience to which individuals are willing to devote time and that they are inclined to repeat.

OPERANT AND BEHAVIORAL VIEWS

Creativity is not always inhibited by extrinsic factors such as rewards. Behavioral and operant views demonstrate that creativity and its correlates can in fact benefit from extrinsic incentive and reward. The behavioral view often rejects creativity as a legitimate topic and refers to the lack of operational definition (Epstein, 1990; Skinner, 1939). Yet, it also describes extrinsic ways of motivating operant behaviors that are related to creativity. For example, people display unusual behaviors from time to time, and the environment rewards those that are desirable. This happens with creative actions in the same way as with any other behaviors. For Skinner, the creator's behavior comes to be shaped toward producing things of beauty, and creative thinking is largely concerned with the production of desirable behavioral "mutations" (Skinner, 1972, p. 114). Others have looked to the basis of creative behavior, including novel behavior (Pryor, Hoag, & O'Reilly, 1969; Stokes, in press) or insight (Epstein, 1990). This is quite interesting because it demonstrates that even though original behaviors are by definition unpredictable and new, they can be shaped and controlled by contingencies. What is shaped is actually the tendency to do something that has never been done before (Ryan & Winson, 1978; Stokes, 2003; Stokes & Balsam, 2003). The individual is shaped and receives reinforcement when she or he displays a specific operant behavior that has not been emitted previously. This is the operant view of originality–novelty (Goetz & Baer, 1973; Holman, Goetz, & Baer, 1977).

The operant approach is in direct contrast to the view that there is an innate talent. It also has difficulty explaining how people create their first works with minimal encouragement (Abra, 1988). Skinner himself suggested that there may be a reinforcement history that can explain why a "starving artist" continues to create even when rewards are seemingly absent. Skinner (1972) also acknowledged that individuals can give themselves intrinsic reinforcement (such as by thinking approving thoughts), provided that this itself is a trained response.

Epstein (1990) investigated the possibility that reinforcement can restrict one's range of behavior rather than foster variation. He attempted to explain how mutations occur. His Generativity Theory suggests that new behaviors always emerge from the interconnection or integration of old ones, in ways which can be predicted, manipulated, and taught (Epstein, 1991). In a recent study (Epstein, Schmidt, & Warfel, 2008), training such competencies improved test scores and led to a significant increase in creative output.

PERSONAL CREATIVITY

Much of the research cited above examined creative products. This is actually true of the entire field of creative studies; as of late, there is a tendency to focus on products and relegate creative processes. When college students are employed in research, products such as poems or collages are assessed. When unambiguously creative persons are studied, their productivity (e.g., inventions, paintings, publications) are counted. This all makes for highly objective research, but it means that findings – including those concerning motivation and creativity – may not apply to everyday creativity and creative efforts that do not lead to a product.

There is good reason to postulate a strong tie between the creative process and intrinsic motivation. This follows most recently from Runco's (1995, 1996, 2011a) theory of *personal creativity* and older theories of cognitive development (Piaget, 1970). The theory of personal creativity was in fact proposed in response to the same product bias that was just described. It posits that creative products, be they everyday insights and solutions or world class breakthroughs, must begin with an original interpretation of experience. This is something each of us can do, and we do it regularly. We do not, however, construct original interpretations unless we need to do so. It is easier, and often entirely effective, to rely on experience, assumption, and routine, and thus to use the same old solution or interpretation we always have. We can, however, if motivated to do so, put the effort into constructing a new interpretation. In fact, it may be that this is a critical individual difference that might predict creative accomplishment; some people may be more likely than others to construct original interpretations.

Two of the claims above are quite important. The first is that everyone shares the capacity to construct original interpretations. This in turn implies that the capacity for personal creativity is widely distributed; it is not something only the highly talented possess. The second claim is that the capacity for creativity – again, the capacity to construct original interpretations – is not used unless the individual is motivated to do so. This is where cognitive developmental theory comes in. Piaget (1970), for example, put great weight on the importance of assimilation. It works along with accommodation when an individual adapts to his or her environment. Assimilation occurs when information is altered, as needed, in order to fit with existing structures and understandings. Accommodation, on the other hand, occurs when structures change in order to take new information into account. Accommodation may be at work when there is an a-ha moment or insight; as such, it may play a role in some creative accomplishment (Gruber, 1981). Assimilation, on the other hand, plays a large role in imagination. It allows the person to transcend reality, even if briefly. It is also a synonym for personal interpretation.

