The Neural Architecture of Grammar

Stephen E. Nadeau

The Neural Architecture of Grammar

The Neural Architecture of Grammar

Stephen E. Nadeau

The MIT Press
Cambridge, Massachusetts
London, England

MIT Press books may be purchased at special quantity discounts for business or sales promotional use. For information, please email special_sales@mitpress.mit.edu or write to Special Sales Department, The MIT Press, 55 Hayward Street, Cambridge, MA 02142.

This book was set in Times New Roman by Toppan Best-set Premedia Limited. Printed and bound in the United States of America.

Library of Congress Cataloging-in-Publication Data

Nadeau, Stephen E.
The neural architecture of grammar / Stephen E. Nadeau.
p. cm.
Includes bibliographical references and index.
ISBN 978-0-262-01702-2 (alk. paper)
1. Neurolinguistics. 2. Language and language—Grammars. I. Title.
QP399.N33 2012
612.8′2336—dc23
2011028979

10 9 8 7 6 5 4 3 2 1

To Sue, Nicole, Hillary, and Leslie

Contents

Preface

Linguists have mapped the topography of language behavior in many languages in immaculate detail. However, to understand how the brain supports language function, it is necessary to bring the principles and regularities of neural function to the table. Mechanisms of neurolinguistic function cannot be inferred solely from observations of normal and impaired language. Our understanding of principles and regularities of neural function relevant to language stems predominantly from two sources: (1) knowledge of neuroanatomy and the neural systems that are based upon this anatomy and (2) knowledge of the patterns of behavior of neural networks composed of large numbers of highly interconnected units and supporting population-based (distributed) representations.

The core neuroanatomy underlying language was largely subsumed in the Wernicke–Lichtheim model (Lichtheim 1885), and our knowledge of it has scarcely advanced beyond the principles laid out in Norman Geschwind's famous paper "Disconnexion Syndromes in Animals and Man" (Geschwind 1965). Functional imaging studies from the outset suggested a remarkable degree of bilateral engagement of the brain in language function, particularly in the perisylvian regions, but functional imaging is generally ill equipped to distinguish regions that are essential from those that are incidental. As it turns out, studies of aphasia, looked at from the right perspective, and with particular attention to the effect of lesions on both white and gray matter, provide us with fairly powerful evidence of the extent to which various components of language function are bilaterally represented, and even the extent to which this might vary from language to language. This aspect of aphasia studies, largely overlooked to date, will constitute one of the recurring themes of this book.

The evolution of our understanding of neural systems over the past 20 years has revealed the importance of systems dedicated to "keeping order in the house"—that is, maintaining coherent patterns of activity in the brain's 100 billion neurons such that all is not cacophony and adaptive behavior more or less consistently emerges. Key are systems underlying selective engagement of particular neural networks in particular ways (Nadeau and Crosson 1997), which support what Patricia Goldman-Rakic (1990) termed working memory. Working memory and its hippocampal complement, episodic memory (Shrager et al. 2008), play very substantial roles in language function, roles that we are beginning to understand and that will constitute another recurring theme of this book. Much less well understood are the mechanisms by which linguistic behavior is driven by systems underlying goal representations.

Our understanding of the population dynamics of neural network systems owes almost entirely to the study of parallel distributed processing (PDP), which was thrust so dramatically onto the world's scientific stage by David Rumelhart and Jay McClelland and their collaborators in their seminal two-volume text, published 25 years ago (McClelland, Rumelhart, and PDP Research Group 1986). The science of PDP has continued to evolve at a stunning pace ever since, enhancing our understanding of constraints governing neural network systems, demonstrating how powerful these systems can be, and demonstrating new ways in which neural networks might support particular functions. Before PDP was established as a field of research, behavioral neuroscientists could only hope that one day, the complex behaviors they were systematically studying could ultimately be related in a precise way to neural structure and function. In a flash, PDP research showed how this could be done, and, repeatedly, PDP simulations have shown the power of neural networks to account in a highly detailed way for behavior in normal and damaged brains.

This book begins with the development of a comprehensive, neurally based, theoretical model of grammatic function, drawing on principles of neuroanatomy and neurophysiology and the PDP literature, together with cognitive psychological studies of normal language, functional imaging studies, and cognitive neuropsychological and psycholinguistic studies of subjects with language disorders due to stroke, Alzheimer's disease, Parkinson's disease, and frontotemporal lobar degeneration. The remarkably detailed understanding of semantic function that has emerged substantially from the 20-year effort of the Addenbrookes Hospital group (Hodges, Patterson, Lambon Ralph, Rogers, and their collaborators, most notably Jay McClelland) has proven to be particularly important. From this, we have a cogent theory of semantic instantiation and breakdown. Much of grammar (that not dependent on networks instantiating sequence knowledge) turns out to be semantics. Research on the neural foundation of semantics, coupled with the studies of many other investigators, has led to a conceptualization of verbs as the product of multicomponent frontal and postcentral distributed representations that engage and modify noun representations, even as they are engaged by noun representations. Equally important has been PDP work on the capacity for instantiation of sequence knowledge by certain neural networks, coupled with work by psycholinguists, most notably Thompson and her colleagues at Northwestern

University, on sentence-level sequence breakdown in aphasia and patterns of reacquisition of this knowledge during speech–language therapy. Concept representations interfaced with sequence knowledge provide the intrinsic basis for the temporal dynamic of language.

The second half of this book reviews the aphasia literature, most importantly including cross-linguistic studies, testing the model in its ability to account for the findings of empirical studies not considered in its development. The model fully accommodates the competition model of Bates and MacWhinney (1989), which provided an enormous advance in our understanding of the neural basis of grammatic function, and it extends the competition model. It accounts for perhaps the single most trenchant finding of cross-linguistic aphasia studies—that the most powerful determinant of patterns of language breakdown in aphasia is the premorbid language spoken by the subject ("You can't take the Turkish out of the Turk"). It does so by accounting for grammatic knowledge in terms of the statistical regularities of particular languages that are encoded in network connectivity. Only the most redundantly encoded regularities, or those that have significant bihemispheric representation, survive focal brain damage. The model provides a surprisingly good account for a large number of findings and unprecedented resolution of a number of controversial problems, including whether grammatic dysfunction reflects loss of knowledge or loss of access to knowledge; relative sparing of grammaticality judgment; the problem of verb past tense formation, including some of the wrinkles that have appeared in the course of cross-linguistic studies; cross-linguistic differences in patterns of syntactic breakdown; and the impact of inflectional richness on the resilience of phrase structure rules and grammatic morphology in the face of brain lesions. To the extent that the proposed model did not fully account for observed patterns of language breakdown, aphasia studies have provided the basis for elaborating the model in ways that are interesting and important, even as these elaborations are entirely consistent with the general principles of the original model and in no way involve ad hoc extensions.

Ultimately, however, the model represents but a new beginning. I have done my best, particularly in the concluding chapter, to delineate possible directions for further research.

Acknowledgments

My greatest debt is to my wife and daughters, who not only put up with me and tolerated the vast time and effort invested in this work but provided their usual loving support throughout the endeavor. This book would not have been written had not Kenneth Heilman inspired me to pursue a career in neurology and behavioral neurology and taught me the very powerful way of thinking about the brain that he developed so brilliantly and that so honored his mentor, Norman Geschwind. The substance of this book owes to the phenomenal work of the many scientists of language who, over the past 150 years, have brought our understanding of language and the brain from rudimentary beginnings to a point where the multitude of threads from various lines of investigation are beginning to come together in a quite marvelous way and give us the first glimmerings of a comprehensive understanding. I am very grateful to two anonymous reviewers, who made enormously helpful suggestions. I am indebted to John Richardson and George Kelvin for the illustrations. Last but not least, I am indebted to my editor, Ada Brunstein, whose enthusiasm and care for this book were so instrumental in making it a reality.

