The Cambridge Handbook of Psycholinguistics

Our ability to speak, write, understand speech, and read is critical to our ability to function in today's society. As such, *psycholinguistics*, or the study of how humans learn and use language, is a central topic in cognitive science. This comprehensive handbook is a collection of chapters written not by practitioners in the field, who can summarize the work going on around them, but by trailblazers from a wide array of subfields, who have been shaping the field of psycholinguistics over the last decade. Some topics discussed include how children learn language, how average adults understand and produce language, how language is represented in the brain, how brain-damaged individuals perform in terms of their language abilities, and computer-based models of language and meaning. This is required reading for advanced researchers, graduate students, and upper-level undergraduates interested in the recent developments and the future of psycholinguistics.

Michael J. Spivey was on the faculty of Cornell University for twelve years before moving to the cognitive and information sciences unit at the University of California, Merced, in 2008. His research uses dense-sampling methods (such as eyetracking and reach tracking) to explore the real-time interaction between language and vision. He has published in a variety of top-tier journals, including *Science*, *Cognitive Science*, *Trends in Cognitive Sciences*, *Psychological Science*, and *Proceedings of the National Academy of Sciences*. Spivey is the recipient of Sigma Xi's William Procter Prize for Scientific Achievement and multiple teaching awards from Cornell University. The dynamical cognition framework that guides his research is described in his book *The Continuity of Mind* (2007).

Ken McRae has been at the University of Western Ontario since 1993, where he has been studying language and concepts. He has published articles regarding sentence processing and semantic memory from numerous perspectives, including modality-specific representations, the roles of statistical correlations and causal relations in object concepts, category-specific semantic deficits, and the integration of meaning and structure in sentence comprehension. He has also published a number of computational models of these important human abilities. McRae has published in journals such as *Cognition*, *Journal of Memory and Language*, *Journal of Experimental Psychology*, *Cognitive Science*, and *Neuropsychologia*.

Marc F. Joanisse has been at the University of Western Ontario since 2000, studying the cognitive and brain bases of spoken and written language. Work in his laboratory emphasizes the importance of studying multiple aspects of language ability, in a variety of populations, using a range of techniques. His research spans a range of topics encompassing speech perception, spoken word recognition, and reading and grammar abilities in adults and children, using everything from traditional behavioral techniques to eyetracking, event-related potentials, and fMRI. In addition, he has published articles in the field of connectionist modeling of language processing, aphasia following brain injury, and language disorders in children. He has published in a wide range of journals, including the *Proceedings of the National Academy of Sciences*, *Journal of Cognitive Neuroscience*, *Cerebral Cortex*, *NeuroImage*, *Journal of Memory and Language*, and *Journal of Experimental Psychology: Learning Memory and Cognition*.

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Edited by

MICHAEL J. SPIVEY

University of California, Merced

KEN MCRAE

University of Western Ontario

MARC F. JOANISSE

University of Western Ontario

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Shortly after completing her chapter, Rebecca Sandak passed away in an auto accident that also took the life of her husband, Sam. As is evident in her chapter, Rebecca was a promising young scholar who made a number of important contributions to our understanding of the neural bases of skilled reading and dyslexia. We are sad to have lost her, but are proud to include her contribution in this handbook. The Cambridge Handbook of Psycholinguistics *is dedicated to her.*

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Contributors

BLAIR C. ARMSTRONG
Department of Psychology
Carnegie Mellon University

DAVID A. BALOTA
Department of Psychology
Washington University
in St. Louis

LAWRENCE W. BARSALOU
Department of Psychology
Emory University

JOS J. A. VAN BERKUM
Neurobiology of Language Department
Max Planck Institute for
Psycholinguistics

LERA BORODITSKY
Department of Psychology
Stanford University

GREGORY A. BRYANT
Department of Communication Studies
Center for Behavior, Evolution, and
Culture
University of California, Los Angeles

CRISTINA CACCIARI
Dipartimento di Scienze Biomediche
University of Modena and Reggio Emilia

