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The Neuroscience of Language

The Neuroscience of Language offers a remarkably accessible introduction to language in the mind and brain. Following the chain of communication from speaker to listener, it covers all fundamental concepts from speech production to auditory processing, speech sounds, word meaning, and sentence processing. The key methods of cognitive neuroscience are covered, as well as clinical evidence from neuropsychological patients and multimodal aspects of language including visual speech, gesture, and sign language. More than eighty full-color figures are included to help communicate key concepts. The main text focuses on big-picture themes, while detailed studies and related anecdotes are presented in endnotes to provide interested students with many opportunities to dive deeper into specific topics. Throughout, language is placed within the larger context of the brain, illustrating the fascinating connections of language with other fields including cognitive science, linguistics, psychology, and speech and hearing science.

Jonathan E. Peelle is an associate professor in the Center for Cognitive and Brain Health at Northeastern University, with appointments in the Department of Communication Sciences and Disorders and the Department of Psychology. He has taught undergraduate and graduate courses on the neuroscience of language; speech, language, and hearing science; cognitive neuroscience; and functional brain imaging. He is a reviewing editor for *eLife* and *Neurobiology of Language*, and former reviewing editor for *NeuroImage* and *Language, Cognition and Neuroscience*. He has authored more than eighty papers on the neuroscience of language and is currently the chair of the Society for the Neurobiology of Language.

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To Murray Grossman,
mentor, colleague, and friend,
who taught me more than anyone about the neuroscience of language.

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Preface

As a researcher, one of the things I've appreciated most about language research is how many other areas of science it comes into contact with: memory, decision-making, acoustics, audiology, linguistics . . . the list goes on. One of the joys of teaching students about the neuroscience of language has been to make connections with other areas of their lives, and I've enjoyed trying to convey this enthusiasm and some of the many fascinating facets of human language throughout this textbook.

The chapters are written so that they can be read in any order, although the first three chapters provide background in terminology and methods that is assumed in subsequent chapters. When I teach this class, I mostly go in order (with some skipping around at the end).

One difference you may notice between this textbook and some others: I have broken with textbook tradition and included a great deal in endnotes. I had several inspirations for doing so. First, for people new to the field – that is, the intended audience of the book – filling the main text with parenthetical citations is not particularly meaningful, and I worried it would actually distract them from the main points. However, having done my best to simplify the text, I wanted to be sure both to give credit where it's due – the endnotes include primary references to support claims made in the text – and to offer interested readers not only more details (and interesting tangents) but also some commentary based on my own perspective. My goal is that the main text is readable and understandable without ever reading an endnote, but that endnotes will be useful and interesting for readers who want a bit more. One teaching strategy that works well is to review specific studies during lectures, or assign research articles as additional class reading, to highlight specific aspects of research. In addition to sources noted in endnotes, each chapter includes a handful of suggestions "for further reading" that can be used for these activities.

Another way in which I have broken with textbook tradition is that I have included a number of figures that I've created myself, including figures summarizing brain imaging results. (It is relevant to note at this point that I am not an artist.) I've modeled these figures from what I would include in a lecture – for example, what I might draw on a blackboard while explaining a concept.[1] As with the written text, these figures are meant to convey main ideas in a consistent visual format, and should not be taken as a substitute for referring to primary research. I envision a useful strategy is to supplement these

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simplified figures with specific examples of research results in class. The figures I created for this book are available from https://osf.io/geqb6/.

The boxes included throughout out are intended to highlight specific concepts that complement the main text. In many cases, they introduce new and complementary topics, and contain endnotes with additional information. One possibility – which I have done in my own teaching – is to assign small groups to dig into one of these "tangential" areas and read one or more of the references appearing in a box or endnote, giving them an opportunity to dive a little bit deeper into an area, supported by the background of suggested readings and context provided by the textbook.

Some of the boxes also include stories of real people whose life experience relates to the neuroscience of language. To those who allowed me to share their stories: thank you! Your contributions have helped make this book richer and more personal. To the readers, I would like to point out that most of the people I interviewed are people I have had contact with in real life, and I suspect many of *you* also know people with interesting stories about the neuroscience of language. As you read this book it may be worth thinking about whether there is someone in your own circle whose experience you can learn from.

To all my colleagues in the field: thank you for all of your wonderful contributions to our understanding of the neuroscience of language, and please forgive my oversimplifications (and, no doubt, mistakes). I have aimed to present enough information to give readers a broad understanding of some of the biggest issues in the field and prepare (if they so choose) for further and deeper study. I have very specifically tried *not* to present every experimental finding or theoretical viewpoint, even very good ones, to prevent information overload. I have also avoided certain paradigms and analysis approaches that I judged too complicated for an introductory text, no matter how compelling. I am very aware that many laudable studies are not included here and I'm sorry if yours is among them.

Note

1. During my PhD, I had the good fortune to be taught foundations of neuroscience by Eve Marder, who during her lectures notoriously avoided PowerPoint slides in favor of colored chalk (described eloquently in Marder, 2000). And now you have a concrete example of one of the ways I use endnotes in this book.

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Acknowledgments

This book was not written in a vacuum and I am deeply grateful to all who supported and encouraged me during its writing.

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I am also incredibly grateful to my colleagues in the field of cognitive neuroscience, particularly the neuroscience of language, for their thoughtful research and interactions. I have benefited incalculably from prior review papers, chapters, talks, and personal interactions over the last 20-plus years. I am particularly indebted to my primary mentors – Art Wingfield, Murray Grossman, and Matt Davis – who taught me about science, speech, and language, and even more importantly, about being a kind and thoughtful human being.

I have included experiences of actual people to help illustrate everyday experiences related to language processing. The stories and people are all real, although some details may have been changed to provide anonymity. I am deeply grateful to everyone who took the time to speak with me and let me share their story.

I am also grateful to authors of academic software that has helped me to both learn neuroimaging analysis and provide some of the figures in this book, including (but not limited to) Chris Rorden for his wonderful MRIcroGL (and its predecessors, MRIcro and MRIcron), the SPM development team at the Wellcome Centre for Human Neuroimaging, and the FSL development team at Oxford University. Developing this software, publishing methodological articles on the underlying algorithms, sharing the code, and organizing workshops and training opportunities has benefited countless scientists through the years.

The book was improved at all stages by many people who provided helpful feedback, especially Kristin Van Engen, Kristen Allison, Drew McLaughlin, Kate McClannahan, Erin Meier, Emily Myers, and Jamie Reilly. I am indebted to their thoughtfulness and useful suggestions. I am also grateful to many lab members, students, friends, and family members who took the time to read and proofread sections of the book.

Finally, I am grateful to Abram Van Engen for convincing me that writing a book was a good idea, and to my family for their constant love and support.

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