What is most relevant is Piaget's idea (1976, 1981) that humans are biologically predisposed to understand their experiences – to develop and adapt. His theory was best labeled genetic epistemology precisely for this reason. Further, he argued that we are motivated to adapt, to understand. For Piaget, intrinsic motivation is a natural by-product or interaction with the environment. Whenever an individual encounters something he or she does not understand, there is an interest in assimilating, then accommodating, and in developing a new understanding.

What we have, then, is an explanation for why individuals person might be intrinsically interested in constructing new interpretations. They are simply reacting to situations that allow or even call for adaptation. That adaptation may benefit from assimilation – that is, interpretation – and the interpretation may be original.

Creativity is not synonymous with adaptability. I touched on this elsewhere:

> Many human behaviors–and especially those of older and mature individuals – are directed towards the conservation of resources (e.g., energy), and thus towards efficiency. We develop routines, for example, to make our lives easier. Creative behavior is typically very different. Frequently creative inventions make our lives easier, but the discovery of the necessary technologies may require a huge amount of effort and avoidance of routine. Creative behavior is not necessarily efficient behavior, nor even always adaptive … and the motivations to act in a creative fashion or develop competencies for creative work are similarly unique. (Runco, 2005b)

Indeed, sometimes it is most adaptive to conform and sit into some social situation, rather than impose an original action. Further, creative behavior is sometimes clearly maladaptive, at least for the individual. Consider in this regard the costs to creativity, health, or social acceptance. (Ludwig, 1995)

A second point to underscore is that originality does not work in isolation. Creative things are more than simply original. They are also useful, effective, or somehow fitting. These two may require motivation, especially in the case where the original insight requires refinement or revision. These, too, may require time and effort, in which case motivation is required. No wonder so many theories of creative accomplishment point to determination and persistence.

The theory of personal creativity also emphasizes the intentions for creative effort. These are indicatives of creative motivation. Personal creativity was defined such that three things are involved: original interpretations, discretion (knowing when to be creative and when to conform), and intentions. The last of these are named, rather than motivation, in order to emphasize the conscious control they assume. Sometimes our motivation results from things beyond our immediate awareness, but intentions are under our control. They fit nicely with the large body of research demonstrating that creative persons are frequently very tactical and strategic (Mumford, Baughman, & Sager, 2003; Root-Bernstein, 1988; Runco, 2011b) for the creative acts are by definition intentional. Creative accomplishment is often designed, intentional, a result of strategic effort.

Not all creative behavior is strategic and by design, however. Some result from playfulness, and thus indirectly; some is accidental, as evidenced by the role of serendipity (Díaz de Chumaceiro, 2004; Hofstadter, 1986). The creativity that results from disturbance, cited previously, would fit under the unintentional category, as well. For reasons such as this, one conclusion about motivation and creativity is that there are different paths to creative performance. With that in mind, we turn to the summary and conclusions.

In fact, it could be concluded that creativity is embedded within a rich motivational network. Nevertheless, as was shown in my earlier extensive review of motivation and creativity (Runco, 2007), the motivation for creativity is very specific. A high level of motivation for competency or achievement, for example, will not necessarily lead the person to develop creative skills and do high-level creative work. This point was supported by at least one fairly recent empirical study, which also assumed that motivation was a reflection of personality. Earlier in this chapter we mentioned that some of the earliest studies of creativity, at IPAR, used a personality approach, then we turned to the more rigorous experimental studies of intrinsic motivation. There are recent personality studies of creativity, however. In one of them, Albert and Runco (2006) found a clear separation of individual achievement motives and social achievement motives. They had administered the California Psychological Inventory (CPI) to exceptionally gifted boys and their parents. The CPI has a scale labeled "achievement through independence." The participants in this research had much higher scores than the norms on the achievement through independence scale of the CPI. At least as important, the participants had significantly lower scores than the normative groups on the "achievement via conformity" scale! This says something about the motivation specifically for creative work, and it makes perfect sense that the focus is on achievement through independence. We say that because independence is one of the core characteristics of creative persons. It is seen in their personality but also in their thinking (its divergence and uniqueness) and their actions. Also, it is implied by any originality. Runco (2007) put it this way: "It is difficult to be creative without being independent. That is because creativity requires originality, and originality can be found through independent thoughts and actions. Originality cannot be found through conformity. As a matter of fact, originality is just about the opposite from normative" (p. 609). Gough and Bradley (1996) also pointed specifically to the Achievement Through Independence scale of the CPI as related to creativity. They found it to be correlated with performances on the Barron Welsh Art Scale.

