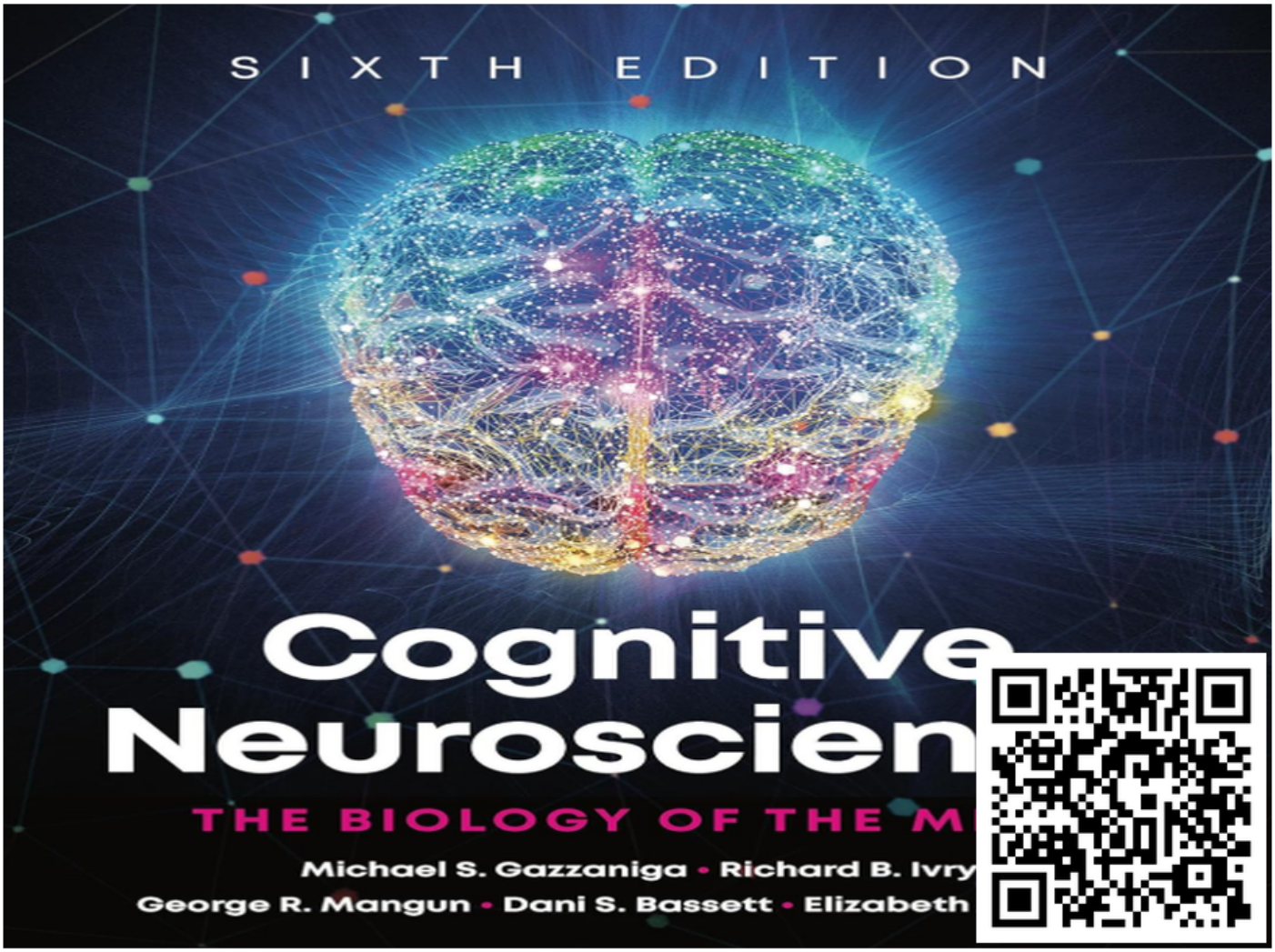

SIXTH EDITION

Cognitive Neuroscience

THE BIOLOGY OF THE MIND

Michael S. Gazzaniga · Richard B. Ivry
George R. Mangun · Dani S. Bassett · Elizabeth A. Phelps

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The Biology of the Mind

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With special appreciation for the Sixth Edition to Rebecca A. Gazzaniga, MD

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Dedication

For Lilly, Emmy, Garth, Dante, Rebecca, Leonardo, Fiala, Carmen, and Lucia

M.S.G.

For Henry and Sam

R.B.I.

For Tamara, Alexander, Nicholas, and Marianne

G.R.M.