1 Introduction

The goal of this book is to develop a neurologically plausible theory of grammatic function. Given all that we now know about neuroanatomy and principles of neural network function, it is no longer possible to propose such a theory without taking this knowledge into account. Linguists have been remarkably successful in mapping the regularities of grammatic performance in exquisite detail, and any neurological theory of language must be able to offer a logical and detailed explanation for these regularities, as well as for the errors of grammatic function that occur with slips of the tongue by normal subjects and in aphasia in subjects with brain injury.

Linguists have also developed a sophisticated mathematics to account for grammatic phenomenology, normal and abnormal, in an orderly way. Unfortunately, they have not been successful in reconciling this mathematics in all its various derivations with principles of neurobiology. Linguistic theories of grammar (e.g., government and binding theory) are discrete, hierarchical, deterministic, explicitly rule defining, and essentially orthogonal to semantics. The brain supports distributed functions; these functions are hierarchical only in the Hughlings Jackson sense (higher systems supporting more complex functions inhibit lower systems, which may become "released" with damage to higher systems); brain order is chaotic rather than deterministic; rules are not defined but instead emerge from network behavior, constrained by network topography and within- and between-network connectivity, which is acquired through experience and reflects statistical regularities of experience; and grammar results from a process involving parallel constraint satisfaction in which semantic knowledge, semantic–phonologic/morphologic (lexical) knowledge, sequence knowledge, skills in concept manipulation, and recall of what has recently been said define the final product. However powerful and heuristically useful linguistic theories are, their failure to accommodate these cardinal principles of brain function constitutes a serious shortcoming.

The chapter and verse of this book consists of the enormous body of work, principally from the fields of psycholinguistics and cognitive neuropsychology, that enables us to infer how the normal brain produces language from the aberrations in language function that follow brain damage. However, the underlying themes of the book derive from knowledge of neural systems, the well-established topography of cerebral association cortices supporting language, patterns of white matter connectivity between these cortices, the geographical and neurological impact of the vascular lesions and degenerative diseases that are the most common causes of aphasia, and the neural representation of knowledge. Because of the very serious methodological problems that have plagued functional imaging methodology, it has made but a modest contribution to our understanding of the neural architecture of grammar (see, e.g., reviews by Crepaldi et al. 2011 and Démonet, Thierry, and Cardebat 2005), and references to works in this field will be limited.[1]

It has become clear that the fundamental unit of cortical function is the neural network (Buonomano and Merzenich 1998), and a paradigmatic leap achieved in the 1980s, which yielded the field of parallel distributed processing (PDP; McClelland, Rumelhart, and PDP Research Group 1986), now enables us to peer deeply into the computational principles of neural network function and directly link complex behaviors to neural network function. Thus, PDP constitutes another major pillar of this book.

PDP models can incorporate a large variety of model-specific assumptions, including ones that are not neurologically plausible. However, in this book, I will argue from the simplest, most limited set of assumptions possible, all of which receive substantial if not overwhelming support from neurobiological research. These are as follows:

- The fundamental unit of cerebral function is the neural network (Buonomano and Merzenich 1998).
- A neural network is comprised of a large number of relatively simple units, each of which is heavily connected with many if not all the other units in the network, hence the term connectionist model.
- The knowledge in a network (long-term memory) consists of the pattern of connection strengths between units, corresponding to synaptic strengths between neurons (an idea that likely originated with Hebb 1949).
- The principal operational currency of a network is the activity of individual units (which corresponds to states of depolarization or firing rates of neurons). Activity in some units will naturally spread to other units, constrained by the pattern of connection strengths.
- Activation levels of units and the flow of activation between units involve nonlinear functions.
- A cognitive representation consists of a specific pattern of activity of the units in a network (which defines working memory). Because this pattern involves a

substantial portion of the units, the representation is referred to as distributed or population encoded (Rolls and Treves 1998).

• Networks are linked to each other by very large numbers of connections. I will presume that the pattern of the network linkages underlying language function reflects the known topography of cortical functions, as substantially defined by information-processing models, and that there is no intrinsic incompatibility between information-processing models and the PDP conceptualizations to be discussed.

• Learning consists of altering connection strengths.

• Links between networks enable transformation of a representation in one modality in one network into a different representation, corresponding to another modality, in the connected network.

These simple properties enable a complex array of functions even as they strongly constrain the nature of processing that must occur. Much of this book will consist of elaboration of this statement in the domain of grammatic function. The surprisingly great functional capacity of networks defined by these principles has been repeatedly demonstrated in the ability of PDP simulations to account in precise quantitative fashion for a vast range of empirical phenomena in normal and brain-injured subjects. More generally, connectionist concepts are now deeply embedded in and receive enormous support from mainstream neuroscientific research (e.g., Rolls and Deco 2002; Rolls and Treves 1998).

Yusef Grodzinsky has been at once one of the scientists most knowledgeable about the aphasia literature and one of the stoutest defenders of a discrete, localized, domain-specific organ of grammar, presumably located in Broca's area. In his 2000 paper, he stated, "It is important to note that a theory is best 'refuted' not by data … but rather by an alternative proposal" (Grodzinsky 2000, p. 56). In this book I seek to provide such an alternative proposal: a theoretical model of language function based in neuroanatomy and connectionist principles that also accommodates the accumulated empirical findings of psycholinguistic and cognitive neuropsychological studies. Before proceeding to the details, it is worth asking how the reader should judge the model presented here. MacWhinney and Bates (Bates and MacWhinney 1989, p. 36) have said it just right:

> [A model] itself cannot be disconfirmed by any single experiment.… [It] must instead be evaluated in terms of (1) its overall coherence, (2) its heuristic value in inspiring further research, and (3) its performance compared with competing accounts. Components of a model are tested one at a time, and if predictions fail, modifications are made and new concepts are introduced. Ideally, these new concepts should have an independent motivation (i.e., they should not be added merely to save the model), and they should lead to new discoveries in their own right. But the framework as a whole will be rejected only if (1) it loses coherence,

weighted down by circularities and ad hoc assumptions, (2) it loses its heuristic value, and/or (3) a better account of the same phenomena comes along.

One last apology: many of the conclusions in this book will be stated with a degree of confidence that is not warranted by the limited data available. To some extent this will be inadvertent. To a large extent, however, it reflects a deliberate strategy to minimize the muddiness that would be introduced by repeated qualifications and caveats. In any event, the conclusions should always be viewed as testable hypotheses rather than accepted facts. No systematic attempt has been made to contrast theories presented in this book with existing linguistic or cognitive neuropsychological theories for the simple reason that none of these theories has been comprehensively related to neural structure.

I begin the discussion of the model with a brief review of phonology from a connectionist perspective. This review will serve to introduce the basic concepts: the organization and operating principles of the phonologic core of language, the neural basis for and the organization of distributed semantic representations, and the neural network basis of sequence knowledge. The *intrinsic* temporal dynamics of language derive from the interplay between distributed concept representations and different domains of sequence knowledge, hence the importance of a clear understanding of these core principles from the outset. The flow of concept representations corresponding to the flow of thought of course provide an external source of temporal dynamic.

References

Abrahams, B. S., D. Tentler, J. V. Perederiy, M. C. Oldham, G. Coppola, and D. H. Geschwind. 2007. Genome-wide analyses of human perisylvian cerebral cortical patterning. *Proceedings of the National Academy of Sciences of the United States of America* 104:17849–17854.

Acheson, D. J., and M. C. MacDonald. 2009. Verbal working memory and language production: common approaches to the serial ordering of verbal information. *Psychological Bulletin* 135:50–68.

Alvarez, P., and L. R. Squire. 1994. Memory consolidation and the medial temporal lobe: a simple network model. *Proceedings of the National Academy of Sciences of the United States of America* 91:7041–7045.

Ansell, B. J., and C. R. Flowers. 1982. Aphasic adults' use of heuristic and structural linguistic cues for sentence analysis. *Brain and Language* 12:61–72.