JOANA CHOLIN
Basque Center on Cognition, Brain and
Language

MORTEN H. CHRISTIANSEN
Psychology Department
Cornell University

STELLA CHRISTIE
Department of Psychology
University of British Columbia

EVE V. CLARK
Department of Linguistics
Stanford University

HERBERT H. CLARK
Department of Psychology
Stanford University

ELIANA COLUNGA
Department of Psychology
University of Colorado, Boulder

JOHN F. CONNOLLY
Department of Linguistics and Languages
McMaster University

MICHAEL J. CORTESE
Department of Psychology
University of Nebraska at Omaha

SEANA COULSON
Department of Cognitive Science
University of California, San Diego

GEORGE S. CREE
Department of Psychology
University of Toronto, Scarborough

CHRISTOPHER M. CREW
Department of Psychology
Columbia University

GARY S. DELL
Department of Psychology
University of Illinois

KEVIN DIEPENDAELE
Department of Experimental Psychology
University of Gent

JUDIT DRUKS
Department of Human Communication
University College London

THOMAS A. FARMER
Department of Psychology
The University of Iowa

ANNE FERNALD
Center for Infant Studies
Stanford University

KELLY FORBES
CAE Professional Services Canada

CAROL A. FOWLER
Haskins Laboratories

MICHAEL FRANK
Department of Psychology
Stanford University

STEPHEN J. FROST
Haskins Laboratories

DEDRE GENTNER
Department of Psychology
Northwestern University

RAYMOND W. GIBBS, JR.
Psychology Department
University of California, Santa Cruz

MONICA GONZALEZ-MARQUEZ
Department of Psychology
Cornell University

ARTHUR C. GRAESSER
The Institute for Intelligent Systems
FedEx Institute of Technology

JONATHAN GRAINGER
National Center for Scientific Research
Université d'Aix-Marseille

ZENZI M. GRIFFIN
Department of Psychology
University of Texas at Austin

MARY HARE
Department of Psychology
Bowling Green State University

HARLAN D. HARRIS
Department of Psychology
New York University

MARC F. JOANISSE
Department of Psychology
Social Science Centre
University of Western Ontario

LEONARD KATZ
Department of Psychology
University of Connecticut

ALBERT KIM
Department of Psychology
and Neuroscience
University of Colorado at Boulder

GINA R. KUPERBERG
Department of Psychology
Tufts University

NICOLE LANDI
Haskins Laboratories

BIRTE LOENNEKER-RODMAN
International Computer Science Institute

DANIELLE S. MACNAMARA
Department of Psychology
Arizona State University

JAMES S. MAGNUSON
Department of Psychology
University of Connecticut

KEN MCRAE
Department of Psychology
Social Science Centre
University of Western Ontario

W. EINAR MENCL
Haskins Laboratories

DANIEL MIRMAN
Moss Rehabilitation Research Institute

JENNIFER B. MISYAK
Psychology Department
Cornell University

SRINI NARAYANAN
International Computer Science Institute

KATE NATION
Language and Cognitive Development Group
Department of Experimental Psychology
St John's College, Oxford

RANDY L. NEWMAN
Department of Psychology
Acadia University

LEE OSTERHOUT
Department of Psychology
University of Washington

ROBERTO PADOVANI
Azienda USL di Modena

KARALYN PATTERSON
MRC Cognition and Brain Sciences Unit

KENNETH R. PUGH
Haskins Laboratories

TERRY REGIER
Department of Linguistics
University of California, Berkeley

DOUGLAS ROLAND
Department of Linguistics
University at Buffalo, The State University of New York

JAY G. RUECKL
Department of Psychology
University of Connecticut

VASILE RUS
Department of Computer Science
Memphis University

JENNY R. SAFFRAN
Psychology Department
University of Wisconsin-Madison

SARAH D. SAHNI
Psychology Department
University of Wisconsin-Madison

ARTHUR G. SAMUEL
Department of Psychology
Stony Brook University and Basque Center on Cognition Brain and Language

REBECCA SANDAK
formerly of Haskins Laboratories

DOMINIEK SANDRA
Center for Psycholinguistics
University of Antwerp

SOPHIE SCOTT
Institute of Cognitive Neuroscience
University College London

MARK S. SEIDENBERG
Department of Psychology
University of Wisconsin-Madison

LINDA B. SMITH
Department of Psychological and Brain Sciences
Indiana University

MICHAEL J. SPIVEY
Cognitive and Information Sciences
University of California, Merced

