BRIEF OVERVIEW

PART I: BACKGROUND AND METHODS

1	A Brief History of Cognitive Neuroscience1
2	Cellular Mechanisms and Cognition18
3	Neuroanatomy and Development59
4	Methods of Cognitive Neuroscience110

PART II: CORE PROCESSES

5	Sensation and Perception164
6	Object Recognition
7	The Control of Action 257
8	Learning and Memory
9	Emotion
10	Language
11	Hemispheric Specialization445

PART III: CONTROL PROCESSES

12	Attention and Consciousness	91
13	Cognitive Control	55
14	Social Cognition	99
15	Evolutionary Perspectives	34



BOXES	XV
PREFACE	xvii
ACKNOWLEDGMENTS	xix

PART I: BACKGROUND AND METHODS

A Brief History of Cognitive Neuroscience
A Historical Perspective 3 • The Brain Story 4 • The Psychological Story 12 • Summary 16
• Key Terms 16 • Take-Home Messages 16 • Thought Questions 17 • Suggested Reading 17

2 Cellular Mechanisms and Cognition

Cells of the Nervous System 19 • The structure of neurons 20 • The role of glial cells 23 • Neuronal Signaling 27 • Overview of neuronal communication 27 • Properties of the neuronal membrane and the membrane potential 28 • Electrical conduction in neurons 31 • Transmembrane proteins: ion channels and pumps 44 • Synaptic Transmission 47 • Chemical transmission 47 • Neurotransmitters 50 • Drugs, neurotransmission, and disease 53 • Electrical transmission 54 • Summary 56 • Key Terms 56 • Take-Home Messages 56 • Thought Questions 58 • Suggested Reading 58 18

3 Neuroanatomy and Development

Neuroanatomy 60 • Methods in neuroanatomy 60 • Gross and Functional Anatomy of the Nervous
System 67 • Cerebral cortex 67 • Limbic system, basal ganglia, hippocampus, and diencephalon 77 •
Brainstem 84 • Cerebellum 86 • Spinal cord 87 • Autonomic nervous system 87 •
Development of the Nervous System 88 • Overview of gross development 88 • Genesis of the cerebral cortex 90 • Birth of new neurons throughout life 96 • Postnatal brain development 99 • Plasticity in the Nervous System 101 • Cortical maps and experience 101 • Plasticity in the adult human brain 103
• Mechanisms of cortical plasticity 105 • Summary 106 • Key Terms 107 • Take-Home
Messages 107 • Thought Questions 108 • Suggested Reading 109

4 Methods of Cognitive Neuroscience

What Is Cognitive Psychology? 111 • Mental representations and transformations 111 •
Characterizing mental operations 113 • Constraints on information processing 115 • Computer
Modeling 117 • Models are explicit 117 • Representations in computer models 118 • Models lead
to testable predictions 119 • Limitations of computer models 119 • Experimental Techniques Used
with Animals 120 • Single-cell recording 120 • Lesions 125 • Genetic manipulations 126 •
The new genomics 127 • Neurology 129 • Structural imaging of neurological damage 130 •
Causes of neurological disorders 133 • Functional neurosurgery 140 • Converging Methods 141 •
Cognitive deficits following brain damage 141 • Virtual lesions: transcranial magnetic stimulation 145 •
Functional imaging 148 • Summary 159 • Key Terms 161 • Take-Home Messages 161 •
Thought Questions 162 • Suggested Reading 163

PART II: CORE PROCESSES

5 Sensation and Perception

Auditory Perception 165 • Neural pathways of audition 165 • Computational goals in audition 167
Multiple cues for sound localization 168 • Olfactory Perception 170 • Neural pathways of olfaction 171 • The role of sniffing in olfactory perception 171 • One nose, two smells 173 • Smell and memory 174 • Gustatory Perception 174 • Neural pathways of gustation 174 • Gustatory processing 175 • Somatosensory Perception 175 • Neural pathways of somatosensation 175 • Somatosensory processing 176 • Vision 177 • Neural pathways of vision 177 • From the eye to the central nervous system 178 • Cortical visual areas 180 • Deficits in visual perception 189 • Multimodal Perception 199 • Multimodal processing in the brain 199 • Does the whole equal more than the sum of the parts? 199 • Synesthesia 200 • Perceptual reorganization 202 • Summary 203
Key Terms 204 • Take-Home Messages 204 • Thought Questions 205 • Suggested Reading 206

