The Cambridge Handbook of Thinking and Reasoning

The Cambridge Handbook of Thinking and Reasoning is the first comprehensive and authoritative handbook covering all the core topics of the field of thinking and reasoning. Written by the foremost experts from cognitive psychology, cognitive science, and cognitive neuroscience, individual chapters summarize basic concepts and findings for a major topic, sketch its history, and give a sense of the directions in which research is currently heading. The volume also includes work related to developmental, social and clinical psychology, philosophy, economics, artificial intelligence, linguistics, education, law, and medicine. Scholars and students in all these fields and others will find this to be a valuable collection.

Keith J. Holyoak is a Distinguished Professor in the Department of Psychology at the University of California, Los Angeles (UCLA). He has made a number of major contributions to the scientific understanding of human thinking and has pioneered modern work on the role of analogy in thinking.

Robert G. Morrison is president of Xunesis (www.xunesis.org), a not-for-profit company that encourages people to integrate science with their everyday lives through performance and media art that engages, entertains, and educates in both traditional and nontraditional educational settings. He received his Ph.D. in cognitive neuroscience from UCLA. His research involves understanding how the human brain implements and constrains higher cognition.
The Cambridge Handbook of Thinking and Reasoning

Edited by
Keith J. Holyoak
and
Robert G. Morrison
The editors gratefully dedicate this volume to
Patricia Wenjie Cheng
(from KJH)
and
Deborah Lee Morrison
(from RGM)
# Contents

**Preface**

<table>
<thead>
<tr>
<th>Contributors</th>
<th>page</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ix</td>
</tr>
</tbody>
</table>

**Contributors**

<table>
<thead>
<tr>
<th>Page</th>
<th>Authors</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Thinking and Reasoning: A Reader’s Guide</td>
</tr>
<tr>
<td></td>
<td>Keith J. Holyoak</td>
</tr>
<tr>
<td>1</td>
<td>Robert G. Morrison</td>
</tr>
<tr>
<td>13</td>
<td>Similarity</td>
</tr>
<tr>
<td></td>
<td>Robert L. Goldstone</td>
</tr>
<tr>
<td></td>
<td>Ji Y un Son</td>
</tr>
<tr>
<td>37</td>
<td>Concepts and Categories: Memory, Meaning, and Metaphysics</td>
</tr>
<tr>
<td></td>
<td>Douglas L. Medin</td>
</tr>
<tr>
<td></td>
<td>Lance J. Rips</td>
</tr>
<tr>
<td>73</td>
<td>Approaches to Modeling Human Mental Representations: What Works, What Doesn’t, and Why</td>
</tr>
<tr>
<td></td>
<td>Leonidas A. A. Doumas</td>
</tr>
<tr>
<td></td>
<td>John E. Hummel</td>
</tr>
</tbody>
</table>

**PART I**

**THE NATURE OF HUMAN CONCEPTS**

<table>
<thead>
<tr>
<th>Page</th>
<th>Authors</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>5. The Problem of Induction</td>
</tr>
<tr>
<td></td>
<td>Steven A. Sloman</td>
</tr>
<tr>
<td>95</td>
<td>David A. Lagnado</td>
</tr>
<tr>
<td></td>
<td>6. Analogy</td>
</tr>
<tr>
<td></td>
<td>Keith J. Holyoak</td>
</tr>
<tr>
<td>117</td>
<td>7. Causal Learning</td>
</tr>
<tr>
<td></td>
<td>Marc J. Buehner</td>
</tr>
<tr>
<td>143</td>
<td>Patricia W. Cheng</td>
</tr>
<tr>
<td></td>
<td>8. Deductive Reasoning</td>
</tr>
<tr>
<td></td>
<td>Jonathan St. B. T. Evans</td>
</tr>
<tr>
<td>169</td>
<td>9. Mental Models and Thought</td>
</tr>
<tr>
<td></td>
<td>P. N. Johnson-Laird</td>
</tr>
<tr>
<td>185</td>
<td>10. Visuospatial Reasoning</td>
</tr>
<tr>
<td></td>
<td>Barbara Tversky</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Page</th>
<th>Authors</th>
</tr>
</thead>
<tbody>
<tr>
<td>243</td>
<td>11. Decision Making</td>
</tr>
<tr>
<td></td>
<td>Robyn A. LeBoeuf</td>
</tr>
<tr>
<td></td>
<td>Eldar B. Shafir</td>
</tr>
</tbody>
</table>
PART VI