Aravena, P., E. Hurtado, R. Riveros, J. F. Cardona, F. Manes, and A. Ibáñez. 2010. Applauding with closed hands: neural signature of action-sentence compatibility effects. *PLoS ONE* 5 (7):e11751.

Bak, T. H., D. G. O'Donovan, J. H. Xuereb, S. Boniface, and J. R. Hodges. 2001. Selective impairment of verb processing associated with pathological changes in Brodmann areas 44 and 45 in the motor neuron disease–dementia–aphasia syndrome. *Brain* 124:103–120.

Baker, M. 2001. *The Atoms of Language*. New York: Basic Books.

Balint, R. 1909. Seelenlahmung des "Schauens", optische Ataxie, raumliche Störung der Aufmerksamkeit. *Monatsschrift für Psychiatrie und Neurologie* 25:57–71.

Barde, L. H. F., M. F. Schwartz, and C. B. Boronat. 2006. Semantic weight and verb retrieval in aphasia. *Brain and Language* 97:266–278.

Barsalou, L. W. 2008. Grounded cognition. *Annual Review of Psychology* 59:617–645.

Basso, A., M. Bracchi, E. Capitani, M. Laiacona, and M. E. Zanobio. 1987. Age and evolution of language area functions: a study of adult stroke patients. *Cortex* 23:475–483.

Bastiaanse, R., G. Bouma, and W. Post. 2009. Linguistic complexity and frequency in agrammatic speech production. *Brain and Language* 109:18–28.

Bastiaanse, R., and R. Jonkers. 1998. Verb retrieval in action naming and spontaneous speech in agrammatic and anomic aphasia. *Aphasiology* 12:951–969.

Bastiaanse, R., R. Jonkers, E. Ruigendijk, and R. Van Zonneveld. 2003. Gender and case in agrammatic production. *Cortex* 39:405–417.

Bastiaanse, R., and C. K. Thompson. 2003. Verb and auxiliary movement in agrammatic Broca's aphasia. *Brain and Language* 84:286–305.

Bastiaanse, R., and R. Zonnefeld. 2005. Sentence production of verbs of alternating transitivity in agrammatic Broca's aphasia. *Journal of Neurolinguistics* 18:59–66.

Bates, E., M. Appelbaum, and L. Allard. 1991. Statistical constraints on the use of single cases in neuropsychological research. *Brain and Language* 40:295–329.

Bates, E., S. Chen, O. J. L. Tzeng, P. Li, and M. Opie. 1991. The noun–verb problem in Chinese aphasia. *Brain and Language* 41:203–233.

Bates, E., and A. Devescovi. 1989. Crosslinguistic studies of sentence production. In *The Crosslinguistic Study of Sentence Processing*, ed. B. MacWhinney and E. Bates, 225–253. Cambridge: Cambridge University Press.

Bates, E., A. Devescovi, and B. Wulfeck. 2001. Psycholinguistics: a cross-language perspective. *Annual Review of Psychology* 52:369–396.

Bates, E., A. Friederici, and B. Wulfeck. 1987a. Comprehension in aphasia: a cross-linguistic study. *Brain and Language* 32:19–67.

Bates, E., A. Friederici, and B. Wulfeck. 1987b. Grammatical morphology in aphasia: evidence from three languages. *Cortex* 23:545–574.

Bates, E., and J. C. Goodman. 1997. On the inseparability of grammar and the lexicon: evidence from acquisition, aphasia and real-time processing. *Language and Cognitive Processes* 12:507–584.

Bates, E., and J. C. Goodman. 1999. On the emergence of grammar from the lexicon. In *The Emergence of Language*, ed. B. MacWhinney, 29–79. Mahwah, NJ: Lawrence Erlbaum Associates.

Bates, E., and B. MacWhinney. 1989. Functionalism and the competition model. In *The Crosslinguistic Study of Sentence Processing*, 3–73. Cambridge: Cambridge University Press.

Bates, E., and B. Wulfeck. 1989. Comparative aphasiology: a cross-linguistic approach to language breakdown. *Aphasiology* 3:111–142.

Bates, E., B. Wulfeck, and B. MacWhinney. 1991. Cross-linguistic research in aphasia: an overview. *Brain and Language* 41:123–148.

Bates, E. A., A. D. Friederici, B. B. Wulfeck, and L. A. Juarez. 1988. On the preservation of word order in aphasia: cross-linguistic evidence. *Brain and Language* 33:323–364.

Benedet, M. J., J. A. Christiansen, and H. Goodglass. 1998. A cross-linguistic study of grammatical morphology in Spanish- and English-speaking agrammatic patients. *Cortex* 34:309–336.

Bergen, B., and K. Wheeler. 2010. Grammatical aspect and mental simulation. *Brain and Language* 112:150–158.

Bergen, B. K., S. Lindsay, T. Matlock, and S. Narayanan. 2007. Spatial and linguistic aspects of visual imagery in sentence comprehension. *Cognitive Science* 31:733–764.

Berndt, R. S. 1987. Symptom co-occurrence and dissociation in the interpretation of agrammatism. In *The Cognitive Neuropsychology of Language*, ed. M. Coltheart, G. Sarton, and R. Job, 221–233. London: Lawrence Erlbaum Associates.

Berndt, R. S., A. N. Haendiges, M. W. Burton, and C. C. Mitchum. 2002. Grammatical class and imageability in aphasic word production: their effects are independent. *Journal of Neurolinguistics* 15:353–371.

Berndt, R. S., A. N. Haendiges, C. C. Mitchum, and J. Sandson. 1997. Verb retrieval in aphasia. 2. Relationship to sentence processing. *Brain and Language* 56:107–137.

Berndt, R. S., and C. C. Mitchum. 1998. An experimental treatment of sentence comprehension. In *Approaches to the Treatment of Aphasia*, ed. N. Helm-Estabrooks and A. Holland, 91–111. San Diego: Singular Publishing Group.

Berndt, R. S., C. C. Mitchum, M. W. Burton, and A. N. Haendiges. 2004. Comprehension of reversible sentences in aphasia: the effects of verb meaning. *Cognitive Neuropsychology* 21:229–244.

Berndt, R. S., C. C. Mitchum, and A. N. Haendiges. 1996. Comprehension of reversible sentences in "agrammatism": a meta-analysis. *Cognition* 58:289–308.

Berndt, R. S., C. C. Mitchum, A. N. Haendiges, and J. Sandson. 1997. Verb retrieval in aphasia. 1. Characterizing single word impairments. *Brain and Language* 56:68–106.

Bird, H., D. Howard, and S. Franklin. 2003. Verbs and nouns: the importance of being imageable. *Journal of Neurolinguistics* 16:113–149.

Bird, H., M. A. Lambon Ralph, K. Patterson, and J. R. Hodges. 2000. The rise and fall of frequency and imageability: noun and verb production in semantic dementia. *Brain and Language* 73:17–49.

Bird, H., M. A. Lambon Ralph, M. Seidenberg, J. L. McClelland, and K. Patterson. 2003. Deficits in phonology and past-tense morphology: what's the connection? *Journal of Memory and Language* 48:502–526.

Blumstein, S. E., H. Goodglass, S. Statlender, and C. Biber. 1983. Comprehension strategies determining reference in aphasia: a study of reflexivization. *Brain and Language* 18:115–127.

Bodén, M., and A. Blair. 2003. Learning the dynamics of embedded clauses. *Applied Intelligence* 19:51–63.

Borghi, A. M., and L. Riggio. 2009. Sentence comprehension and simulation of object temporary, canonical and stable affordances. *Brain Research* 1253:117–128.

Botvinick, M. M., and D. C. Plaut. 2006. Short-term memory for serial order: a recurrent neural network model. *Psychological Review* 113:201–233.

Boulenger, V., L. Mechtouff, S. Thobois, E. Broussolle, M. Jeannerod, and T. A. Nazir. 2008. Word processing in Parkinson's disease is impaired for action verbs but not for concrete nouns. *Neuropsychologia* 46:743–756.