164

59

6 Object Recognition

Two Cortical Pathways for Visual Perception 209
Representational differences between the dorsal and ventral pathways 211
Perception for identification versus perception for action 213
Computational Problems in Object Recognition 217
Variability in sensory information 217
View-dependent or view-invariant recognition? 219
Shape encoding 221
Grandmother cells and ensemble coding 222
Summary of computational problems 225
Failures in Object Recognition 225
Subtypes of agnosia 225
Integrating parts into wholes 230
Category specificity in agnosia 233
Computational account of category-specific deficits 235
The Perception of Faces 237
Are faces special? 238
Neural mechanisms for face perception 238
Dissociations of face and object perception 244
Two Systems for Object Recognition 247
The Relationships of Visual Perception, Imagery, and Memory 249
Summary 254
Key Terms 254
Take-Home Messages 254
Thought Questions 256
Suggested Reading 256

7

The Control of Action

Motor Structures 259 • Muscles, motor neurons, and the spinal cord 259 • Subcortical motor structures 260 • Cortical regions involved in motor control 261 • Organization of motor areas 263 • Computational Issues in Motor Control 265 • Peripheral control of movement and the role of feedback 265 • Representation of movement plans 267 • Physiological Analysis of Motor Pathways 271 • Neural coding of movement 271 • Mirror neurons 281 • Planning and Execution of Movement 284 • Internal versus external guidance of movement 284 • Shift in cortical control with learning 286 • Functional Analysis of the Motor System and Movement Disorders 288 • Cortical areas 289 • Subcortical areas: cerebellum and basal ganglia 295 • Summary 307 • Key Terms 309 • Take-Home Messages 309 • Thought Questions 311 • Suggested Reading 311

8 Learning and Memory

Theories of Learning and Memory 313 • Sensory and short-term memory mechanisms 313 •
Models of short-term memory 315 • Models of long-term memory 321 • Summary of memory models
323 • Memory and Brain 324 • Human memory, brain damage, and amnesia 324 • Animal
models of memory and the medial temporal lobe 340 • Imaging the human brain and memory 344 •
Cellular Bases of Learning and Memory 356 • Long-term potentiation and the hippocampus 357 •
Summary 360 • Key Terms 361 • Take-Home Messages 361 • Thought Questions 362
Suggested Reading 363

207

312

9 Emotion

10 Language

Theories of Language 389 • Storage of words and concepts: the mental lexicon 389 • Perceptual analyses of the linguistic input 395 • Recognition of words 405 • Integration of words in sentences 410 • Lexical integration in discourse 415 • Speech production 419 • Summary of language theories 422 • Neuropsychology of Language and Language Disorders 423 • Aphasia 423 • History of aphasia 423 • Classification of aphasia 427 • Damage to connections between language areas 429 • Mechanisms of aphasic deficits 431 • Neurophysiology of Language 432 • Functional neuroimaging of language 433 • Electrophysiology of language 434 • Neural models of language comprehension 440 • Summary 442 • Key Terms 442 • Take-Home Messages 442 • Thought Questions 444 • Suggested Reading 444

11 Hemispheric Specialization

Principles of Cerebral Organization 447 • Anatomical correlates of hemispheric specialization 447 •
Microanatomical investigations of anatomical asymmetries 449 • How the Two Hemispheres
Communicate 450 • Cortical disconnection 452 • Functional consequences of the split-brain
procedure 453 • Specificity of callosal function 454 • Hemispheric Specialization 456 •
Language and speech 456 • Visuospatial processing 459 • Attention and perception 460 • Complex
cognition 464 • Converging Evidence of Hemispheric Specialization 466 • Functional
asymmetries in patients with unilateral cortical lesions 466 • Functional asymmetries in the normal brain
468 • What Brain Functions Are Lateralized? 471 • Asymmetries in perceptual representations 473
Asymmetries in representing spatial relations 478 • Variations in Hemispheric Specialization 483
The relation between handedness and left-hemisphere language dominance 483 • Hemispheric
specialization in nonhumans 485 • Summary 488 • Key Terms 488 • Take-Home Messages
488 • Thought Questions 490 • Suggested Reading 490