MEGHAN SUMNER
Department of Linguistics
Stanford University

DANIEL TRANEL
Department of Neurology
University of Iowa Hospitals and Clinics

GABRIELLA VIGLIOCCO
Centre for Deafness, Cognition and Language
University College London

NICOLE L. WILSON
Pearson Knowledge Technologies

ANNA WOOLLAMS
Neuroscience and Aphasia Research Unit (NARU)
School of Psychological Sciences
University of Manchester

Preface

Michael J. Spivey, Ken McRae, and Marc F. Joanisse

In previous years, there have been other handbooks of psycholinguistics, however none of them has been as expansive and comprehensive as this one. With the unusually large number of highly influential authors in this volume, it took a fair bit of time to herd all of these chapters together. But it was definitely worth the wait. We are extremely grateful to Janet Aucoin for assistance in compiling this volume.

The Cambridge Handbook of Psycholinguistics is written not by practitioners in the field who can summarize the work going on around them. It is written by the trailblazers themselves, from a wide array of subfields, who have been forming the field of psycholinguistics and are responsible for its current shape. In addition to its emphasis on comprehensiveness, this handbook displays a commitment to identifying the important changes taking place in various areas of psycholinguistics. In some areas of the cognitive and neural sciences, it could perhaps be argued that the past dozen years have not quite seen enough change in theory and methods to genuinely warrant a new handbook. However, it is abundantly clear that psycholinguistics has seen more than its usual share of large and small paradigm shifts in just these past dozen years or so – both in the form of transitions of dominance between competing theories and in the form of methodological developments that have changed the way these theories are tested. Thus the field of psycholinguistics unmistakably needs a comprehensive handbook that updates the scientific community (researchers, instructors, and graduate students) on the radically altered empirical and theoretical landscape that has developed.

Several subfields have watched exciting new conceptual developments and previously subordinate theories come to the forefront. For example, the area of language development, from speech perception to sentence comprehension, has experienced a renewed emphasis on the role of the statistical structure in a language learner's input (e.g., Gerken, 2004; Gomez, 2002; Saffran, 2003; Saffran, Aslin, and Newport, 1996). The subfield of sentence processing has been undergoing a shift – already detectable in the textbooks – from a preponderance of stage-based processing accounts to a

largely dynamic and interactive (neural network–inspired) theoretical framework (e.g., MacDonald, Pearlmutter, and Seidenberg, 1994; Spivey et al., 2002; Tabor and Hutchins, 2004). Furthermore, developmental, adult, modeling, patient, and neurological research is considerably more integrated than was the case ten years ago. The debate over how to represent the morphology of regular and irregular past tenses in English returned with a new vigor (e.g., Joanisse, 2004; Marchman, Plunkett, and Goodman, 1997; Ramscar, 2003; Ullman, 2001). The embodied meanings of words, as opposed to amodal symbolic representations, is becoming a staple of contemporary literature reviews of semantic memory (e.g., Barsalou, 1999; Glenberg, 1997; Richardson et al., 2003). The field of semantic memory has undergone huge changes: the shift from amodal to perceptually based and event-based representations (Barsalou, 1999; Glenberg, 1997), the vastly increased role of patient and neuroimaging research (Martin and Caramazza, 2003), the centrality of connectionist modeling (Plaut and Shallice, 1993), and the advent of corpus-based approaches to word meaning (Landauer and Dumais, 1997). The list could go on and on – and in this handbook, it does.

Many of the recent sways in these theoretical battles have been made possible by major advances in the methods being used by the field in just the past several years. For example, continued development of connectionist modeling techniques has allowed more explicit specification of theories and accommodated new data in the areas of sentence processing (e.g., MacDonald and Christiansen, 2002; McRae, Spivey-Knowlton, and Tanenhaus, 1998) word meaning (McRae, de Sa, and Seidenberg, 1997), language acquisition (e.g., Rohde and Plaut, 1999), and language disorders (e.g., Joanisse and Seidenberg, 2003), to name just a few. Moreover, functional magnetic resonance imaging has, along with magnetoencephalography and electroencephalography, produced reams of important new neuroimaging results in many areas of language research (e.g., Connolly and D'Arcy, 2000; Martin and Caramazza, 2003; Osterhout and Nicol, 1999; Pulvermüller, Assadollahi, and Elbert, 2001; Scott and Wise, 2004) that alone could justify a new handbook. And head-mounted eye-tracking – providing the first noninterruptive, real-time measure of spoken language comprehension and production in rich situational contexts (e.g., Griffin and Bock, 2000; Tanenhaus et al., 1995) – has been revealing new discoveries in speech perception, spoken word recognition, sentence processing, language production, figurative language, and even naturalistic conversation.