Boulenger, V., A. C. Roy, Y. Paulignan, V. Déprez, M. Jeannerod, and T. A. Nazer. 2006. Cross-talk between language processes and overt motor behavior in the first 200 ms of processing. *Journal of Cognitive Neuroscience* 18:1607–1615.

Braak, H., and E. Braak. 1991. Neuropathological staging of Alzheimer-related changes. *Acta Neuropathologica* 82:239–259.

Braak, H., K. Del Tredici, U. Rüb, R. A. I. de Vos, E. N. H. Jansen Steur, and E. Braak. 2003. Staging of brain pathology related to sporadic Parkinson's disease. *Neurobiology of Aging* 24:197–211.

Breedin, S., E. M. Saffran, and H. B. Coslett. 1994. Reversal of the concreteness effect in a patient with semantic dementia. *Cognitive Neuropsychology* 11:617–660.

Breedin, S. D., and R. C. Martin. 1996. Patterns of verb impairment in aphasia: an analysis of four cases. *Cognitive Neuropsychology* 13:51–91.

Breedin, S. D., E. M. Saffran, and M. F. Schwartz. 1998. Semantic factors in verb retrieval: an effect of complexity. *Brain and Language* 63:1–31.

Brown, J. W., and E. Grober. 1983. Age, sex, and aphasia type: evidence for a regional cerebral growth process underlying lateralization. *Journal of Nervous and Mental Disease* 171:431–434.

Bub, D. N., M. E. J. Masson, and G. S. Cree. 2008. Evocation of functional and volumetric gestural knowledge by objects and words. *Cognition* 106:27–58.

Buonomano, D. V., and M. M. Merzenich. 1998. Cortical plasticity: from synapses to maps. *Annual Review of Neuroscience* 21:149–186.

Burchert, F., R. De Bleser, and K. Sonntag. 2003. Does morphology make the difference? Agrammatic sentence comprehension in German. *Brain and Language* 87:323–342.

Burchert, F., N. Meissner, and R. De Bleser. 2008. Production of non-canonical sentences in agrammatic aphasia: limits in representation or rule application? *Brain and Language* 104:170–179.

Buxbaum, L. J., and S. Kalénine. 2010. Action knowledge, visuomotor activation, and embodiment in the two action systems. *Annals of the New York Academy of Sciences* 1191:201–218.

Bybee, J. 2001. *Phonology and Language Use*. Cambridge: Cambridge University Press.

Byng, S. 1988. Sentence processing deficits: theory and therapy. *Cognitive Neuropsychology* 5:629–676.

Caplan, D., and J. E. Hana. 1998. Sentence production deficits by aphasic patients is constrained by task. *Brain and Language* 63:184–218.

Cappa, S. F., G. Binetti, A. Pezzini, A. Pdovani, L. Rozzini, and M. Trabucchi. 1998. Object and action naming in Alzheimer's disease and frontotemporal dementia. *Neurology* 50:351–355.

Cappelletti, M., F. Fregni, K. Shapiro, A. Pascual-Leone, and A. Caramazza. 2008. Processing nouns and verbs in the left frontal cortex: a transcranial magnetic stimulation study. *Journal of Cognitive Neuroscience* 20:707–720.

Caramazza, A., A. G. Basili, J. J. Koller, and R. S. Berndt. 1981. An investigation of repetition and language processing in a case of conduction aphasia. *Brain and Language* 14:235–271.

Caramazza, A., and R. S. Berndt. 1985. Multicomponent deficit view of agrammatic Broca's aphasia. In *Agrammatism*, ed. M. L. Kean, 27–63. Orlando: Academic Press.

Caramazza, A., R. Capasso, E. Capitani, and G. Miceli. 2005. Patterns of comprehension performance in agrammatic Broca's aphasia: a test of the trace deletion hypothesis. *Brain and Language* 94:43–53.

Caramazza, A., E. Capitani, A. Rey, and R. S. Berndt. 2001. Agrammatic Broca's aphasia is not associated with a single pattern of comprehension performance. *Brain and Language* 76:158–184.

Caramazza, A., D. Chialant, R. Capasso, and G. Miceli. 2000. Separable processing of consonants and vowels. *Nature* 403:428–430.

Caramazza, A., and A. E. Hillis. 1991. Lexical organization of nouns and verbs in the brain. *Nature* 349:788–790.

Caramazza, A., G. Miceli, and G. Villa. 1986. The role of the (output) phonological buffer in reading, writing, and repetition. *Cognitive Neuropsychology* 3:37–76.

Caramazza, A., and E. Zurif. 1976. Dissociation of algorithmic and heuristic processes in language comprehension: evidence from aphasia. *Brain and Language* 3:572–582.

Carpenter, A. F., A. P. Georgopoulos, and G. Pellizer. 1999. Motor cortical encoding of serial order in a context recall task. *Science* 283:1752–1757.

Cartling, B. 2008. On the implicit acquisition of a context-free grammar by a simple recurrent neural network. *Neurocomputing* 71:1527–1537.

Catani, M., R. J. Howard, S. Pajevic, and D. K. Jones. 2002. Virtual in vivo interactive dissection of white matter fasciculi in the human brain. *NeuroImage* 17:77–94.

Catani, M., D. K. Jones, and D. H. Fytche. 2005. Perisylvian language networks of the human brain. *Annals of Neurology* 57:8–16.

Centeno, J. G. 2007. Canonical features in the inflectional morphology of Spanish-speaking individuals with agrammatic speech. *Advances in Speech Language Pathology* 9:162–172.

Chatterjee, A., L. M. Maher, and K. M. Heilman. 1995. Spatial characteristics of thematic role representation. *Neuropsychologia* 33:643–648.

Chavis, D. A., and D. N. Pandya. 1976. Further observations on corticofrontal connections in the rhesus monkey. *Brain Research* 117:369–386.

Chen, S., and E. Bates. 1998. The dissociation between nouns and verbs in Broca's and Wernicke's aphasia: findings from Chinese. *Aphasiology* 12:5–36.

Chertkow, H., D. Bub, C. Deaudon, and V. Whitehead. 1997. On the status of object concepts in aphasia. *Brain and Language* 58:203–232.

Cheung, S. W., P. H. Bedenbaugh, S. S. Nagarajan, and C. E. Schreiner. 2001. Functional organization of squirrel monkey primary auditory cortex: responses to pure tones. *Journal of Neurophysiology* 85:1732–1749.

Chomsky, N. 1957. *Syntactic Structures*. The Hague: Mouton.

Chomsky, N. 1981. *Lectures on Government and Binding*. Cinnaminson, NJ: Foris Publications.

Chomsky, N. 1986. *Knowledge of Language: Its Nature, Origins and Use*. New York: Praeger.

Choy, J. J., and C. K. Thompson. 2010. Binding in agrammatic aphasia: processing to comprehension. *Aphasiology* 24:551–579.

Christiansen, M. H., and N. Chater. 1999. Toward a connectionist model of recursion in human linguistic performance. *Cognitive Science* 23:157–205.

Clahsen, H., and M. Ali. 2009. Formal features in aphasia: tense, agreement, and mood in English agrammatism. *Journal of Neurolinguistics* 22:436–450.

Colombo, L., C. Fonti, and A. Stracciari. 2009. Italian verb inflection in Alzheimer dementia. *Neuropsychologia* 47:1069–1078.

Cortese, M. J., D. A. Balota, S. D. Sergent-Marshall, R. L. Buckner, and B. T. Gold. 2006. Consistency and regularity in past-tense verb generation in healthy aging, Alzheimer's disease, and semantic dementia. *Cognitive Neuropsychology* 23:856–876.

Cotelli, M., B. Borroni, R. Manenti, A. Alberici, M. Palabria, et al. 2006. Action and object naming in frontotemporal dementia, progressive supranuclear palsy, and corticobasal degeneration. *Neuropsychology* 20:558–565.