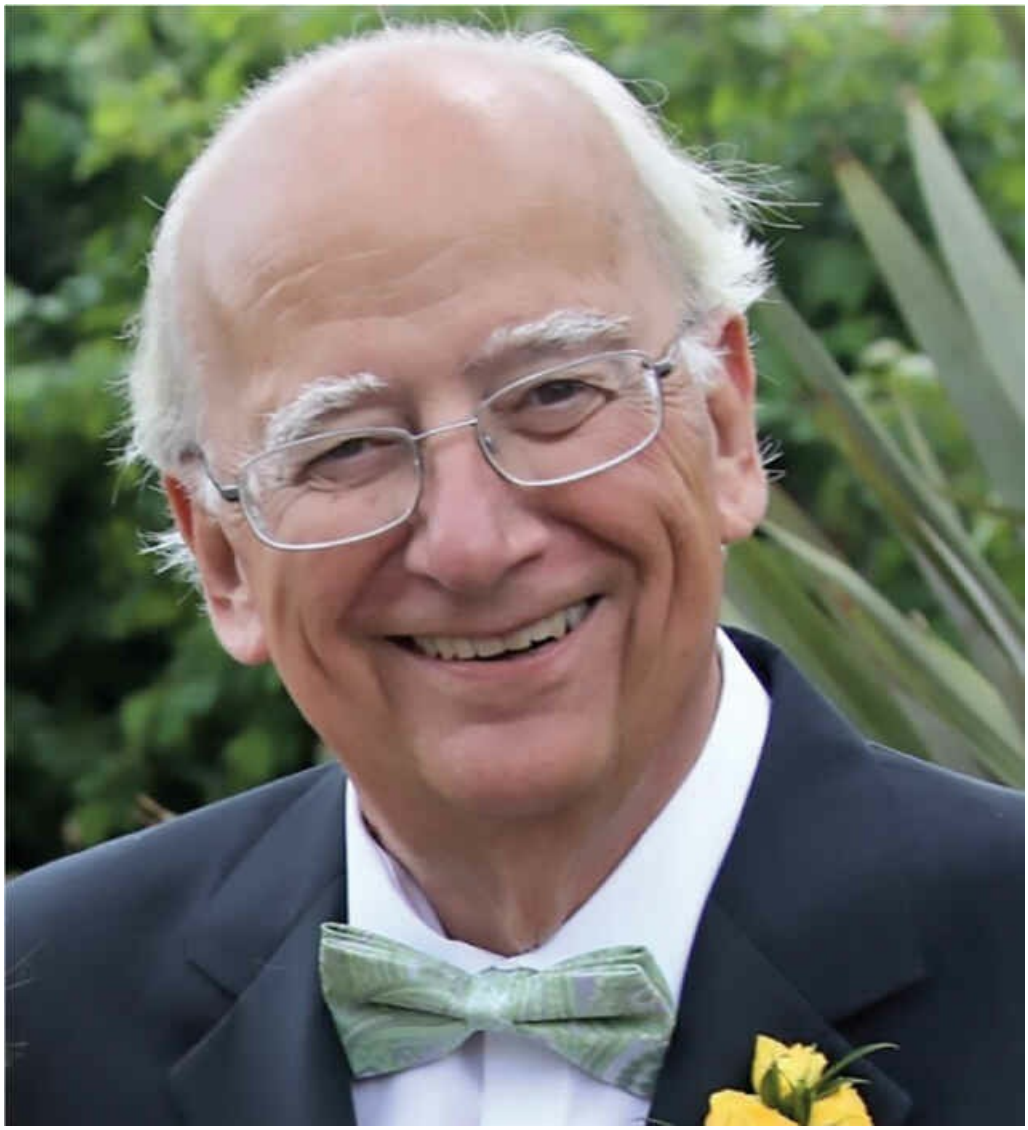
For Silas and Simi

D.S.B.

For Tyler, Alexandra, Connor, Samantha, and Evangeline

E.A.P.

About the Authors



A headshot of Michael Gazzaniga, smiling. He is bald with a white fringe of hair. He wears rimless eyeglasses.

Michael S. Gazzaniga was the founding director of the SAGE Center for the Study of the Mind, and is Distinguished Professor Emeritus of Psychological and Brain Sciences, at the University of California, Santa Barbara. He received a PhD from the California Institute of Technology in 1964, where he worked with Roger Sperry and had primary responsibility for initiating human split-brain research. He has carried out extensive studies on both subhuman primate and human behavior and cognition. He established the Program in Cognitive Neuroscience at Cornell Medical School, the Center for Cognitive Neuroscience at Dartmouth College, and the Center for

Neuroscience at the University of California, Davis. He is the founding editor of the *Journal of Cognitive Neuroscience* and also a founder of the Cognitive Neuroscience Society. For 20 years he directed the Summer Institute in Cognitive Neuroscience, and he serves as editor in chief of the major reference text *The Cognitive Neurosciences* . He was a member of the President's Council on Bioethics from 2001 to 2009. He is a member of the American Academy of Arts and Sciences, the National Academy of Medicine, and the National Academy of Sciences.

A headshot of Richard Ivry, with a slight smile. He has a high forehead and salt-and-pepper gray hair.

Richard B. Ivry is a Distinguished Professor of Psychology and Neuroscience at the University of California, Berkeley. He received his PhD from the University of Oregon in 1986, working with Steven Keele on a series of studies that helped bring the methods of cognitive neuroscience into the domain of motor control. His research program focuses on human performance, asking how cortical and subcortical networks in the brain select, initiate, and control movements. At Berkeley, he was a founding member of the Helen Wills Neuroscience Institute and has served as director of the Institute of Cognitive and Brain Sciences and chair of the Department of

Psychology. He was an associate editor for the *Journal of Cognitive Neuroscience* and senior editor at *eLife* . His research accomplishments have been recognized with numerous awards, including the Troland Award from the National Academy of Sciences, the William James Fellow Award for lifetime achievement from the Association for Psychological Science, and election to the American Academy of Arts and Sciences.

A headshot of George R. Mangun, smiling. He has graying brown hair with a receding hairline. He is wearing metal-rimmed eyeglasses.

George R. Mangun is the founding and co-director of the Center for Mind and Brain, and Distinguished Professor of Psychology and Neurology, at the University of California, Davis. He received his PhD in neuroscience from the University of California, San Diego in 1987. His research into brain attention mechanisms involves pioneering studies of multimodal brain imaging in cognitive neuroscience. He founded and directed the Center for Cognitive Neuroscience at Duke University, and the Center for Mind and Brain at the University of California, Davis, where he was also Dean of Social Sciences. He was the editor of *Cognitive Brain Research* , a senior editor of the *Journal of Cognitive Neuroscience* , and the founding

editor of *Frontiers in Cognition* , and he was a member of the founding committee of the Cognitive Neuroscience Society. Among other awards, Mangun received a Distinguished Scientist Lecture Award from the American Psychological Association, an NIMH Senior Scientist Award, a Fulbright U.S. Distinguished Scholar Award, and the Society for Neuroscience Award for Education in Neuroscience. He is an elected fellow of the Association for Psychological Science and the American Association for the Advancement of Science.

A headshot of Dani Bassett, with a slight smile. Her brown-blonde hair is cut short.

Dani S. Bassett is the J. Peter Skirkanich Professor at the University of Pennsylvania, with appointments in Bioengineering, Electrical and Systems Engineering, Physics and Astronomy, and Neurology and Psychiatry. Bassett received a BS in physics from Penn State University and a PhD in physics from the University of Cambridge as an NIH Oxford–Cambridge Scholar. Bassett is best known for blending neural and systems engineering to identify fundamental mechanisms of cognition and disease in human brain networks. They have received multiple

prestigious awards, including the American Psychological Association's "Rising Star" award (2012), the Alfred P. Sloan Research Fellowship (2014), and a MacArthur Fellow Genius Grant (2014). Bassett has also been named one of Web of Science's most Highly Cited Researchers for 4 years running. They are the author of more than 450 peer-reviewed publications as well as numerous book chapters and teaching materials. They recently co-authored *Curious Minds: The Power of Connection* (MIT Press) with philosopher and twin Perry Zurn.