Handbook Structure

The Cambridge Handbook of Psycholinguistics provides relatively short reports on the psycholinguistic literature in a wide variety of subfields, written by the experts who made those subfields what they are, with discussions of these many recent theoretical and methodological developments. The *Handbook* is divided into ten sections: Speech Perception, Spoken Word Recognition, Written Word Recognition, Semantic Memory, Morphological Processing, Sentence Comprehension, Sentence Production, Figurative Language, Discourse and Conversation, and Language and Thought, in that order. To ensure a wide representation of empirical methodologies and conceptual issues, and equally important, to highlight the theoretical and methodological advances of the past dozen years or so, each section has chapters that together cover adult behavioral measures, developmental research, computational modeling, and patient and neuroimaging research. By having these four perspectives emphasized in each of the ten sections, not only will current areas of research that strongly integrate those four perspectives receive proper treatment (e.g., spoken and written word recognition, semantic memory, sentence processing), but younger areas of experimental psycholinguistic study (e.g., figurative language, language and thought, discourse and conversation) will be encouraged to strengthen all four of those perspectives in their future

research. Thus, in addition to summarizing the *state of the art* of psycholinguistics, it is our hope that this handbook can bolster the metatheoretical richness and methodological diversity of the *future* of psycholinguistics.

The justification for the ten sections we have chosen is twofold. First, we wish this handbook to be representative of the entire field, so it includes chapters on all active areas of contemporary psycholinguistic research. Second, for those portions of certain fields that have become sufficiently active to warrant being identified as their own subfield, we have given them their own section. Nonetheless, it is neither possible nor desirable to have in-depth chapters on every subfield. Therefore, the reader may indeed find sections that could have been subdivided into two sections, and future editions of this handbook could perhaps purse that finer-grain specification. Later in this preface we provide brief summaries of these sections to help guide the reader.

Speech perception

With chapters from major contributors to this field such as Carol A. Fowler, Sophie Scott, Jenny R. Saffran, and their colleagues, this section focuses on how individuals perceive units of speech such as phonemes. The hot topic of speech perception very much remains what it has been for decades – the question of whether "speech is special." That is, does speech represent a unique mode of perception distinct from other types of auditory perception? This is a contentious issue, and we have selected authors who bring forward a range of perspectives on the topic, including exemplar- and prototype-based models of speech and the revised motor theory of speech perception. This section also addresses the role of statistical learning in speech perception, especially as it relates to suprasegmental phenomena such as word segmentation.

Spoken word recognition

With noticeably less emphasis on the level of acoustic properties and phonological features, and significantly more emphasis on interactions between words, the literature on spoken word recognition is sufficiently distinct from the literature on speech perception – and certainly large enough on its own – to warrant its own section in this handbook. Arthur G. Samuel, James S. Magnuson, Anne Fernald, John F. Connolly, and their colleagues contribute four chapters discussing recent theoretical shifts in the area of spoken word recognition that have been instigated by recent research, including novel eyetracking methods and numerous improvements and comparisons of computational models.

Written word recognition

In many ways this area of research captures what we see as a major trend in psycholinguistics: the move toward using behavioral data to test the quantitative predictions of implemented models. In the past decade we have seen the Seidenberg and McClelland model emerge as a key theory of visual word recognition, though the classical dual-route theory also remains popular. We have selected authors who are conversant in this important theoretical debate (e.g., David A. Balota, Mark S. Seidenberg, Kate Nation, and Rebecca Sandak) in order to best represent the state of the art. A second theme in this section concerns the role of phonology in reading acquisition and disorders (including dyslexia). This is a hot topic addressed not only in the developmental chapter, but also in the neuroimaging and computational modeling chapters.