SUMMARY AND CONCLUSIONS

Creativity is a theme that has sparked the interest of psychologists and other behavioral scientists for many decades. There is barely a discipline in psychology, including dynamic approaches and the behaviorist schools, that has not tried to answer the question "Why do people create?" This chapter has shown that creativity has multiple links with motivation in a variety of forms, ranging from drives, needs on various levels, emotions, attitudes, and cognitions down to personality traits or predispositions and specific learned behaviors.

There certainly are diverse perspectives on the relationship of motivation and creativity. That is especially true if we recognize that creativity is related to independence, originality, and insight, and moreover, is always distinct from conformity, conventionality, and the like. Someone highly motivated to get along with others will have greater difficulty being creative than someone who is interested in being a unique person. Yet being a contrarian does not guarantee creativity, either.

One thing may not have jumped out of the review presented above: motivation is not simply an affective influence on creativity. It is more than emotion. It is also related to thinking and cognition. This may be clearest in the theory of personal creativity. Recall that the intrinsic motivation to construct original interpretations resulted from the inborn drive to understand as well as the lack of understanding. Ideas and insights, in this light, are constructed to facilitate adaptation. Some of them might be elaborated and eventually creative. What is most relevant here is that the motivation is a result of the cognitive predicament. There is, in that light, a process that requires both affect and cognition. Admittedly, there is some debate over which comes first, the affect or the cognition (Lazarus, 1991a, 1991b; Zajonc, 1980), but to us it seems most realistic to accept the fact that humans are complicated; we have emotions and thoughts. We might attempt to delineate them and argue which is first, but in fact they work together. They are both a part of what it means to be human, and they both play a role in creative efforts.

References

Abra, J. (1988). *Assaulting Parnassus Theoretical views of creativity*. Lanham, MD:. University Press of America.

Albert, R. S., & Runco, M. A. (2006). Parents' personality and the creative potential of exceptionally gifted boys. *Creativity Research Journal*, **17**, 355–367.

Amabile, T. M. (1990). *Within you, without you: Towards a social psychology of creativity and beyond*. In M. A. Runco & R. S. Albert (Eds.), *Theories of creativity* (pp. 61–91). Newbury Park, CA: Sage Publications.

Amabile, T. (1996). *Creativity in context*. Boulder, CO: Westview Press.

Andreasen, N. (1997). Creativity and mental illness: Prevalence rates in writers and their first-degree relatives. In M. A. Runco & R. Richards (Eds.), *Eminent creativity, everyday creativity, and health* (pp. 7–18). Norwood, NJ: Ablex.

Barron, F. (1963). The need for order and for disorder as motives in creative activity. In C. W. Taylor & F. Barron (Eds.), *Scientific creativity: Its recognition and development* (pp. 153–160). New York: Wiley.

(1972). *Artists in the making*. New York: Seminar Press.

(1995). *No rootless flower: An ecology of creativity*. Cresskill, NJ: Hampton Press.

Campbell, D. (1960). Blind variation and selective retention in creative thought as in other knowledge processes. *Psychological Review*, **67**, 380–400.

Chown, S. M. (1961). Age and the rigidities. *Journal of Gerontology*, **16**, 353–362.

Cox, C. M. (1926). Genetic studies of genius. Vol. 2: *The early mental traits of three hundred geniuses*. Stanford: Stanford University Press.

Csikszentmihalyi, M. (1975). *Beyond boredom and anxiety*. San Francisco: Jossey-Bass.

(1988). The dangers of originality: Creativity and the artistic process. In M. M. Gedo (Ed.), *Psychoanalytic perspectives on art* (pp. 213–224). Hillsdale, NJ: Analytic Press.

(1990). The domain of creativity. In M. A. Runco & R. S. Albert (Eds.), *Theories of creativity* (pp. 190–212). Newbury Park, CA: Sage Publications.

(1996). *Creativity: Flow and the psychology of discovery and invention*. New York: HarperCollins.

Davis, G. (1999). Barriers to creativity and creative attitudes. In M. A. Runco & S. Pritzker (Eds.), *Encyclopedia of creativity* (pp. 165–174). San Diego, CA: Academic Press.

Deci, R. L., & Ryan, R. M. (1985). *Intrinsic motivation and self-determination in human behavior*. New York: Plenum.