A headshot of Elizabeth Phelps, smiling. Her chestnut-brown hair is shoulder length.

Elizabeth A. Phelps is the Pershing Square Professor of Human Neuroscience at Harvard University. She received her PhD from Princeton University and served on the faculty of Yale University and New York University. Her laboratory has earned widespread acclaim for its groundbreaking research on how the human brain processes emotion, particularly as it relates to learning and memory. She is the recipient of career achievement awards from the Cognitive Neuroscience Society, the Social and Affective Neuroscience Society, the Association for Psychological Science, and the Brain and Behavior Research Foundation, and she received a

Mentor Award from the Association for Psychological Science. She is a fellow of the Society of Experimental Psychologists and the American Academy of Arts and Sciences, and was a founding board member of the International Neuroethics Society. She has served as president of the Association for Psychological Science, the Social and Affective Neuroscience Society, and the Society for Neuroeconomics.

Brief Contents

Preface

Welcome to the Sixth Edition! Looking back over previous editions of *Cognitive Neuroscience: The Biology of the Mind* , we see that the field has made great strides in addressing the most fundamental questions of life—how do our brains and bodies enable us to remember faces, solve problems, navigate complex environments, build tools, and communicate?—in essence, defining who we are as a species. Despite this progress, an understanding of the biological foundations of the mind has remained elusive; indeed, these advances have revealed new questions and potential solutions that were beyond the imagination of our community back in 1998 with the release of the First Edition.

How does one keep up with such a dynamic and expanding field? To help us on the journey, we are joined by two new authors, Dani S. Bassett (University of Pennsylvania) and Elizabeth A. Phelps (Harvard University), extraordinary scientists and educators who bring unique expertise to this enterprise. Professor Bassett moved to cognitive neuroscience from a background in theoretical physics, where they had developed an interest in understanding network activity. Early work in brain science tended to focus on individual neurons, seeking to understand the operations performed by specific regions of the brain. Bassett is a leader in the introduction of new scientific approaches, computational methods, and theoretical views that have inspired a paradigm shift, one in which the field seeks to understand how these regions form networks whose integrated activity enables complex cognition. A network science perspective is a valuable addition to this edition of *Cognitive Neuroscience: The Biology of the Mind* .

Professor Phelps is one of the leading scientists studying learning, memory, social behavior, and emotion, topics that are central to cognitive neuroscience. None of these processes act in isolation; instead, they operate in concert to create our subjective selves. And, of course, we are social animals, usually friendly and cooperative, sometimes not. The Sixth Edition benefits from her cognitive neuroscience insights and wisdom.

When cognitive neuroscience emerged in the late 1970s, it remained to be seen whether this new field would have “legs.” Today, the answer is clear: The field has blossomed in spectacular fashion. Cognitive neuroscience is well represented in universities and colleges around the world providing researchers and students with the tools and opportunities to develop the interdisciplinary research and training programs that are the mainstay of the field. Multiple journals, some designed to cover the entire field, and others specialized for particular methodologies or research themes, have been launched to provide venues to report the latest findings. All major international funding agencies and foundations have added cognitive neuroscience programs to their portfolios. The number of papers in our field continues to increase at an exponential rate. The Cognitive Neuroscience Society has flourished, having recently celebrated its 30th year. Today, more than ever, cognitive neuroscience is a discipline that values diverse researchers and perspectives.

The fundamental challenge we faced in laying the groundwork for our early editions was to determine the basic principles that make cognitive neuroscience distinct from physiological psychology, neuroscience, cognitive psychology, and neuropsychology. It is now clear that

cognitive neuroscience overlaps with, and synthesizes, these disciplinary approaches as researchers aim to understand the neural bases of cognition. In addition, cognitive neuroscience increasingly informs and is informed by disciplines outside the mind–brain sciences, such as complex systems science and statistical physics, as exemplified by our Chapter 14 , "The Consciousness Problem."

As in previous editions of this book, we continue to seek a balance between psychological theory, with its focus on the mind, and the neuropsychological and neuroscientific evidence about the brain that informs this theory. We make liberal use of patient case studies to illustrate essential points and observations that provide keys to understanding the architecture of cognition, rather than providing an exhaustive description of brain disorders. In every section, we strive to include the most current information and theoretical views, supported by evidence from cutting-edge technologies that are such a driving force in cognitive neuroscience. To complete the story, we also provide examples of research that use computational techniques.

Teaching students to think and ask questions like cognitive neuroscientists is a major goal of our textbook. As cognitive neuroscientists, we examine mind–brain relationships using a wide range of techniques, such as functional and structural brain imaging, neurophysiological recording in animals, human electroencephalographic (EEG) and magnetoencephalographic (MEG) recording, brain stimulation methods, and analysis of syndromes resulting from brain damage. We highlight the strengths and weaknesses of these methods to demonstrate how these techniques must be used in a complementary manner.

We want our readers to learn what questions to ask, how to choose the tools and design experiments to answer these questions, and how to evaluate and interpret the results of those experiments. Despite the stunning progress of the neurosciences, the brain remains a great mystery, with each insight inspiring new questions. For this reason, we avoid using a declarative style of writing in the book. Instead, we tend to present results that can be interpreted in more than one way, helping the reader to recognize that alternative interpretations are possible.

With each edition, we seek to bring in the field's many new major technological, methodological, and theoretical developments. Advances in neuroimaging and neurophysiology deepen our understanding of the functional organization of the brain and how brain networks communicate. Machine learning has opened exciting new avenues for analyzing neural data and simulating complex functions. New technologies used for noninvasive brain stimulation, magnetic resonance spectroscopy, electrocorticography, and optogenetics have added to the cognitive neuroscientist's arsenal. Fascinating links to genetics, comparative anatomy, computation, and robotics have emerged. Parsing this body of work and deciding which studies should be included has been a major challenge for us. We firmly believe that technology is a cornerstone of scientific advancement. Thus, we felt it essential to capture the cutting-edge trends in the field, while keeping in mind that this is an undergraduate survey text.

The first five editions provided compelling evidence that our efforts have resulted in a highly useful text for undergraduates taking their first course in cognitive neuroscience, as well as a concise reference volume for graduate students and researchers. More than 500 colleges and universities worldwide have adopted the text, and it has been translated into several languages. Moreover, in addition to our interdisciplinary approach, instructors tell us they like that our book

has a strong narrative voice and offers a manageable number of chapters to teach in a one-semester survey course.