Crepaldi, D., M. Berlingeri, E. Paulesu, and C. Luzzatti. 2011. A place for nouns and a place for verbs? A critical review of neurocognitive data on grammatical-class effects. *Brain and Language* 116:33–49.

Crutch, S. J. 2006. Qualitatively different semantic representations for abstract and concrete words: further evidence from the semantic reading errors of deep dyslexic patients. *Neurocase* 12:91–97.

Crutch, S. J., S. Connell, and E. K. Warrington. 2009. The different representational frameworks underpinning abstract and concrete knowledge: evidence from odd-one-out judgments. *Quarterly Journal of Experimental Psychology* 62:1377–1390.

Crutch, S. J., and E. K. Warrington. 2005. Abstract and concrete concepts have structurally different representational frameworks. *Brain* 128:615–627.

Crutch, S. J., and E. K. Warrington. 2007. Semantic priming in deep-phonological dyslexia: contrasting effects of association and similarity upon abstract and concrete word reading. *Cognitive Neuropsychology* 24:583–602.

Crutch, S. J., and E. K. Warrington. 2008. Contrasting patterns of comprehension for superordinate, basic-level, and subordinate names in semantic dementia and aphasic stroke patients. *Cognitive Neuropsychology* 25:582–600.

Dalla Volta, R., C. Gianelli, G. Campione, and M. Gentilucci. 2009. Action word understanding and overt motor behavior. *Experimental Brain Research* 196:403–412.

Damasio, A. R., and D. Tranel. 1993. Nouns and verbs are retrieved with differently distributed neural systems. *Proceedings of the National Academy of Sciences of the United States of America* 90:4957–4960.

Daniele, A., L. Giustolisi, M. C. Silveri, C. Colosimo, and G. Gainotti. 1994. Evidence for a possible neuroanatomical basis for lexical processing of nouns and verbs. *Neuropsychologia* 32:1325–1341.

Daugherty, K., and M. S. Seidenberg. 1992. Rules or connections? The past tense revisited. In *Proceedings of the Fourteenth Annual Conference of the Cognitive Science Society*, 259–264. Hillsdale, NJ: Lawrence Erlbaum Associates.

Dawkins, R. 1976. *The Selfish Gene*. Oxford: Oxford University Press.

Dawkins, R. 2004. *The Ancestor's Tale*. Boston: Houghton Mifflin.

de Bleser, R. 1987. From agrammatism to paragrammatism. German aphasiologic traditions and grammatical disturbances. *Cognitive Neuropsychology* 4:187–256.

de Bleser, R., and C. Kauschke. 2003. Acquisition and loss of nouns and verbs: parallel or divergent patterns? *Journal of Neurolinguistics* 16:213–229.

de Diego Balaguer, R., A. Costa, N. Sebastián-Galles, M. Juncadella, and A. Caramazza. 2004. Regular and irregular morphology and its relationship with agrammatism: evidence from two Spanish–Catalan bilinguals. *Brain and Language* 91:212–222.

De Renzi, E., and G. di Pellegrino. 1995. Sparing of verbs and preserved but ineffectual reading in patient with impaired word production. *Cortex* 31:619–636.

De Witte, L., I. Wilssens, S. Engelborghs, P. P. De Deyn, and P. Mariën. 2006. Impairment of syntax and lexical semantics in a patient with bilateral paramedian thalamic infarction. *Brain and Language* 96:69–77.

Démonet, J.-F., F. Chollet, S. Ramsay, D. Cardebat, J.-L. Nespoulous, R. Wise, A. Rascol, and R. Frackowiak. 1992. The anatomy of phonological and semantic processing in normal subjects. *Brain* 115:1753–1768.

Démonet, J.-F., G. Thierry, and D. Cardebat. 2005. Renewal of the neurophysiology of language: functional neuroimaging. *Physiological Reviews* 85:49–95.

Desimone, R., and D. Duncan. 1995. Neural mechanisms of selective visual attention. *Annual Review of Neuroscience* 18:193–222.

Dick, F., E. Bates, B. Wulfeck, J. A. Utman, N. Dronkers, and M. A. Gernsbacher. 2001. Language deficits, localization, and grammar: evidence for a distributive model of language breakdown in aphasic patients and neurologically intact individuals. *Psychological Review* 108:759–788.

Diesfeldt, H. F. A. 2004. Syntactic comprehension of reversile sentences in semantic dementia. *Aphasiology* 18:715–742.

Druks, J. 2006. Morpho-syntactic and morpho-phonological deficits in the production of regularly and irregularly inflected verbs. *Aphasiology* 20:993–1017.

Druks, J., and E. Carroll. 2005. The crucial role of tense for verb production. *Brain and Language* 94:1–18.

Dryer, M. 2007. Word order. In *Language Typology and Syntactic Description.* Vol 1. *Clause Structure*, ed. T. Shopen, 61–113. Cambridge: Cambridge University Press.

Duffau, H., P. Gatignol, E. Mandonnet, P. Peruzzi, N. Tzourio-Mazoyer, and L. Capelle. 2005. New insights into the anatomo-functional connectivity of the semantic system: a study using cortico-subcortical electrostimulations. *Brain* 128:797–810.

Dunn, M., S. J. Greenhill, S. C. Levinson, and R. D. Gray. 2011. Evolved structure of language shows lineage—specific trends in word-order universals. *Nature* 473:79–82.

Edmonds, L. A., S. E. Nadeau, and S. Kiran. 2009. Effect of verb network strengthening treatment (VNeST) on lexical retrieval of content words in sentences in persons with aphasia. *Aphasiology* 23:402–424.

Eggert, G. H. 1977. *Wernicke's Works in Aphasia: A Sourcebook and Review*. vol. 1. The Hague, Netherlands: Mouton.

Ellis, A. W., and A. W. Young. 1988. *Human Cognitive Neuropsychology*. Hillsdale, NJ: Lawrence Erlbaum Associates.

Elman, J. L. 1990. Finding structure in time. *Cognitive Science* 14:179–211.

Elman, J. L. 1992. Distributed representations, simple recurrent networks, and grammatical structure. *Machine Learning* 7:195–225.

Elman, J. L. 2009. On the meaning of words and dinosaur bones: lexical knowledge without a lexicon. *Cognitive Science* 33:547–582.

Evangeliou, M. N., V. Raos, C. Galletti, and H. E. Savaki. 2009. Functional imaging of the parietal cortex during action execution and observation. *Cerebral Cortex* 19:624–639.

Everett, D. L. 2005. Cultural constraints on grammar and cognition in Pirahã. *Current Anthropology* 46:621–646.

Farah, M. J., and J. L. McClelland. 1991. A computational model of semantic memory impairment: modality-specificity and emergent category-specificity. *Journal of Experimental Psychology. General* 120:339–357.

Faroqi-Shah, Y., and C. K. Thompson. 2007. Verb inflections in agrammatic ahasia: encoding of tense features. *Journal of Memory and Language* 56:129–151.

Fernandino, L., and M. Iacoboni. 2010. Are cortical motor maps based on body parts of coordinated actions? Implications for embodies semantics. *Brain and Language* 112:44–53.

Ferretti, T. R., K. McRae, and A. Hatherell. 2001. Integrating verbs, situation schemas, and thematic role concepts. *Journal of Memory and Language* 44:516–547.

Fillenbaum, S., L. Jones, and J. Wepman. 1961. Some linguistic features of speech from aphasic patients. *Language and Speech* 4:91–108.

Forde, E. M. E., and G. W. Humphreys. 1999. Category specific recognition impairments: a review of important case studies and influential theories. *Aphasiology* 13:169–193.

Frak, V., T. A. Nazir, M. Goyette, H. Cohen, and M. Jeannerod. 2010. Grip force is part of the semantic representation of manual action verbs. *PLoS ONE* 5 (3):e9728.