ONTOGENY, PHYLOGENY, LANGUAGE, AND CULTURE

22. Development of Thinking 529
Graeme S. Halford

23. Mathematical Cognition 559
C. R. Gallistel
Rochel Gelman

24. Effects of Aging on Reasoning 589
Timothy A. Salthouse

25. Reasoning and Thinking in Nonhuman Primates 607
Josep Call
Michael Tomasello

26. Language and Thought 633
Lisa Gleitman
Anna Papafragous

27. Paradigms of Cultural Thought 663
Patricia M. Greenfield

PART VII

THINKING IN PRACTICE

28. Legal Reasoning 685
Phoebe C. Ellsworth

29. Scientific Thinking and Reasoning 705
Kevin Dunbar
Jonathan Fugelsang

30. Thinking and Reasoning in Medicine 727
Vimla L. Patel
Jose F. Arecha
Jazie Zhang

31. Intelligence 751
Robert J. Sternberg

32. Learning to Think: The Challenges of Teaching Thinking 775
Ron Ritchhart
David N. Perkins

Index 803
Preface

A few decades ago, when the science of cognition was in its infancy, the early textbooks on cognition began with perception and attention and ended with memory. So-called higher-level cognition – the mysterious, complicated realm of thinking and reasoning – was simply left out. Things have changed – any good cognitive text (and there are many) devotes several chapters to topics such as categorization, inductive and deductive reasoning, judgment and decision making, and problem solving. What has still been missing, however, is a true handbook for the field of thinking and reasoning – a book meant to be kept close “at hand” by those involved in the field. Such a book would bring together top researchers to write chapters, each of which summarizes the basic concepts and findings for a major topic, sketches its history, and provides a sense of the directions in which research is currently heading. This handbook would provide quick overviews for experts in each topic area, and more importantly for experts in allied topic areas (because few researchers can keep up with the scientific literature over the full breadth of the field of thinking and reasoning). Even more crucially, this handbook would provide an entry point into the field for the next generation of researchers by providing a text for use in classes on thinking and reasoning designed for graduate students and upper-level undergraduates.

The Cambridge Handbook of Thinking and Reasoning is intended to be this previously missing handbook. The project was first conceived at the meeting of the Cognitive Science Society in Edinburgh, Scotland, during the summer of 2001. The contents of the volume are sketched in Chapter 1. Our aim is to provide comprehensive and authoritative reviews of all the core topics of the field of thinking and reasoning, with many pointers for further reading. Undoubtedly, there are still omissions, but we have included as much as we could realistically fit in a single volume. Our focus is on research from cognitive psychology, cognitive science, and cognitive neuroscience, but we also include work related to developmental, social, and clinical psychology; philosophy; economics; artificial intelligence; linguistics; education; law; and medicine. We hope that scholars and students in all these
fields and others will find this to be a valuable collection.

We have many to thank for their help in bringing this endeavor to fruition. Philip Laughlin, our editor at Cambridge University Press, gave us exactly the balance of encouragement and patience we needed. It is fitting that a handbook of thinking and reasoning should bear the imprint and indeed the name of this illustrious press, with its long history reaching back to the origins of scientific inquiry. Michie Shaw, Senior Project Manager at TechBooks, provided us with close support throughout the arduous editing process. At UCLA, Christine Vu did a great deal of organizational work in her role as our editorial assistant for the entire project. During this period, our own efforts were supported by grants R305H030141 from the Institute of Education Sciences and SES-0080375 from the National Science Foundation to KJH, and from Xunesis and National Service Research Award MH-064244 from the National Institute of Mental Health to RGM.

Then there are the authors. (It would seem a bit presumptuous to call them “our” authors!) People working on tough intellectual problems sometimes experience a moment of insight – a sense that although many laborious steps may lay ahead, the basic elements of a solution are already in place. Such fortunate people work on happily, confident that ultimate success is assured. In preparing this handbook, we also had our moment of “insight.” It came when all these outstanding researchers agreed to join our project. Before the first chapter was drafted, we knew the volume was going to be of the highest quality. Along the way, our distinguished authors graciously served as each other’s critics as we passed drafts around, working to make the chapters as integrated as possible, adding in pointers from one to another. Then the authors all changed hats again and went back to work revising their own chapters in light of the feedback their peers had provided. We thank you all for making our own small labors a great pleasure.

KEITH J. HOLYOAK
University of California, Los Angeles

ROBERT G. MORRISON
Xunesis, Chicago

October 2004
Contributors

John R. Anderson
Carnegie Mellon University
Department of Psychology
Pittsburgh, PA 15213-3890
ja+@cmu.edu

José F. Arocha
Department of Health Studies & Gerontology
University of Waterloo
200 University Ave. W.
Waterloo, Ontario
Canada N2L 3G1
jfarocha@healthy.uwaterloo.ca

Peter Bachman
University of California, Los Angeles
Department of Psychology
Franz Hall
Los Angeles, CA 90095-1563
bachman@psych.ucla.edu

Miriam Bassok
University of Washington
Department of Psychology
Box 351225
Seattle, WA 98195-1525
mbassok@uw.washington.edu

Marc J. Buehner
School of Psychology
Cardiff University
Tower Building
Park Place
Cardiff, CF10 3AT
Wales, UK
BuehnerM@Cardiff.ac.uk

Josep Call
Max Planck Institute for Evolutionary Anthropology
Deutscher Platz 6
D-04103 Leipzig, Germany
call@eva.mpg.de

Tyrone D. Cannon
University of California, Los Angeles
Department of Psychology
Franz Hall
Los Angeles, CA 90095-1563
cannon@psych.ucla.edu

Patricia W. Cheng
University of California, Los Angeles
Department of Psychology
Franz Hall
Los Angeles, CA 90095-1563
cheng@psych.ucla.edu