Inspired by feedback from our adopters, we have also made the text even more user-friendly and focused on the takeaway points. Some ways in which we have made the Sixth Edition more accessible include the following:

- Cognitive neuroscience is a terminology-heavy field. The Sixth Edition provides a **running glossary** on each page to help students remember key terms and their definitions.
- **Behind the Citation** interviews, in print and online, offer Q & A sessions with contemporary cognitive neuroscientists. Marlene Behrmann, Roberto Cabeza, Becket Ebitz, Jack Gallant, Arturo Hernandez, Amishi Jha, Antonia Kaczkurkin, Alan Kingstone, John Krakauer, Adina Roskies, Rebecca Saxe, Taraz Lee, Tirin Moore, Lucina Uddin, and Joni Wallis explain aspects of their research and the insights generated.
- The **Norton Illumine Ebook** offers multiple-choice Check Your Understanding questions at the end of each major section. These questions test students on their understanding and application of key concepts.
- A manipulatable **3-D model of the brain** also appears in the Norton Illumine Ebook.

As with each previous edition, this book is the result of a dynamic yet laborious interactive effort among the five of us, along with extensive discussions with our colleagues, our students, and our reviewers. The product has benefited immeasurably from these interactions. Of course, we are ready to modify and improve any and all of our work. In our earlier editions, we asked readers to contact us with suggestions and questions, and we do so again. We are found as follows: gazzaniga@ucsb.edu; ivry@berkeley.edu; mangun@ucdavis.edu; dsb@seas.upenn.edu; and phelps@fas.harvard.edu.

Good reading and learning!

Changes in the Sixth Edition

With every revised edition, including this one, we have had to do some pruning and considerable updating to stay current with all the developments in the field of cognitive neuroscience. We thought it essential to include new methods and, correspondingly, new insights that these tools have provided into the function of the brain, while being selective in the description of specific experimental results. The following table highlights some of the major changes for each chapter.

Chapter	Changes in the Sixth Edition
1. A Brief History of Cognitive Neuroscience —and a Look	• Expanded discussion of the theoretical leap made by the early Greeks that enabled scientific endeavors • Prose, examples, and researchers updated for diversity and inclusivity, highlighting the work of Alisa Bokulich, Alexa Irene Canady, Mazviita Chirimuuta, Clarence Sumner Greene, Antonia Kaczkurkin, Celeste Kidd, Dorothy Klenke Nash, Audrey S. Penn, and Lauren N. Ross

Beyond	• New discussion of the philosophy of science, and the different sorts of explanations that we seek in cognitive neuroscience
2. Structure and Function of the Nervous System	• Expanded discussion of how the temporal lobes are also primary receiving areas for olfactory inputs, and how they contain vast association areas subserving high-level visual functions • Updated/expanded content from Herculano-Houzel and colleagues on elephant brains versus human brains regarding number of neurons and discussion of large-scale neural networks presented as bullets as well as other content • Section 2.2 , "Synaptic Transmission," offers more streamlined, concise, and general discussions of the biochemical classification of neurotransmitters, the functional classification of neurotransmitters, and electrical transmission
3. Methods of Cognitive Neuroscience	• Expanded discussion on testing unique populations, such as people who have suffered brain injury or who have atypical brains such as those with neurological conditions, psychiatric conditions, or other neuroatypicalities • New discussion of *N* -methyl- D -aspartate (NMDA) function and brain network flexibility; NMDA receptor signaling plays a fundamental role in the dynamic reconfiguration of brain networks over time • New discussion of machine learning methods and techniques, including classification and regression, clustering techniques, and compression techniques
4. Hemispheric Specialization	• Updated section on the function of the corpus callosum; for example, expanded description of the interhemispheric competition hypothesis • New discussion of the link that may exist between reduced language lateralization and autism-like traits • New discussion of the developmental perspective on hemispheric specialization proposed by Behrmann and Plaut (2020), questioning the view that hemispheric specializations in visual object recognition are modular
	• Updated discussion explaining how other sensory systems have evolved to respond to stimuli at a distance (remote sensing) • Expanded coverage of high-resolution 7-T fMRI to provide detailed analysis of sensory regions of the brain

5. Sensation and Perception	• New material on the use of intracranial recordings and stimulations to examine the neural basis of perceptual experience • Detailed discussion of the development of the visual system including work on the surgical restoration of vision in children born with severe cataracts • Revised and updated content on brain–machine interface systems to restore hearing and vision
6. Object Recognition	• Expanded discussion on how dorsal and ventral pathways are integrated to provide a coherent percept, and the importance of spatial information in specifying not only where something is, but also what it is • A new section, "Visual AI: Exploiting the Computational Power of Neural Networks," discussing the power and limitations of artificial neural networks (ANNs) • Expanded discussion on the debate concerning category specificity within the ventral pathway for properties such as places, body parts, and faces • New material on anatomical variation in the fusiform cortex and how this may relate to individual differences in face perception
7. Attention	• New sections: "Attention Rhythms in the Brain" and "Improving Attention" • New discussion of cognitive training protocols and nonpharmacological therapies such as meditation and the practice of mindfulness • Significant streamlining of the discussion of the frontal cortex and attentional control as well as the discussion of the parietal cortex and control of attention • Updated content on the ventral attention network
	• New, significantly revised, and/or expanded discussion of the cortical regions involved in motor control, including recent, radical revision of the organization of the primary motor cortex • New discussion of precision functional mapping—a big data approach in which large amounts of task-based and resting-state fMRI data are used to track the changes associated with motor learning and identify predictors of skill acquisition • Updated section on motor planning and the neural mechanisms that underlie the competition between alternative actions • Updated research on the benefits of intensive and early