Friederici, A. D. 1982. Syntactic and semantic process in aphasic deficits: the availability of prepositions. *Brain and Language* 15:249–258.

Friedmann, Na'ama, and Y. Grodzinsky. 1997. Tense and agreement in agrammatic production: pruning the syntactic tree. *Brain and Language* 56:397–405.

Friedrich, F. J., C. G. Glenn, and O. S. M. Marin. 1984. Interruption of phonological coding in conduction aphasia. *Brain and Language* 22:266–291.

Garrard, P., M. A. Lambon Ralph, J. R. Hodges, and K. Patterson. 2001. Prototypicality, distinctiveness, and intercorrelation: analyses of the semantic attribues of living and nonliving concepts. *Cognitive Neuropsychology* 18:125–174.

Garrett, M. F. 1976. Syntactic processes in sentence production. In *New Approaches to Language Mechanisms*, ed. R. J. Wales and E. Walker, 231–256. Amsterdam: North-Holland.

Gennari, S. P., and M. C. MacDonald. 2009. Linking production and comprehension processes: the case of relative clauses. *Cognition* 111:1–23.

Geschwind, N. 1965. Disconnexion syndromes in animals and man. *Brain* 88:237–294, 585–644.

Gilmour, G. C., H. E. Wenk, L. A. Naylor, and E. Koss. 1994. Motor perception and Alzheimer's disease. *Journals of Gerontology. Series B, Psychological Sciences and Social Sciences* 49:52–57.

Gleason, J. B., H. Goodglass, E. Green, N. Ackerman, and M. R. Hyde. 1975. The retrieval of syntax in Broca's aphasia. *Brain and Language* 2:451–471.

Gleason, J. B., H. Goodglass, L. Obler, E. Green, M. R. Hyde, and S. Weintraub. 1980. Narrative strategies of aphasic and normal-speaking subjects. *Journal of Speech and Hearing Research* 23:370–382.

Glenberg, A. M., and M. P. Kaschak. 2002. Grounding language in action. *Psychonomic Bulletin & Review* 9:558–565.

Goebel, R., and P. Indefrey. 2000. A recurrent network with short-term memory capacity learning the German -s plural. In *Models of Language Acquisition*, ed. P. Broeder and J. Murre, 177–200. Oxford: Oxford University Press.

Gold, M., S. E. Nadeau, D. H. Jacobs, J. C. Adair, L. J. Gonzalez-Rothi, and K. M. Heilman. 1997. Adynamic aphasia: a transcortical motor aphasia with defective semantic strategy formation. *Brain and Language* 57:374–393.

Goldberg, E., and R. Goldfarb. 2005. Grammatical category ambiguity in aphasia. *Brain and Language* 95:293–303.

Goldman-Rakic, P. S. 1990. Cellular and circuit basis of working memory in prefrontal cortex of nonhuman primates. *Progress in Brain Research* 85:325–336.

Gonzalez Rothi, L. J., R. Fuller, S. A. Leon, D. Kendall, A. B. Moore, S. S. Wu, B. Crosson, K. M. Heilman, and S. E. Nadeau. 2009. Errorless practice as a possible adjuvant to donepezil in Alzheimer's disease. *Journal of the International Neuropsychological Society* 15:311–321.

Goodglass, H. 1993. *Understanding Aphasia*. San Diego: Academic Press.

Goodglass, H., J. A. Christiansen, and R. Gallagher. 1993. Comparison of morphology and syntax in free narrative and structured tests: fluent vs. nonfluent aphasics. *Cortex* 29:377–407.

Goodglass, H., J. B. Gleason, and M. R. Hyde. 1970. Some dimensions of auditory language comprehension in aphasia. *Journal of Speech and Hearing Research* 13:595–606.

Gordon, J. K., and G. S. Dell. 2003. Learning to divide the labor: an account of deficits in light and heavy verb production. *Cognitive Science* 27:1–40.

Greenberg, J. H. 1963. Some universals of grammar with particular reference to the order of meaningful elements. In *Universals of Language*, ed. J.H. Greenberg, 73–113. Cambridge, MA: MIT Press.

Grodzinsky, Y. 2000. The neurology of syntax: language use without Broca's area. *Behavioral and Brain Sciences* 51:1–71.

Grodzinsky, Y., M. M. Piñango, E. Zurif, and D. Drai. 1999. The critical role of group studies in neuropsychology: comprehension regularities in Broca's aphasia. *Brain and Language* 67:134–147.

Grossman, M., C. Anderson, A. Khan, B. Avants, L. Elman, and L. McCluskey. 2008. Impaired action knowledge in amyotrophic lateral sclerosis. *Neurology* 71:1396–1401.

Grossman, M., R. Murray, P. Koenig, S. Ash, K. Cross, P. Moore, and V. Troiani. 2007. Verb acquisition and representation in Alzheimer's disease. *Neuropsychologia* 45:2508–2518.

Gupta, P., and G. S. Dell. 1999. The emergence of language: from serial order and procedural memory. In *The Emergence of Language*, ed. B. MacWhinney, 447–481. Mahwah, NJ: Lawrence Erlbaum Associates.

Halliwell, J. F. 2000. Korean agrammatic production. *Aphasiology* 14:1187–1203.

Hamilton, A. C., and H. B. Coslett. 2008. Refractory access disorders and the organization of concrete and abstract semantics: do they differ? *Neurocase* 14:131–140.

Hart, J., and B. Gordon. 1990. Delineation of single-word semantic comprehension deficits in aphasia, with anatomical correlation. *Annals of Neurology* 27:226–231.

Hauser, M. D., N. Chomsky, and W. T. Fitch. 2002. The faculty of language; what is it, who has it, and how did it evolve? *Science* 298:1569–1579.

Hawkins, J. A. 2009. Language universals and the performance-grammar correspondence hypothesis. In *Language Universals*, ed. M. H. Christiansen, C. Collins, and S. Edelman, 54–78. Oxford: Oxford University Press.

Hebb, D. O. 1949. *The Organization of Behavior*. New York: Wiley.

Heeschen, C. 1980. Strategies of decoding actor–object–relations by aphasic patients. *Cortex* 16:5–19.

Heilman, K. M., R. T. Watson, and E. Valenstein. 2003. Neglect and related disorders. In *Clinical Neuropsychology*, ed. K. M. Heilman and E. Valenstein, 296–346. Oxford: Oxford University Press.

Hillis, A. E., and A. Caramazza. 1995. Representation of grammatical categories of words in the brain. *Journal of Cognitive Neuroscience* 7:396–407.

Hillis, A. E., E. Tuffiash, and A. Caramazza. 2002. Modality-specific deterioration in naming verbs in nonfluent primary progressive aphasia. *Journal of Cognitive Neuroscience* 14:1099–1108.

Hillis, A. E., R. J. Wityk, P. B. Barker, and A. Caramazza. 2003. Neural regions essential for writing verbs. *Nature Neuroscience* 6:19–20.

Hinton, G. E., and T. Shallice. 1991. Lesioning an attractor network: investigations of acquired dyslexia. *Psychological Review* 98:74–95.

Hodges, J. R., N. Graham, and K. Patterson. 1995. Charting the progression in semantic dementia: implications for the organization of semantic memory. *Memory (Hove, England)* 3:463–495.

Hodges, J. R., K. Patterson, S. Oxbury, and E. Funnell. 1992. Semantic dementia: progressive fluent aphasia with temporal-lobe atrophy. *Brain* 115:1783–1806.

Hoeffner, J. 1992. Are rules a thing of the past? The acquisition of verbal morphology by an attractor network. In *Proceedings of the Fourteenth Annual Conference of the Cognitive Science Society*, 861–866. Hillsdale, NJ: Lawrence Erlbaum Associates.

Jaeger, J. J., A. H. Lockwood, D. L. Kemmerer, R. D. Van Valin, B. W. Murphy, and H. G. Khalak. 1996. A positron emission tomographic study of regular and irregular verb morphology in English. *Language* 72:451–497.

