

Cognitive Neuroscience

Marie T. Banich uses brain imaging techniques to understand the neural systems that enable us to direct actions and thoughts in a goal-oriented manner, often referred to as executive function. Her research findings have been published in leading journals, including *Science*. Among her professional experiences, Prof. Banich has been a member of the MacArthur Foundation on Adolescent Development and Juvenile Justice, a Fulbright Senior Scholar in Verona, Italy, and a recipient of a James Cattell sabbatical award. Currently she serves as the co-Principal Investigator for the Colorado site of the Adolescent Brain Cognitive Development Study, an unprecedented 10-year longitudinal study that uses neuroimaging to provide an unrivaled window on development of the adolescent brain and its influences on cognitive and emotional development.

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PREFACE

The fifth edition of this book, although extensively revised, retains the spirit, organization, and many of the features of the first four editions. Like the earlier editions, it provides a systematic introduction to the neural basis of mental function. It includes state-of-the-art research from experimental work performed with humans and animals, as well as findings from clinical populations. The goal, as before, is to provide a balanced, synthesized, and integrated view of what we know both about the brain and about cognition. Simultaneously, the text aims to provide these views in accessible prose that will excite students to think critically about the potential of cognitive neuroscience to yield new insights.

The entire text has been thoroughly revised with an eye toward both updating and streamlining the content. Understanding that students can sometimes become bogged down in detail, especially in technical fields, we have reduced the word count by approximately 10 percent compared to the fourth edition of the text. As in prior editions, we aim for a comprehensive treatment of the field. But abiding by the maxim that sometimes “less is more,” we present examples and evidence somewhat more selectively so as not to overwhelm those relatively new to the field. As always, we aim to engage students’ critical thinking about key issues and evidence in cognitive neuroscience while still propelling the student forward in each chapter’s narrative.

Every chapter has been thoroughly updated to reflect current findings in the fast-growing field of cognitive neuroscience. While the current edition still includes findings from traditional methods, such as the study of brain-damaged patients, which have provided foundational knowledge to the field, we pay special attention to the integration of findings from a variety of newer approaches, including transcranial magnetic stimulation, diffusion tensor imaging, multi-voxel pattern analysis, studies examining functional connectivity, and meta-analytic methods. Throughout, our intention is to provide students with a thorough and solid grounding in the basic principles and findings of cognitive neuroscience, tools that they can then use to further understand applied and clinical problems.

Text Organization and Features

The book’s soul remains very much the same as in the first four editions, as the following main features have been retained.

■ The book provides a systematic survey of the neural bases of a wide variety of mental functions

The overall organization of the book is divided into three main sections: fundamentals (Chapters 1–3), neural bases of specific mental functions (Chapters 4–13), and broader applications (Chapters 14–17). The first three chapters provide students with a basic foundation for the exploration of cognitive neuroscience. Chapter 1 provides information about the basic parts of the central nervous system and the fundamentals of neural transmission. This chapter may be unnecessary for students who have already completed a course in neuroscience, but will be of use to students who have not. Chapter 2 outlines the historical milestones in the development of the field, with special attention to methodological and conceptual developments that advanced the field in different eras. Chapter 3 acquaints students with the myriad of burgeoning techniques, both standard and novel, that are available to scientists and clinicians in their quest to understand the neural bases of mental function.

The second part of the book, Chapters 4–13, provides a survey of the neural bases of mental function, with each chapter devoted to a distinct mental function. The chapter topics discussed are, in order, motor processes, early perceptual processing, object recognition, spatial cognition, language, memory, attention, executive function, emotion, and social cognition. The last part of the book, comprising the last four chapters, examines broad-based applications in cognitive neuroscience, including development, aging, clinical syndromes, and the interface between neuroscience and society. Instructors may view these chapters as more discretionary than earlier ones, in the sense that they cover more advanced issues. In our teaching, we’ve found that these advanced, applied, and clinical issues are of special interest to many students, as they find it very rewarding to use the knowledge that they have gained earlier in the text to approach these broader applications. Chapter 14 examines mental conditions such as schizophrenia, depression, anxiety disorders, and substance abuse from a cognitive neuroscience perspective. Chapter 15 examines neural plasticity from a lifespan perspective, including developmental changes during childhood, adolescence, and aging, and the neural bases of developmental disabilities. Chapter 16 examines clinical conditions that are characterized by generalized cognitive difficulties (rather than the more localized and specific disorders discussed in Chapters 4–13), including closed head injury, dementia,

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demyelinating diseases, and epilepsy. Finally, the text ends with Chapter 17, “Cognitive Neuroscience and Society,” which critically examines the ways in which cognitive neuroscience knowledge can be applied to domains of broad societal concern, such as education, social inequality, the law, and morality.

■ The sequence of the chapters is designed for progressive learning

The chapters have been carefully sequenced so that information in later chapters builds upon information in earlier ones. Notably, the processes most linked to motoric and sensory functions are presented earlier, and those that depend on more integrative aspects of brain function, such as executive function and emotion, are presented later. For example, the chapter on object recognition directly precedes that on spatial processing, so that the student is introduced to the ventral and dorsal visual processing streams in consecutive chapters. The chapter on memory is preceded by the language and object recognition chapters so that the distinction between generalized memory disorders and the “memory” problems that are specific to certain domains (e.g., anomia in language or agnosia with regard to objects) is clear. Yet, despite the intentional progression of ideas across chapters, chapters are written to be self-contained so that instructors may alter the order of material depending on specific syllabus needs.

