Contents

List of Contributors xiii

Introduction xv

PART I REPRESENTATION AND CONSTRAINT IN COMPLEX PROCESSING 1

1 The Lateralization of BRIAN: A Computational Theory and Model of Visual Hemispheric Specialization 3
Stephen M. Kosslyn, Michael A. Sokolov, and Jack C. Chen

Introduction 3
High-Level Vision 4
Subsystems of High-Level Visual Recognition 5
Mechanisms of Hemispheric Differentiation 11
Lateralization Simulations 16
Results 21
Conclusions 25

2 The Role of Working Memory in Language Comprehension 31
Patricia A. Carpenter and Marcel A. Just

Working Memory From a Computational Viewpoint 34
Trade-Offs Among Processes in Working Memory 42

Syntactic Analysis and Working Memory 52
The Nature of Working Memory 59
A Final Note 66

3 Representation and Transfer in Problem Solving **69**
Kenneth Kotovsky and David Fallside

Experimental Background: Problem Difficulty 71
Experimental Background: Transfer of Training and Problem Move Operators 77
Experiment 1: Representation and Transfer 81
Experiment 2: The Effects of Stimulus and Representational Similarity on Transfer 93
Discussion 104

4 Developmental Differences in Scientific Discovery Processes **109**
Kevin Dunbar and David Klahr

On the Origins of Discovery Processes 109
Developmental Issues in Scientific Reasoning 111
Studying the Discovery Process: General Procedure 113
Study 1: Adults Discovering a New Function 114
Study 2: Hypothesis-Space Search and Experimentation by Adults 125
Study 3: Scientific Reasoning in Children 127
A Dual-Search Model of Scientific Discovery 132
Discussion 137
Postscript: Acknowledgments to Herbert Simon 141

5 Scientists of the Artificial **145**
George A. Miller

The Computational Nervous System 146
The Hard Working Memory 150
The Many Towers of Hanoi 153
Search and Research 158
Concluding Apology 160

PART II EXPERTISE IN HUMAN AND ARTIFICIAL SYSTEMS **163**

6 What Hath Simon Wrought? **165**
Edward A. Feigenbaum

Some Moments of Personal History 166
The Genesis of the Science
(Early Life in the Search Space) 166
An Interlude: The Dimensions of Intelligence 169
The Exodus: From the Search-Based to the
Knowledge-Based Paradigm 172
Leviticus: Laws in the Land of Promise 178
Conclusion: The Many Manifestations of Simon 180

7 Expertise in Chess and Bridge **183**
Neil Charness

An Anecdote 183
Chess: A Drosophilia for Cognitive Psychology 184
Skill in Bridge 193
Lessons About Skill Acquisition 204

8 Writing Research: The Analysis of a Very Complex Task **209**
John R. Hayes

Planning 211
Sentence Generation 213
Revision 215
Task Environment 218
The Writers' Knowledge 224
Conclusion 231

9 Skilled Memory and Expertise: Mechanisms of Exceptional Performance **235**
K. Anders Ericsson and James J. Staszewski

Expert Performance and the Paradox of Expertise 236
Skilled Memory Theory 238
Skilled Memory Theory and Exceptional
Memory Performance 241
Skilled Memory Theory and Expertise 245
Concluding Remarks 263

10 Expertise and Learning: How Do We Think About Instructional Processes Now That We Have Discovered Knowledge Structures? **269**
Robert Glaser

Components of Competent Performance 271
Approaches to Instruction 275
Comment and Questions 278

PART III INSTRUCTION AND SKILL ACQUISITION 283

11 Situations, Mental Models, and Generative Knowledge 285
James G. Greeno

A View of Semantics *289*
Some Research on Meaning and Models *296*
An Extended View of Semantics *305*
Conclusions *313*

12 Display-Based Problem Solving 319
Jill H. Larkin

Description of the Model *323*
Illustrations of Using External Data Structures to Solve Problems *326*
DiBS and Human Problem Solving *331*
Potential Applications *337*
Conclusion *339*

13 The Analogical Origins of Errors in Problem Solving 343
John R. Anderson

The PUPS Theory of Learning *345*
Sources of Errors in PUPS *349*
Errors With the Lisp Tutor *351*
Errors With the Geometry Tutor *357*
Errors With the Algebra Tutor *363*
Summary *366*
Einstellung *366*
Comparisons With VanLehn's Theories *367*
Conclusions *370*

PART IV SCIENCE AND THOUGHT 373

14 The Scientist as Problem Solver 375
Herbert A. Simon

Formulating Problems *376*
Laws From Data *379*
Representations *383*
Finding an Explanatory Model *386*
Designing Good Experiments *388*
The Scientist as a Satisficer *394*

15 Putting It All Together **399**
Allen Newell

Herbert Simon *400*
Unified Theories of Cognition *402*
The Chapters of This Volume *416*
Conclusion *435*

EPILOGUE
How It All Got Put Together **441**
Allen Newell

Author Index **447**

Subject Index **455**