Janssen, U., and M. Penke. 2002. How are inflectional affixes organized in the mental lexicon? Evidence from the investigation of agreement errors in agrammatic aphasics. *Brain and Language* 81:180–191.

Jarema, G., and E. Kehayia. 1992. Impairment of inflectional morphology and lexical storage. *Brain and Language* 43:541–564.

Jesperson, O. 1965. *A Modern English Grammar on Historical Principles*. London: Allen and Unwin.

Joanisse, M. F., and M. S. Seidenberg. 1999. Impairments in verb morphology after brain injury: a connectionist model. *Proceedings of the National Academy of Sciences of the United States of America* 96:7592–7597.

Joanisse, M. F., and M. S. Seidenberg. 2003. Phonology and syntax in specific language impairment: evidence from a connectionist model. *Brain and Language* 86:40–56.

Jones, E. V. 1984. Word order processing in aphasia: effect of verb semantics. *Advances in Neurology* 42:159–181.

Jonkers, R., and R. Bastiaanse. 1998. How selective are selective word class deficits? Two case studies of action and object naming. *Aphasiology* 12:245–256.

Jonkers, R., and A. de Bruin. 2009. Tense processing in Broca's and Wernicke's aphasia. *Aphasiology* 23:1252–1265.

Kalénine, S., L. J. Buxbaum, and H. B. Coslett. 2010. Critical brain regions for action recognition: lesion symptom mapping in left hemisphere stroke. *Brain* 133:3269–3280.

Kavé, G., H. G. Ze'ev, and A. Lev. 2007. Morphological processing with deficient phonological short-term memory. *Cognitive Neuropsychology* 24:516–534.

Kegle, J. 1995. Levels of representation and units of access relevant to agrammatism. *Brain and Language* 50:151–200.

Kehayia, E., G. Jarema, and D. Kadzielawa. 1990. Cross-linguistic study of morphological errors in aphasia: evidence from English, Greek, and Polish. In *Morphology, Phonology, and Aphasia*, ed. J.-L. Nespoulous and P. Villiard, 140–155. New York: Springer-Verlag.

Kello, C. T. 2003. The emergence of a double dissociation in the modulations of a single control parameter in a nonlinear dynamic system. *Cortex* 34:132–134.

Kello, C. T., and D. C. Plaut. 2000. Strategic control in word reading: evidence from speeded responding in the tempo-naming task. *Journal of Experimental Psychology. Learning, Memory, and Cognition* 26:719–750.

Kello, C. T., and D. C. Plaut. 2003. Strategic control over rate of processing in word reading: a computational investigation. *Journal of Memory and Language* 48:207–232.

Kello, C. T., D. E. Sibley, and D. C. Plaut. 2005. Dissociations in performance on novel versus irregular items: single-route demonstrations with input gain in localist and distributed models. *Cognitive Science* 29:627–654.

Kemmerer, D. 2006. The semantics of space: integrating linguistic typology and cognitive neuroscience. *Neuropsychologia* 44:1607–1621.

Kemmerer, D., J. Gonzalez Castillo, T. Talavage, S. Patterson, and C. Wiley. 2008. Neuronanatomical distribution of five semantic components of verbs: evidence from fMRI. *Brain and Language* 107:16–43.

Kemmerer, D., and J. Gonzalez-Castillo. 2010. The two-level theory of verb meaning: an approach to integrating the semantics of action with the mirror neuron system. *Brain and Language* 112:54–76.

Kemmerer, D., and D. Tranel. 2000. Verb retrieval in brain-damaged subjects: 1. Analysis of stimulus, lexical and conceptual factors. *Brain and Language* 73:347–392.

Kemmerer, D., and D. Tranel. 2003. A double disociation between the meanings of action verbs and locative prepositions. *Neurocase* 9:421–435.

Kemmerer, D., D. Tranel, and C. Zdanczyk. 2009. Knowledge of the semantic constraints on adjective order can be selectively impaired. *Journal of Neurolinguistics* 22:91–108.

Kendall, D. L., J. C. Rosenbek, K. M. Heilman, T. W. Conway, K. Klenberg, L. J. Gonzalez Rothi, and S. E. Nadeau. 2008. Phoneme-based rehabilitation of anomia in aphasia. *Brain and Language* 105:1–17.

Kertesz, A., and A. Sheppard. 1981. The epidemiology of aphasic and cognitive impairment in stroke: age, sex, aphasia type, and laterality differences. *Brain* 104:117–128.

Kilborn, K. 1991. Selective impairment of grammatical morphology due to induced stress in normal listeners: implications for aphasia. *Brain and Language* 41:275–288.

Kim, M., and C. K. Thompson. 2000. Patterns of comprehension and production of nouns and verbs in agrammatism: implications for lexical organization. *Brain and Language* 74:1–25.

Kim, M., and C. K. Thompson. 2004. Verb deficits in Alzheimer's disease and agrammatism: implications for lexical organization. *Brain and Language* 88:1–20.

Kiran, S., K. Ntourou, and M. Eubank. 2007. The effect of typicality on online category verification of inanimate category exemplars in aphasia. *Aphasiology* 21:844–866.

Kiran, S., and C. K. Thompson. 2003. The role of semantic complexity in treatment of naming deficits: training semantic categories in fluent aphasia by controlling exemplar typicality. *Journal of Speech, Language, and Hearing Research: JSLHR* 46:608–622.

Kljajevic, V., and K. Murasugi. 2010. The role of morphology in the comprehension of *wh*-dependencies in Croatian aphasic speakers. *Aphasiology* 24:1354–1376.

Kohn, S. E., M. P. Lorch, and D. M. Pearson. 1989. Verb finding in aphasia. *Cortex* 25:57–69.

Kok, P., H. H. J. Kolk, and M. Haverkort. 2006. Agrammatic sentence production: is verb second impaired in Dutch? *Brain and Language* 96:243–254.

Kok, P., A. van Doorn, and H. H. J. Kolk. 2007. Inflection and computational load in agrammatic speech. *Brain and Language* 102:273–283.

Kolk, H. H. J. 1978. Judgment of sentence structure in Broca's aphasia. *Neuropsychologia* 16:617–626.

Kolk, H. H. J., M. J. F. vanGrunsven, and A. Keyser. 1985. On parallelism between production and comprehension in agrammatism. In *Agrammatism*, ed. M. L. Kean, 165–206. Orlando: Academic Press.

Kranjec, A., E. R. Cardillo, G. L. Schmidt, and A. Chatterjee. 2010. Prescribed spatial prepositions influence how we think about time. *Cognition* 114:111–116.

Laiacona, M., and A. Caramazza. 2004. The noun/verb dissociation in language production: varieties of causes. *Cognitive Neuropsychology* 21:103–123.

Laine, M., J. Niemi, G. Koivuselkä-Sallinen, E. Ahlsén, and J. Hyönä. 1994. A neurolinguistic analysis of morphological deficits in a Finnish–Swedish bilingual aphasic. *Clinical Linguistics & Phonetics* 8:177–200.

Lambon Ralph, M. A., and S. Ehsan. 2006. Age of acquisiton effects depend on the mapping between representations and the frequency of occurrence: empirical and computational evidence. *Visual Cognition* 13:928–948.

Landau, B., and R. Jackendoff. 1993. "What" and "where" in spatial language and spatial cognition. *Behavioral and Brain Sciences* 16:217–238.

Lee, M., and C. K. Thompson. 2004. Agrammatic aphasic production and comprehension of unaccusative verbs in sentence contexts. *Journal of Neurolinguistics* 17:315–330.

Lerer, S. 2007. *Inventing English. A Portable History of the Language*. New York: Columbia University Press.

Lhermitte, F. 1984. Language disorders and their relationship to thalamic lesions. *Advances in Neurology* 42:99–113.

Lichtheim, L. 1885. On aphasia. *Brain* 7:433–484.