Díaz de Chumaceiro, C. L. (2004). Serendipity and Pseudo-Serendipity in Career Paths of Successful Women: Orchestra Conductors. *Creativity Research Journal*, **16**, 345–356.

Dudek, S. Z., & Hall W. (1991). Personality consistency: Eminent architects 25 years later. *Creativity Research Journal*, **4**, 213–232.

Eisenberger, R., & Shanock, L. (2003). Reward, intrinsic motivation, and creativity: A case study of conceptual and methodological isolation. *Creativity Research Journal*, **15**, 121–130.

Eisenman, R. (1997). Creativity, preference for complexity, and physical and mental health. In M. A. Runco & R. Richards (Eds.), *Eminent creativity, everyday creativity, and health* (pp. 99–106). Norwood, NJ: Ablex.

Elliot, A. J. (1997). Integrating "classic" and "contemporary" approaches to achievement motivation: A hierarchical model of approach and avoidance achievement motivation. In P. Pintrich & M. Maehr (Eds.), *Advances in motivation and achievement* (vol. 10, pp. 143–179). Greenwich, CT: JAI Press.

(1999). Approach and avoidance motivation and achievement goals. *Educational Psychologist*, **34**, 149–169.

Elliot, A. J., & McGregor, H. A. (2001). A 2 x 2 achievement goal framework. *Journal of Personality and Social Psychology*, **80**, 501–519.

Epstein, E., Schmidt, S. M., & Warfel, R. (2008). Measuring and Training Creativity Competencies: Validation of a New Test. *Creativity Research Journal*, **20**, 7–12.

Epstein, R. (1990). Generativity theory as a theory of creativity. In M. A. Runco & R. S. Albert (Eds.), *Theories of creativity* (pp. 116–140). Newbury Park, CA: Sage.

Finke, R., 1990. *Creative imagery: Discoveries and inventions in visualization*. Hillsdale, NJ: Erlbaum.

Freud, S. (1966). *The standard edition of the complete psychological works of Sigmund Freud*. London: Hoarth.

Galton, F. (1869). *Hereditary genius*. New York: MacMillan.

Goetz, E. M., & Baer, D. M. (1973). Social control of form diversity and the emergence of new forms in children's blockbuilding. *Journal of Applied Behavior Analysis*, **6**, 209–217.

Gough, H. G., & Bradley, P. (1999). *Manual for the California Psychological Inventory*, 3rd ed. Palo Alto, CA: Consulting Psychologists Press.

Gruber, H. E. (1981). On the relation between 'a ha' experiences and the construction of ideas. *History of Science*, **19**, 41–59.

(1988). The evolving systems approach to creative work. *Creativity Research Journal*, **1**, 27–51.

Hayes, J. R. (1978). *Cognitive psychology*. Homewood, IL: Dorsey.

Heinzen, T. (1994). Situational affect: Proactive and reactive creativity. In M. A. Runco & M. Shaw (Eds.), *Creativity and affect* (pp. 127–146). Norwood, NJ: Ablex.

Hennessey, B. A. (2000). Self-determination theory and the social psychology of creativity. *Psychological Inquiry*, **11**, 293–298.

Hofstadter, D. (1986). *Metamagical themas*. New York: Basic Books.

Holman, J., Goetz, E. M., & Baer, D. M. (1977). The training of creativity as an operant and an examination of its generalization characteristics. In B. C. Etzel, J. M. LeBlanc, & D. M. Baer (Eds.), *New directions for behavioral research* (pp. 441–472). Hillsdale, NJ: Erlbaum.

Jamison, K. (1997). *Mood disorders and patterns of creativity in British writers and artists*. In M. A. Runco & R. Richards (Eds.), *Eminent creativity, everyday creativity, and health* (pp. 19–32). Norwood, NJ: Ablex.

Jones, K., Runco, M. A., Dorinan, C., & Freeland, D. C. (1997). Influential factors in artists' lives and themes in their art work. *Creativity Research Journal*, **10**, 221–228.

Kaufman, J. C. (2001). The Sylvia Plath effect: Mental illness in eminent creative writers. *Journal of Creative Behavior*, **35***(1)*, 37–50.

Kaufman, J. C., & Baer, J. (2002). I bask in dreams of suicide: Mental illness and poetry. *Review of General Psychology*, **6***(3)*, 271–286.

Keller, J., & Bless, H. (2008). When positive and negative expectancies disrupt performance: Regulatory focus as a catalyst. *European Journal of Social Psychology*, **38**, 187–212.