8. Action	rehabilitation in the recovery of upper-limb function following stroke • Revised and streamlined discussion of how brain–machine interfaces have become more sophisticated, inspiring a broad range of applications for motor recovery in patients with movement disorders arising from stroke, degenerative diseases of the motor system, or spinal cord injury. Many of these advances have come about by using the computational power of deep learning algorithms • Expanded and updated/revised discussion of motor learning and skill acquisition
9. Memory	• Updated and streamlined Section 9.4 , "Declarative Memory and the Medial Temporal Lobe Memory System," includes expanded discussion of declarative memory and related deficits, along with new discussion of amnesic patient Clive Wearing • New discussion of developmental amnesic patients includes findings suggesting a double dissociation between episodic and semantic memory, with the hippocampus important for the formation of episodic memories that contain contextual information and the anterior temporal lobes and perirhinal cortex playing a role in the acquisition, storage, or retrieval of semantic memories • Expanded discussion on the multiple trace theory • New discussion of reconsolidation and research findings suggesting that some consolidated memories may undergo a second consolidation process • New discussion of reconsolidation and episodic memory • New discussion of encoding and post-encoding "replay" in human memory consolidation • New discussion of grid cells, their relation to place cells, and their role in episodic memory
10. Emotion	• New, creative, and engaging chapter-opening narrative that uses the film *Inside Out* as an example to discuss the science of emotion • New discussion of high-dimensional and blended emotions • Updated discussion of the limbic system construct • Revised discussion of theories of emotion generation, including a new discussion of constructed emotion • New discussion of brain systems of extinction learning and their role in changing emotions

11. Language	• New discussion of artificial neural networks, generative artificial intelligence, large language models, and the rise of ChatGPT • Updated/revised and streamlined discussion of neurophysiological studies using EEG and MEG recordings and the speed at which auditory speech is processed • Expanded and updated discussion on event-related potentials and electrophysiological measures of language processing and the N400 response • Expanded discussion of using multimodal methods to investigate brain areas involved in syntactic processing, and how there appear not to be distinct semantic and syntactic brain regions
12. Cognitive Control	• Added frontotemporal dementia to discussion of psychiatric conditions in which cognitive control deficits are a hallmark • Added discussion of the impaired response inhibition and salience attribution (IRISA) model of drug addiction • Added discussion of the distinction between how value is represented in individual neurons and how value is represented in a population of neurons, and discussion of linear and nonlinear representational geometry as applied to value representations in studies using monkeys • Expanded discussion of the inferior frontal cortex's role in distinguishing relevant from irrelevant information, and the dorsal prefrontal cortex's role in target protection during a visual delayed recognition test, consistent with the hypothesis of functional specialization within different frontal regions • Expanded discussion of transcranial direct current stimulation with an added video game study
13. Social Cognition	• Extended discussion of the default network, including a new discussion of episodic future thinking, optimism bias, and social memories • Expanded discussion with updated research on the ventromedial prefrontal cortex (vmPFC) and the adjacent orbitofrontal cortex, along with recent work in patients with intracranial electroencephalography. Studies of patients with damage to the vmPFC support the notion that it contributes to predictions about an individual's own likes and dislikes • Added content on the hypothesis that a network consisting of the anterior insula and mid–anterior cingulate cortex supports processing specifically for disgust, pain, and unfairness in overlapping but distinct regions • Updated and revised discussion of the link between reversal

	learning deficit in patients with vmPFC damage and impairments in social processing • Expanded discussion of research on the neuroscience of moral decision-making
14. The Consciousness Problem	• Expanded discussion of sleepwalking and its triggers, which can also include sleep disordered breathing and restless leg syndrome, and when it usually occurs • Updated statistics on the brain as having 86.1 ± 8.1 billion neurons and 84.6 ± 9.8 billion non-neuronal cells in Section 14.4 , "The Organizational Architecture of Complex Systems" • Added discussion on hyperscanning and hyperscanning research • Streamlined discussions of blindsight, nonconscious processing, and quantum theory

Teaching and Learning Resources for *Cognitive Neuroscience* , Sixth Edition

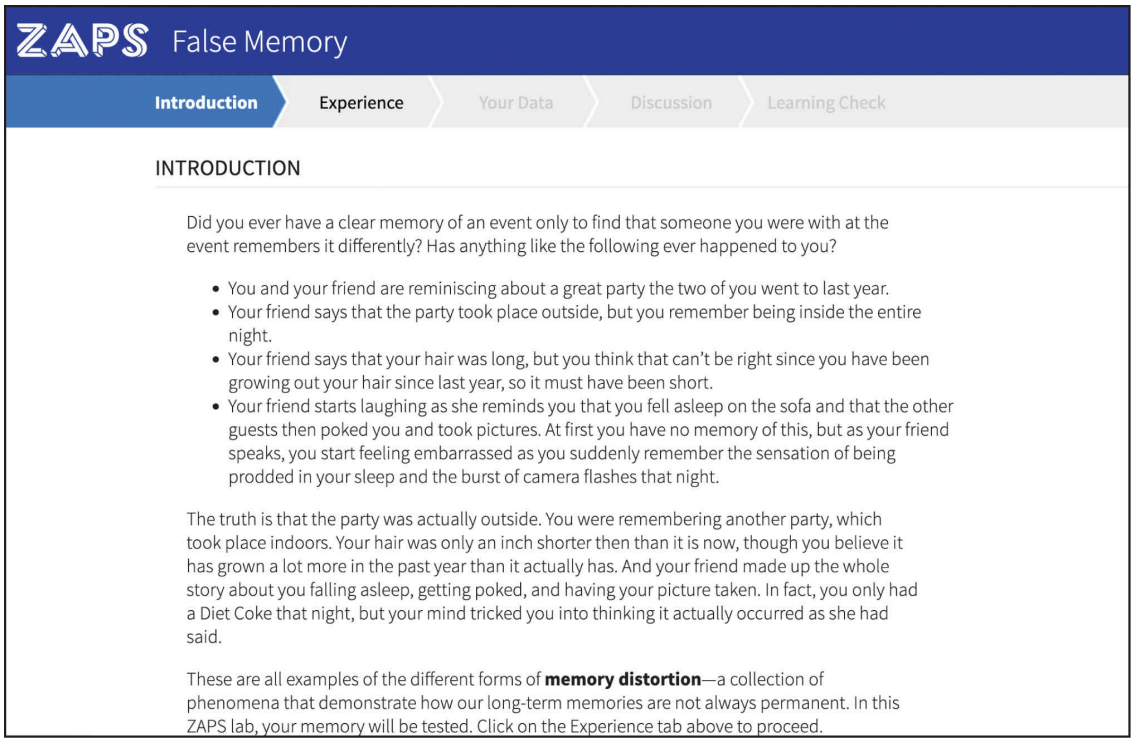
We are pleased to offer the following resources to enhance students' and instructors' experience with *Cognitive Neuroscience* , Sixth Edition.