Semantic memory

The area of semantic memory has changed drastically over the past ten years and become significantly coextensive with psycholinguistics. These three chapters by Lawrence W. Barsalou, George S. Cree, Linda B. Smith, and their colleagues highlight those changes, such as the advances toward perceptually based rather than amodal representations; the (competing) theory of corpus-based representations; the

central roles that connectionist modeling, neuroimaging, and patient research play; and the always present and increasing role of the study of the development of concepts and word meaning. This section makes apparent the fact that these four approaches are better integrated than ever, which is, in itself, a very exciting development.

Morphological processing

The debate between single- and dual-mechanism models of past tense processing has reemerged as a major theme in psycholinguistics. In addition to new approaches to modeling morphology, evidence has come from the neuropsychology literature, including work with aphasic patients and neuroimaging studies. That said, these chapters by Jonathan Grainger, Karalyn Patterson, and their colleagues go well beyond past tense, focusing on issues related to how morphology interacts with visual word recognition, how children use different types of evidence to learn morphological patterns, and differences between inflectional and derivational morphology.

Sentence comprehension

Sentence comprehension is a key area where psycholinguists and theoretical linguists have shared structural formalisms and experimental methods to study language processing. The field of sentence comprehension has undergone substantial methodological and theoretical changes over the past dozen years, as documented in these chapters by Lee Osterhout and colleagues, Morten H. Christiansen and colleagues, and Douglas Roland and Mary Hare. These include the introduction of implemented computational models and a plethora of evidence supporting constraint-based models. These advances (as well as the *visual world paradigm* in which auditory instructions are interpreted in the context of a visual display) have played powerful roles in changing both theoretical and empirical work. Analyses of large-scale electronic corpora are now a central part of sentence comprehension research. Finally, neuroimaging research has grown rapidly in this area, as it seems to have across many areas of psycholinguistics.

Sentence production

The raw amount of research on language production, both at the lexical level and at the sentential level, has grown substantially over the past dozen years. Invigorated by new methods such as eyetracking, neuroimaging, and improved computational models, this subfield is approaching the size and visibility of the sentence comprehension subfield. In addition to describing the state of the art of this area of research, these chapters by Zenzi M. Griffin, Gary S. Dell, Gabriella Vigliocco, and their colleagues together provide a vision for the future directions in this subfield, encouraging simultaneous attention to multiple sources of evidence.

Figurative language

Figurative language is where psycholinguists and cognitive linguists share theories and methods to understand the wide array of natural everyday language use patterns (within which nonliteral meanings are actually the norm rather than the exception). In the past dozen years, theoretical cognitive linguists (along with cognitive linguistically minded psycholinguists) have begun to integrate findings from real-time laboratory experiments (even conducting experiments themselves at times), as well as extend their theoretical treatments to explicit computational implementations, formal treatments, and neurophysiological constraints. This growing area of research, well-documented here in chapters by Raymond W. Gibbs, Jr., Srini Narayanan, Cristina Cacciari, Seana Coulson, and their colleagues, holds considerable promise for offering a framework of linguistic representation and processing that treats language as an integral component of cognition in general.

Discourse and conversation

With much of its tradition in the philosophy of language (and also somewhat in artificial intelligence), psycholinguistic research on discourse and conversation has seen a resurgence of interest lately by researchers using real-time measures such as EEG and eyetracking. Computational models have also begun to figure prominently again in the description of specific conversational situations such as question answering. These four chapters, by Herbert H. Clark, Arthur C. Graesser, Danielle S. MacNamara, Eve V. Clark, and Jos J. A. Van Berkum, sample this subfield in a manner that sets the stage for the future of this area of research.

Language and thought

This area of inquiry was once all but discarded in the field of theoretical linguistics on the grounds of specific criticisms of a specific handful of linguistic analyses. However, due significantly to the recent high-profile psycholinguistic research (documented here in chapters by Lera Boroditsky, Terry Regier, Dedre Gentner, and Monica Gonzalez-Marquez), the Whorfian hypothesis – that one's language influences how one thinks – has come again to the table of debate. Psycholinguistic methods and computational models, rather than linguistic analyses, have been producing results that strongly suggest this hypothesis still has some genuine (though perhaps limited) merit. As this field is clearly on the rise once again in psycholinguistics, this collection of chapters will help to frame the contemporary research in, as well as distinguish it from, its historical context.

Acknowledgments

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