Lazarus, R. S. (1991a). Cognition and motivation in emotion. *American Psychologist*, **46**, 352–367.

(1991b). Progress on a cognitive-motivational-relational theory of emotion. *American Psychologist*, **46**, 819–834.

Lepper, M. R., & Greene, D. (1978). *The hidden costs of reward*. Hillsdale, NJ: Erlbaum.

Ludwig, A. (1995). *The Price of Greatness*. New York: Guilford.

MacKinnon, D. W. (1965). Personality and the realization of creative potential. *American Psychologist*, **20**, 273–281.

(1970). The personality correlates of creativity: A study of American architects. In P. E. Vernon (Ed.), *Creativity* (pp. 289–311). Harmondsworth, England: Penguin.

MacKinnon, D. (1983). The highly effective individual. In R. S. Albert (Ed.), *Genius and eminence: A social psychology of creativity and exceptional achievement* (pp. 114–127). Oxford: Pergamon. (Original work published 1960).

Maslow, A. (1968). Creativity in self-actualizing people. In A. Maslow (Ed.), *Toward a psychology of being* (pp. 135–145). New York: Van Nostrand Reinhold.

Montuori, A., & Purser, R. (Eds.) (1999). *Social creativity* (vol. 1, pp. 237–264). Cresskill, NJ: Hampton.

Mumford, M. D., Baughman, W., & Sager, C. E. (2003). Picking the right material: Cognitive processing skills and their role in creative thought. In M. A. Runco (Ed.), *Critical creative processes* (pp. 19–68). Cresskill, NJ: Hampton Press.

Mumford, M. D., & Gustafson, S. B. (1988). Creativity syndrome: Integration, application, and innovation. *Psychological Bulletin*, **103**, 27–43.

Ocshe, R. (1990). *Before the gates of excellence*. New York: Cambridge University Press.

Patrick, C. (1935). Creative thought in poets. *Archives of Psychology*, **26**, 1–74.

(1937). Creative thought in artists. *Journal of Psychology*, **4**, 35–73.

Pennebaker, J. W.., Kiecolt-Glaser, J. K., & Glaser, R. (1997). Disclosure of traumas and immune function: health implications for psychotherapy. In M. A. Runco & R.

Richards (Eds.), *Eminent creativity, everyday creativity, and health* (pp. 287–392). Norwood, NJ: Ablex.

Perry, S. (1999). *Writing in flow*. New York: Writer's Digest Books.

Piaget, J. (1970). Piaget's theory. In P. H. Mussen (Ed.), *Carmichael's handbook of child psychology* (3rd ed., pp. 703–732). New York: Wiley

(1976). *To understand is to invent*. New York: Penguin.

(1981). Foreword. In H. E. Gruber (Ed.), *Darwin on man: A psychological study of scientific creativity*. Chicago, IL: Chicago University Press.

Piirto, J. (1998). *Understanding those who create*. 2nd Ed. Scottsdale, AZ: Gifted Psychology Press

Pryor, K. W., Hoag, R., & O'Reilly, J. (1969).The creative porpoise: Training for novel behavior. *Journal of the Experimental Analysis of Behavior*, **12**, 653–662.

Rhodes, M. (1961). An analysis of creativity. *Phi Delta Kappan*, **42**, 305–310.

Richards, R. (1999). The subtle attraction: Beauty as a force in awareness, creativity and survival. In S. W. Russ (Ed.), *Affect, creative experience and psychological adjustment* (pp.195–219). Philadelphia: Brunner/Mazel.

Rivers-Norton, J. (2002). Creativity as an agent of change: Transforming childhood adversity through literary regeneration and the poser of place. *The International Journal of Environmental, Cultural, Economic and Social Sustainability*, **1**, 31–38.

Rogers, C. R. (1961). *On becoming a person*. Boston, MA: Houghton Mifflin.

Root-Bernstein, R. (1988). *Discovering*. Cambridge, MA: Harvard University Press.

Rothenberg, A. (1990). Creativity, mental health, and alcoholism. *Creativity Research Journal*, **3**, 179–201.

Rubenson, D. L., & Runco, M. A. (1992). The psychoeconomic approach to creativity. *New Ideas in Psychology*, **10**, 131–147.

(1995). The psychoeconomic view of creative work in groups and organizations. *Creativity and Innovation Management*, **4**, 232–241.