■ The book is designed to actively engage students in the process of learning

Most chapters begin with an opening case history or story to pique students’ interest and preview issues that are discussed later in the chapter. For example, the opening case history in Chapter 4 discusses how Muhammad Ali’s boxing career led him to have a parkinsonian disorder, and the opening case history in Chapter 16 discusses the mental decline of Marie’s maternal grandmother due to dementia. The text is written in a conversational tone rather than in a technical style, to grab and retain students’ interest. We use analogies extensively so that difficult conceptual issues can become more tractable. Each chapter includes an “In Focus” box that explores in depth a specific applied issue in cognitive neuroscience, helping students to see the implications of research for everyday life.

Key pedagogical features are designed to facilitate students’ retention of information. To keep students oriented to terminology, key terms are introduced in boldface and defined in a glossary at the back of the book. Chapter summaries allow students to review the material learned or preview what is to be discussed, and outlines at the beginning of each chapter provide a

clear conceptual structure of the contents. Figures are designed, and in many cases have been revised, to convey key concepts visually as well as textually, and therefore to enhance multimodal learning. In this edition, we have added key questions at the end of each section to reinforce the most important concepts. We have also added bigger-picture “thought questions” at the end of each chapter, designed to expand students’ thinking to broader issues beyond the chapter content. These questions could serve as the basis for small-group discussions or could be used to elicit written responses from students. All these features are designed to make this book as user-friendly as possible.

■ State-of-the-art knowledge in the field is presented without sacrificing accuracy or oversimplifying the material

As researchers who maintain highly active and visible research programs, we aim to ensure that the book contains not only a discussion of the “classic” findings in the field, but also the cutting-edge portion of our knowledge. The field of cognitive neuroscience continues to explode with new discoveries. As a result, all of the chapters of the book were extensively rewritten to incorporate this vast amount of additional knowledge, which is reflected in hundreds of new references from studies using diverse methodologies. Yet, students should not be overwhelmed with a laundry list of findings or with overly technical arcane issues. Rather, representative studies are used to highlight the nature of current debates, so that students can understand, and think critically about, the conceptual issues under consideration and how researchers attempt to reason based on experimental evidence. Our extensive work in both research and teaching in cognitive neuroscience allows us to present issues in a manner that is precise and sophisticated, yet also accessible and integrative.

With this edition, we have worked to hit the sweet spot of learning in a number of ways. We have, as always, ensured that our coverage is thorough, rigorous, and up-to-date to ensure that students are provided a comprehensive overview of the current state of the field. We have enhanced the book’s features with key issues and thought questions to further ensure that students are actively engaged in learning. We have refreshed the art program so that figures convey key ideas with greater clarity. And we have focused more on key concepts and findings, minus nonessential details, to allow these concepts to be more easily absorbed. We have strived, as in all prior editions, to explain to students how the concepts presented in our text have importance and are applicable in real life. Finally, and importantly, we have worked our best to make their learning of cognitive neuroscience both exciting and enjoyable.

ACKNOWLEDGMENTS

We have benefited greatly from the generous help of many colleagues who reviewed this edition of the book, either in part or in full, as anonymous reviewers for Cambridge University Press. We were genuinely touched by these reviewers' time and efforts in sharing their expert advice to improve the book for the fifth edition. Their expertise and enthusiasm for the project deepened our knowledge, broadened our perspective, and kept us on our toes. Although we may not have taken all of their advice, we thought carefully about every one of their suggestions. We are most grateful for their input. We also thank the reviewers of prior editions, whose contributions helped to construct a solid foundation upon which this new edition could be built.

Additionally, we are most grateful to the talented and dedicated editorial staff at Cambridge, who guided us in the overall vision for this edition and helped us track the innumerable details needed to bring it to fruition. Stephen Acerra convinced us of the need for a fifth edition and helped us to develop achievable goals for the revision; development editors Stefanie Seaton and Tineke Bryson expertly and patiently shepherded us through all stages of review and revision; Charles Howell supervised the production of the manuscript with impressive professionalism; and Katherine Foreman made important contributions to the visual representations and design of the book. It was wonderful to have our materials in the hands of such outstanding editors. As this is the fifth edition of the book, it builds on editorial advice we have received on previous editions from Jane Knetzger, Danielle Richardson, Tali Beesley, and Matthew Bennett, and the support of Jane Potter, whom we thank as well.

In the end, we were able to write this book not only thanks to the professional contributions of all the people named above, but also due to the unwavering support of our spouses, Jeremy Meyer and Laura Edwards.

From Marie

My contributions to this edition of the text, like all previous editions, reflect what my mother taught me about teaching and learning. She was an educator by profession with a speciality in curriculum development, which not only considers the manner and order in which material is presented to enable maximal learning, but also focuses on how to make learning an engaging and relevant adventure. And while my mother took her leave of this world while this edition of the book was being completed, her spirit and the perspective she gave me infuses every page. And so this book is dedicated to the memory of my favorite teacher, my mother, Serafina Banich.

From Rebecca

I dedicate this text to my son, Noah, who died suddenly in March 2022 at the age of 12 from a rare undiagnosed medical condition. There are no words to adequately describe such a devastating loss. Noah sparkled; he was kinetic; he was hilarious; he was affectionate; he was everything. May his memory be a blessing.

Marie T. Banich
Rebecca J. Compton

To my Mom, who remains my North Star

M.T.B.

To Noah, may your light always shine

R.J.C.