Instructor Resources

Norton uses evidence-based assessment practices to deliver high-quality testing materials. The **Test Bank** questions for *Cognitive Neuroscience* , Sixth Edition, cover every topic in the book, allowing instructors to build evaluations tailored for the needs of their course. With **Norton Testmaker** , filter more than 1,000 questions by difficulty, Bloom's taxonomy, or learning objective to choose the best questions for your quizzes and tests.

All **art** from the book, sized for classroom display, is available in **PowerPoint** with alt-text and in JPEG format. In addition, **Lecture PowerPoints** are available for every chapter in the text. Featuring images and bulleted outlines for in-class presentations, they are fully customizable and accessible.

ZAPS 3.0 Interactive Labs are easy-to-use activities that allow students to participate in experimental trials, analyze the resulting data, and complete assessment questions along the way. To access ZAPS 3.0, visit https://digital.wwnorton.com/cogneuro6 .



A screenshot of the ZAPS environment, showing the introduction to a unit on false memory.

False Memory module from ZAPS 3.0.

The **Instructor's Manual** contains links to dozens of videos that illustrate key neuroscience phenomena. It also offers helpful and creative resources for lecture planning and classroom activities, including instructor notes for ZAPS activities.

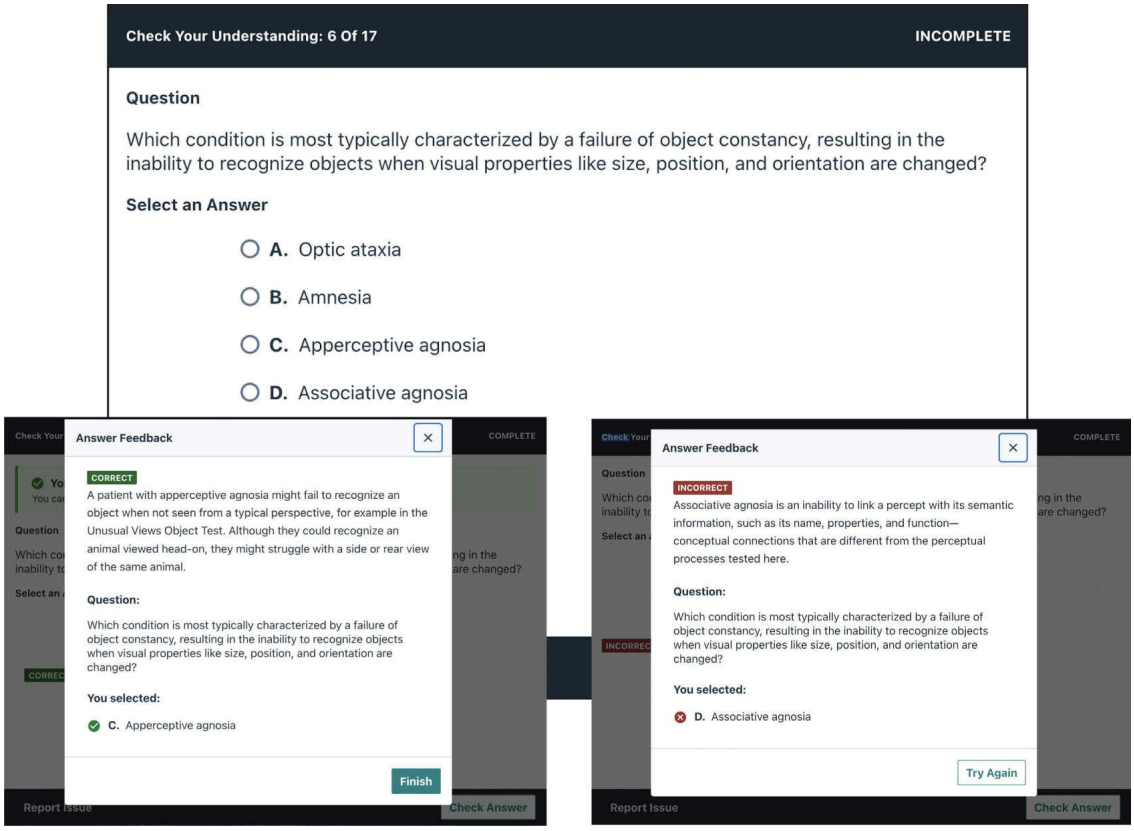
You can easily add these high-quality digital resources to your online, hybrid, and lecture courses through integrated links. Build your course using a carefully designed learning pathway, or customize your setup to reflect your teaching needs. Graded activities can be configured to report to the learning management system (LMS) gradebook. *Important note:* You will need to ensure that Learning Tools Interoperability (LTI) integration is enabled and supported on your school's LMS. If you are unsure, you can contact your local LMS administrator (Blackboard, Canvas, Brightspace/D2L, or Moodle) and ask if Norton is an LTI provider at your school. If Norton is not yet an approved tool provider, please contact your local Norton representative for assistance. You can find your local rep by accessing this link: https://wwnorton.com/find-your-rep .

The Norton Illumine Ebook: Student Resources

To access all of these tools, go to **https://digital.wwnorton.com/cogneuro6** .

Check Your Understanding multiple-choice questions, found in the **Norton Illumine Ebook** , follow every study unit in the text. These questions help students self-evaluate on their

comprehension and application of key terms and concepts. Each question offers answer-specific feedback to help students correct possible misconceptions.



A sample of a multiple-choice Check Your Understanding question, asking for the name of a condition involving failure of object constancy