Runco, M. A. (1987). The generality of creative performance in gifted and nongifted children. *Gifted Child Quarterly*, **31**, 121–25.

(1993). Operant theories of insight, originality, and creativity. *American Behavioral Scientist*, **37**, 59–74.

(1994a). Creativity and its discontents. In M. P. Shaw & M. A. Runco (Eds.), *Creativity and affect* (pp. 102–123). Norwood, NJ: Ablex.

Runco, M. A. (Ed.) (1994b). *Problem finding, problem solving, and creativity*. Norwood, NJ: Ablex.

Runco, M. A. (1995). Insight for creativity, expression for impact. *Creativity Research Journal*, **8**, 377–390.

(1996). Personal creativity: Definition and developmental issues. *New Directions for Child Development*, No. 72 (Summer), pp. 3–30.

(2011a). Personal creativity. In M. A. Runco & S. Pritzker (Eds.), *Encyclopedia of creativity* (2nd ed., pp.). San Diego, CA: Academic Press.

(2011b). Tactics and strategies for creativity. In M. A. Runco & S. Pritzker (Eds.), *Encyclopedia of creativity* (2nd ed., pp. 423–426). San Diego, CA: Academic Press.

(2003). *Creativity, cognition, and their educational implications*. In J. C. Houtz (Ed.), *The educational psychology of creativity* (pp. 25–56). Cresskill, NJ: Hampton Press.

(2005a). Creative giftedness. In R. S. Sternberg & J. E. Davidson (Eds.), *Conceptions of giftedness* (rev. ed.) (pp. 295–311). New York: Cambridge University Press.

(2005b). Motivation, competence, and creativity. In A. Elliott & C. Dweck (Eds.), *Handbook of competence and motivation*. (pp. 609-623). New York: Guilford Press.
(2007). *Creativity: Theories and themes: Research, development, and practice*. San Diego: Academic Press.
(2010). *Creativity: An interdisciplinary perspective*. London: Routledge.
Runco, M. A., & Albert, R. S. (1986). The threshold hypothesis regarding creativity and intelligence: An empirical test with gifted and nongifted children. *Creative Child and Adult Quarterly*, **11**, 212–218.
Runco, M. A., & Chand, I. (1995). Cognition and creativity. *Educational Psychology Review*, **7**, 243–267.
Runco, M. A., Ebersole, P., & Mraz, W. (1991). Self-actualization and creativity. *Journal of Social Behavior and Personality*, **6**, 161–167.
Runco, M. A., & Smith, W. R. (1992). Interpersonal and intrapersonal evaluations of creative ideas. *Personality and Individual Differences*, **13**, 295–302.
Ruscio, J., Whitney, D. M., & Amabile, T. M. (1998). Looking Inside the Fishbowl of Creativity: Verbal and Behavioral Predictors of Creative Performance. *Creativity Research Journal*, **11**, 243–263.
Ryan, B. A., & Winston, A. S. (1978). Dimensions of creativity in children's drawings. *Journal of Educational Psychology*, **70**, 651–656.
Simon, H. A., & Chase, W. (1973). Skill in chess. *American Scientist*, **61**, 394–403.
Simonton, D. K. (1984). *Genius, creativity, and leadership*. Cambridge, MA: Harvard University Press.
(1988). *Scientific genius*. New York: Cambridge University Press.
Skinner, B. F. (1939). The alliteration in Shakespeare's sonnets: A study in literary behavior. *Psychological Record*, **3**, 186–192.
(1972). Creating the creative artist. In B. F. Skinner (Ed.), *Cumulative record*. New York: Appleton-Century-Crofts.
Sternberg, R. (2000). *Handbook of creativity.* Cambridge University Press.
Stokes, P. D. (in press). Creativity and operant research: Selection and reorganization of responses. In M. A. Runco (Ed.) (in press). *Creativity research handbook* (vol. 3). Cresskill, NJ: Hampton Press.
Stokes, P. D., & Balsam, P. (2003). Effects of early strategic hints on sustained variability levels. *Creativity Research Journal*, **15**, 331–341.
Wallas, G. (1926). *The art of thought*. New York: Harcourt Brace & World.
Zajonc, R. B. (1980). Feeling and thinking: Preferences need no inferences. *American Psychologist*, **35**, 151–175.
Zhong, C.-B., Dijksterhuis, A. P., & Galinsky, A. D. (2008). The Merits of Unconscious Thought in Creativity. *Psychological Science*, **19**, 912–918.

Index