445

12

Attention and Consciousness

Theoretical Models of Attention 492 • The cocktail party effect 494 • Early and late selection 496
Quantifying attention in perception 498 • Neural Mechanisms of Attention and Selective
Perception 502 • Neurophysiology of human selective attention 502 • Functional imaging of brain attention systems 511 • Animal studies of attentional mechanisms 525 • Neurology and
Neuropsychology of Attention 537 • Extinction 537 • The fate of neglected information 545 • Models of Attention and Awareness 548 • Unattended information and awareness 548 •
Unconscious processing and attention 549 • Subliminal, preconscious, and conscious processing 550 •
Summary 551 • Key Terms 552 • Take-Home Messages 552 • Thought Questions 554 •



Cognitive Control

Subdivisions of the Frontal Lobes 556 • The Lateral Prefrontal Cortex and Working Memory 558 • Distinguishing between stored knowledge and activated information 558 • Prefrontal cortex is necessary for working memory but not associative memory 559 • Physiological correlates of working memory 561 • The Prefrontal Cortex and Other Memory Domains 564 • The frontal lobes and the temporal organization of memory 564 • Source memory 566 • Component Analysis of the Prefrontal Cortex 567 • Content-based accounts of functional specialization within the prefrontal cortex 567 • Processbased accounts of functional specialization within the prefrontal cortex 567 • Processbased accounts of functional specialization within the prefrontal cortex 569 • Goal-Oriented Behavior 571 • Planning and selecting an action 572 • Cognitive control of goal-oriented behavior 573 • Retrieval and selection of task-relevant information 574 • Task switching 577 • Top-Down Cognitive Control 580 • Inhibitory and facilitatory mechanisms for top-down control 581 • Inhibition of action 586 • Ensuring That Goal-Oriented Behaviors Succeed 587 • The medial frontal cortex as a monitoring system 589 • Summary 596 • Key Terms 596 • Take-Home Messages 596 • Thought Questions 598 • Suggested Reading 598

14 Social Cognition (by Jennifer S. Beer)

Self-Perception and Self-Knowledge 600 • Self-referential processing 601 • Self-reference as a baseline mode of brain function 603 • Self-perception as a motivated process 604 • Perception of Other People 606 • Understanding the mental states of others 607 • The neural correlates of theory of mind 607 • Integrating nonverbal cues and mental states 610 • Autism: deficits in understanding the minds and nonverbal cues of other people? 611 • Convergence in the Perception of Self and Others 617 • Medial prefrontal cortex: similar and close others 617 • Empathy 618 • Social Knowledge 621 • Representations of social knowledge 621 • Using social knowledge to make decisions 623 • Neuroeconomics 626 • Moral decisions 628 • Summary 631 • Key Terms 632 • Take-Home Messages 632 • Thought Questions 633 • Suggested Reading 633

555

491

599

xiii

15 Evolutionary Perspectives (with Jeff Hutsler)

Evolution of the Brain 635 • Historical underpinnings of contemporary evolutionary neurobiology 635
Modern evolutionary neurobiology: assumptions and aims 637 • First Principles 640 •
Evolutionary mechanisms 644 • The Comparative Approach 645 • The scale of nature revisited 648
Adaptation and the Brain 650 • Adaptations at multiple brain levels 651 • Sexual selection and evolutionary pressures on behavior 653 • The effect of sex on spatial abilities 655 • Evolution and physiology 658 • Adaptive specializations and learning mechanisms 658 • Evolutionary Insights Into Human Brain Organization 661 • Summary 664 • Key Terms 664 • Take-Home Messages 664 • Thought Questions 666 • Suggested Reading 666

634

G-1

GLOSSARY

R-1
C-1
I-1