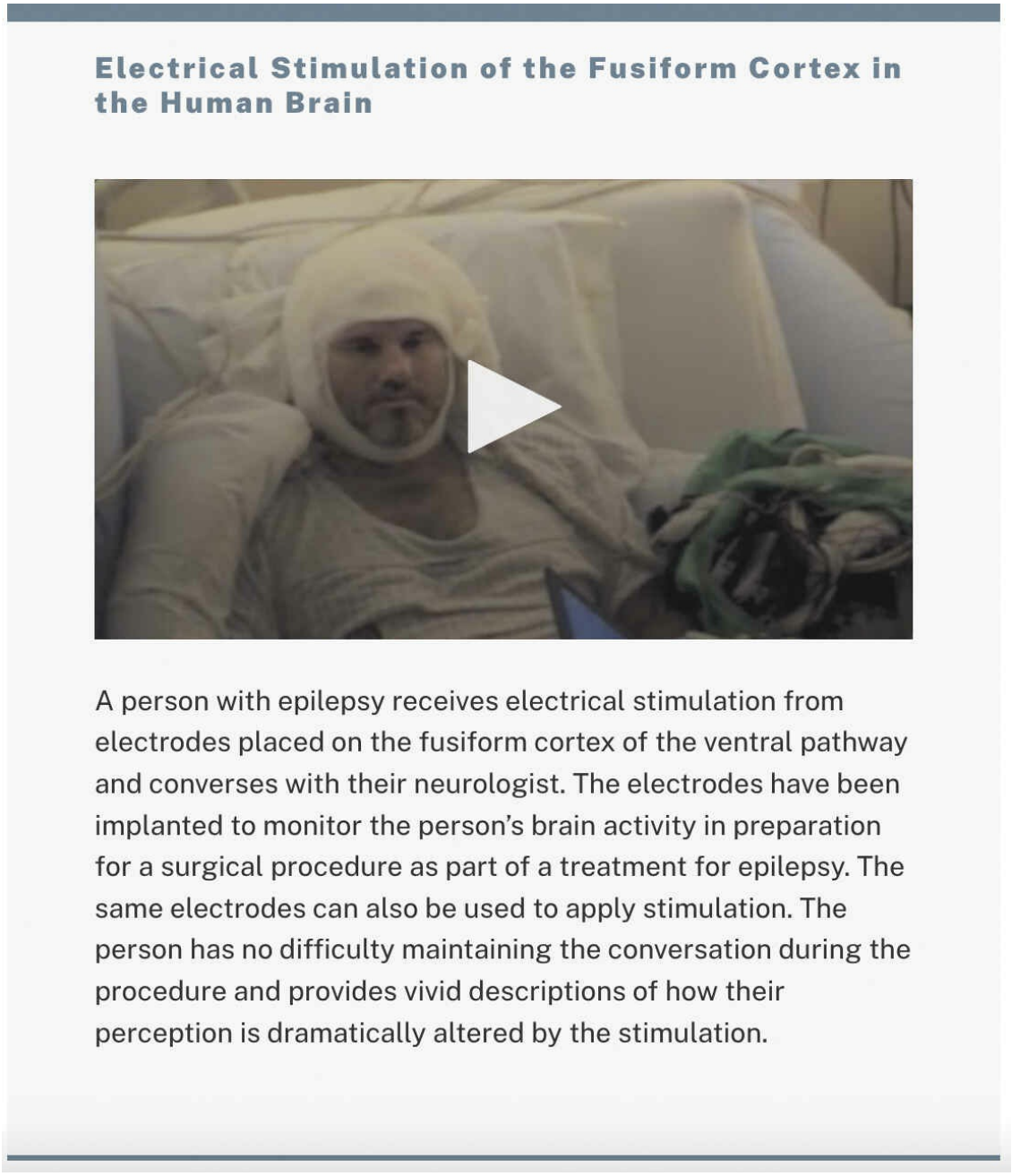
A sample of correct-answer feedback for a Check Your Understanding question. The correct answer was apperceptive agnosia.

A sample of incorrect-answer feedback for a Check Your Understanding question. In this case, the incorrect answer was associative agnosia.

Check Your Understanding question with feedback on correct and incorrect answers.

Two different types of videos in the Norton Illumine Ebook supplement this book's content.

Video insights provide glimpses into the experiences of people with neurological damage as well as demonstrations of neuroscience concepts and principles. **Behind the Citation videos** are interviews with neuroscientists who discuss aspects of their current research and look to the future of cognitive neuroscience.

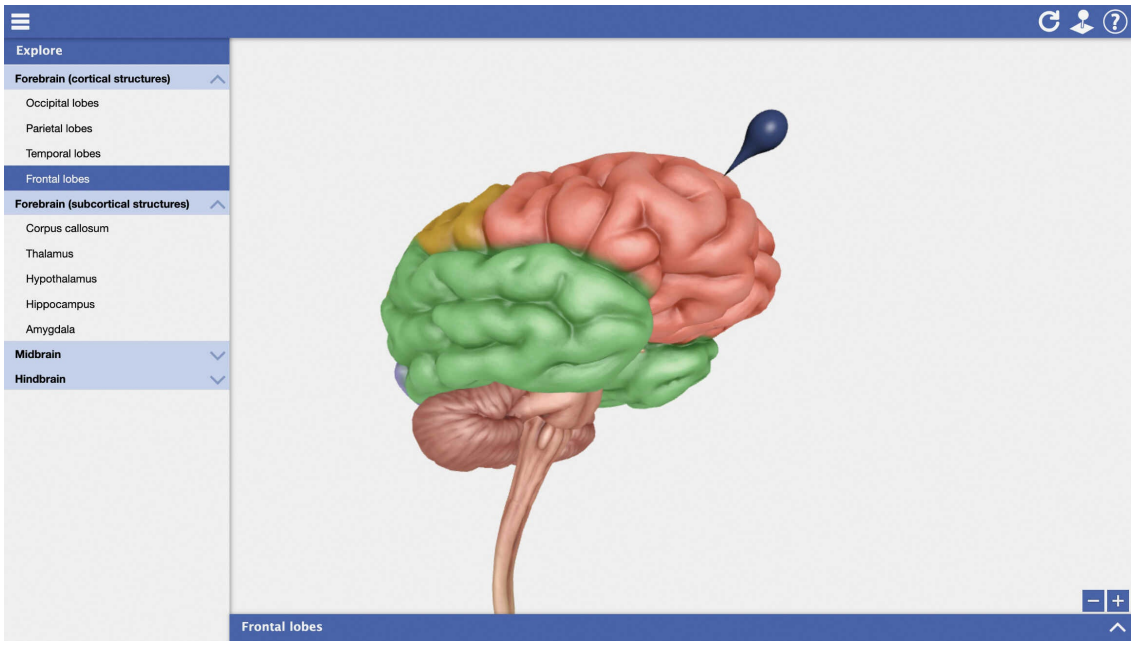


A screenshot of a video about Electrical Stimulation of the Fusiform Cortex in the Human Brain. The image shows a man who is lying in a hospital bed and has his head bandaged. Text describes him as a person with epilepsy who is receiving electrical brain stimulation through implanted electrodes.

These videos provide glimpses into the experiences of people with neurological damage as well as demonstrations of neuroscience concepts and principles.

The **3-D Brain** is a multimedia tool that reviews the key areas of the brain, helping students

understand how the specific regions discussed in each chapter fit into the brain's overall structure. Users can rotate the brain, zoom in and out, and add or remove structures to look more closely at the inside of the brain.



A screenshot of a visual model of the human brain. The major lobes are color coded. A blue pointer singles out the frontal lobe.

3-D Brain available in the Norton Illumine Ebook.

Finally, **electronic flashcards** can help students learn the vocabulary of cognitive neuroscience.

Acknowledgments

Personal Acknowledgments

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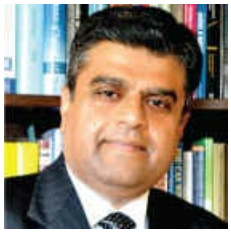

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Reviewers of Previous Editions

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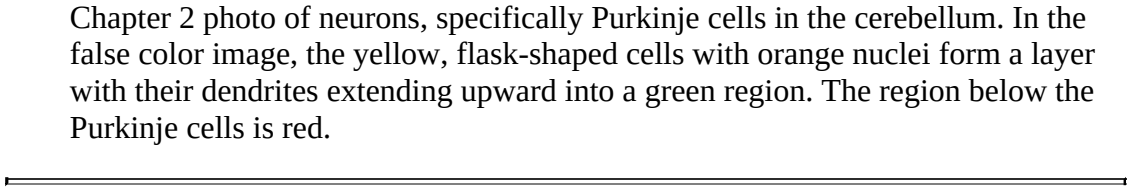
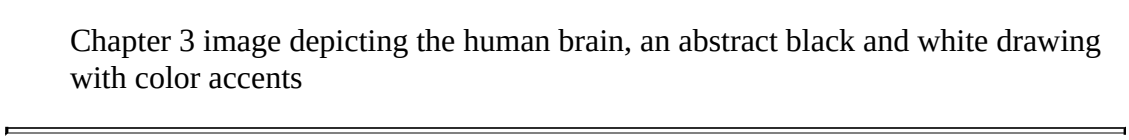
Contents

Chapter 1 photo of several lab-coated people looking at a model of a human brain, which one of the people is holding.



Chapter 2 photo of neurons, specifically Purkinje cells in the cerebellum. In the false color image, the yellow, flask-shaped cells with orange nuclei form a layer with their dendrites extending upward into a green region. The region below the Purkinje cells is red.



Chapter 3 image depicting the human brain, an abstract black and white drawing with color accents

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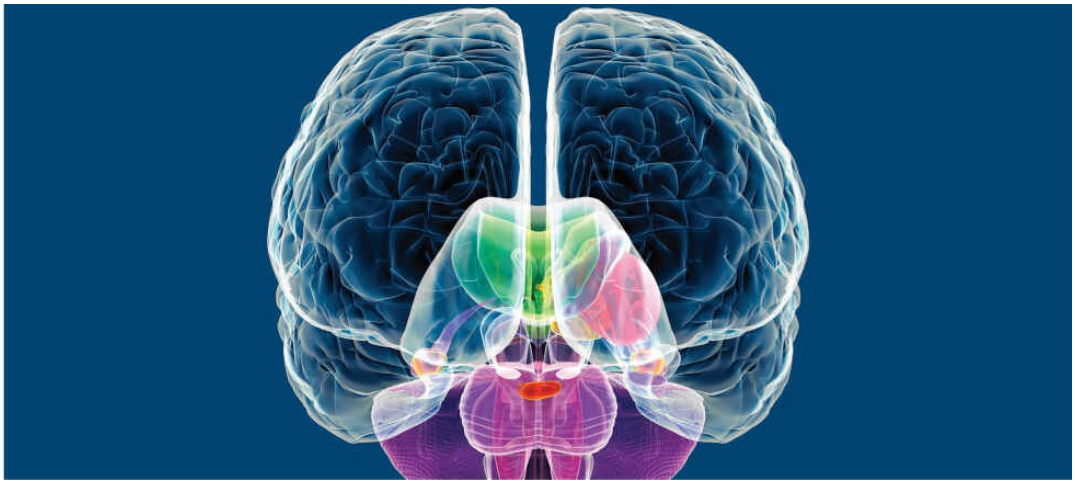
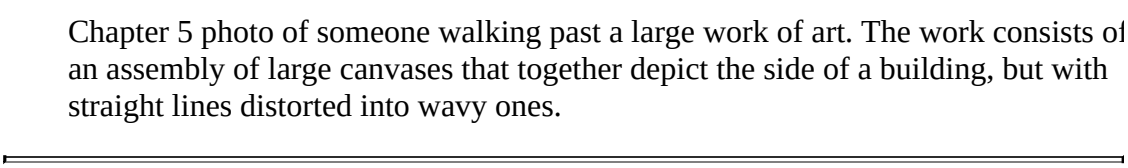
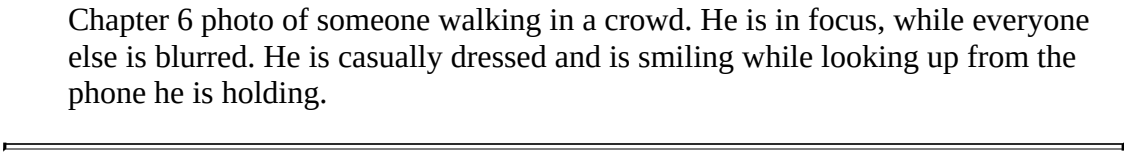


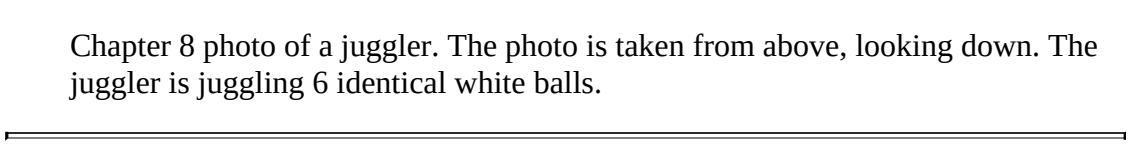
Chapter 4 image of the human brain, a see-through model



Chapter 5 photo of someone walking past a large work of art. The work consists of an assembly of large canvases that together depict the side of a building, but with straight lines distorted into wavy ones.



Chapter 6 photo of someone walking in a crowd. He is in focus, while everyone else is blurred. He is casually dressed and is smiling while looking up from the phone he is holding.



Chapter 8 photo of a juggler. The photo is taken from above, looking down. The juggler is juggling 6 identical white balls.