Linebarger, M., M. F. Schwartz, and E. M. Saffran. 1983. Sensitivity to grammatic structure in so-called agrammatic aphasics. *Cognition* 13:361–392.

Lissauer, H. 1988. Ein fall von seelenblindheit nebst einem beitrag sur theorie derselven. *Cognitive Neuropsychology* 5:157–192.

Longworth, C. E., S. E. Keenan, R. A. Barker, W. D. Marslen-Wilson, and L. K. Tyler. 2005. The basal ganglia and rule-governed language use: evidence from vascular and degenerative conditions. *Brain* 128:584–596.

Lu, L. H., B. Crosson, S. E. Nadeau, K. M. Heilman, L. J. Gonzalez Rothi, A. M. Raymer, R. Gilmore, R. M. Bauer, and S. N. Roper. 2002. Category-specific naming deficits for objects and actions: semantic attribute and grammatical role hypotheses. *Neuropsychologia* 40:1608–1621.

Lukatela, K., S. Crain, and D. Shankweiler. 1988. Sensitivity to inflectional morphology in agrammatism: investigation of a highly inflected language. *Brain and Language* 33:1–15.

Luria, A. R. 1984. *Higher Cortical Functions in Man*. 2nd ed. New York: Basic Books.

Luria, A. R., and L. S. Tsvetkova. 1967. Towards the mechanisms of dynamic aphasia. *Acta Neurologica et Psychiatrica Belgica* 67:1045–1057.

Luzzatti, C., R. Raggi, G. Zonca, C. Pistarini, A. Contardi, and G.-D. Pinna. 2002. Verb–noun double dissociation in aphasic lexical impairments: the role of word frequency and imageability. *Brain and Language* 81:432–444.

MacWhinney, B. 1987. The competition model. In *Mechanisms of Language Acquisition*, ed. B. MacWhinney, 249–308. Hillsdale, NJ: Lawrence Erlbaum Associates.

MacWhinney, B. 2005. New directions in the competition model. In *Beyond Nature–Nurture: Essays in Honor of Elizabeth Bates*, ed. M. Tomasello and D. I. Slobin, 81–110. Mahwah, NJ: Lawrence Erlbaum Associates.

MacWhinney, B., and E. Bates, eds. 1989. *The Crosslinguistic Study of Sentence Processing*. Cambridge: Cambridge University Press.

MacWhinney, B., and J. Leinbach. 1991. Implementations are not conceptualizations: revising the verb learning model. *Cognition* 40:121–153.

MacWhinney, B., and J. Osmán-Sági. 1991. Inflectional marking in Hungarian aphasics. *Brain and Language* 41:165–183.

MacWhinney, B., J. Osmán-Sági, and D. I. Slobin. 1991. Sentence comprehension in aphasia in two clear case-marking languages. *Brain and Language* 41:234–249.

Maher, L. M., A. Chatterjee, L. J. Gonzalez Rothi, and K. M. Heilman. 1995. Agrammatic sentence production: the use of a temporal-spatial strategy. *Brain and Language* 49:105–124.

Makris, N., D. N. Kennedy, S. McInerney, A. G. Sorensen, R. Wang, V. S. Caviness, and D. N. Pandya. 2005. Segmentation of subcomponents within the superior longitudinal fascicle in humans: a quantitative, *in vivo*, DT-MRI study. *Cerebral Cortex* 15:854–869.

Manning, L., and E. K. Warrington. 1996. Two routes to naming: a case study. *Neuropsychologia* 34:809–817.

Marshall, J., S. Chiat, J. Robson, and T. Pring. 1995/96. Calling a salad a federation: an investigation of semantic jargon. 2. Verbs. *Journal of Neurolinguistics* 4:251–260.

Marshall, J., T. Pring, and S. Chiat. 1998. Verb retrieval and sentence production in aphasia. *Brain and Language* 63:159–183.

Marslen-Wilson, W. D., and L. K. Tyler. 1997. Dissociating types of mental computation. *Nature* 387:592–594.

Marslen-Wilson, W. D., and L. K. Tyler. 1998. Rules, representations, and the English past tense. *Trends in Cognitive Sciences* 2:428–435.

Masterson, J., J. Druks, M. Kopelman, L. Clare, C. Garley, and M. Hayes. 2007. Selective naming (and comprehension) deficits in Alzheimer's disease. *Cortex* 43:921–934.

Matlock, T. 2004. Fictive motion as cognitive simulation. *Memory & Cognition* 32:1389–1400.

Mätzig, S., J. Druks, J. Masterson, and G. Vigliocco. 2009. Noun and verb differences in picture naming: past studies and new evidence. *Cortex* 45:738–758.

McAllister, T., A. Bachrach, G. Waters, J. Michaud, and D. Caplan. 2009. Production and comprehension of unaccusatives in aphasia. *Aphasiology* 23:989–1004.

McCarthy, R., and E. K. Warrington. 1984. A two-route model of speech production: evidence from aphasia. *Brain* 107:463–485.

McCarthy, R. A., and E. K. Warrington. 1985. Category specificity in an agrammatic patient: the relative impairment of verb retrieval and comprehension. *Neuropsychologia* 23:709–727.

McClelland, J. L., B. L. McNaughton, and R. C. O'Reilly. 1995. Why there are complementary learning systems in the hippocampus and neocortex: insights from the successes and failures of connectionist models of learning and memory. *Psychological Review* 102:419–457.

McClelland, J. L., and K. Patterson. 2002. Rules or connections in past-tense inflections: what does the evidence rule out? *Trends in Cognitive Sciences* 6:465–472.

McClelland, J. L., D. E. Rumelhart, and the PDP Research Group. 1986. *Parallel Distributed Processing*. Cambridge, MA: MIT Press.

McRae, K., M. Hare, J. L. Elman, and T. R. Ferretti. 2005. A basis for generating expectancies for verbs from nouns. *Memory & Cognition* 33:1174–1184.

Menichelli, A., and C. Semenza. 2006. A noun-relative-to-verb deficit in accessing an intact word form. *Brain and Language* 99:155–156.

Menn, L., and L. K. Obler. 1990a. Cross-language data and theories of agrammatism. In *Agrammatic Aphasia: A Cross-Language Narrative Sourcebook*, ed. L. Menn and L. K. Obler, 1369–1389. Philadelphia: John Benjamins Publishing Company.

Menn, L., and L. K. Obler, eds. 1990b. *Agrammatic Aphasia: A Cross-Language Narrative Sourcebook. 3 vols*. Philadelphia: John Benjamins Publishing Company.

Meteyard, L., and K. Patterson. 2009. The relation between content and structure in language production: an analysis of speech errors in semantic dementia. *Brain and Language* 110:121–134.

Miceli, G., C. Caltagirone, G. Gainotti, C. Masullo, M. C. Silveri, and G. Villa. 1981. Influence of age, sex, literacy and pathologic lesion on incidence, severity and type of aphasia. *Acta Neurologica Scandinavica* 64:370–382.

Miceli, G., and A. Mazzucchi. 1990. Agrammatism in Italian: two case studies. In *Agrammatic Aphasia: A Cross-Language Narrative Sourcebook*, ed. L. Menn and L. K. Obler, 717–816. Philadelphia: John Benjamins Publishing Company.

Miceli, G., A. Mazzucchi, L. Menn, and H. Goodglass. 1983. Contrasting cases of Italian agrammatic aphasia without comprehension disorder. *Brain and Language* 19:65–97.

Miceli, G., C. Silveri, U. Nocentini, and A. Caramazza. 1988. Patterns of dissociation in comprehension and production of nouns and verbs. *Aphasiology* 2:351–358.

Miceli, G., M. Silveri, C. Romani, and A. Caramazza. 1989. Variation in the pattern of omissions and substitutions of grammatical morphemes in the spontaneous speech of so-called agrammatic patients. *Brain and Language* 36:447–492.

Miceli, G., M. C. Silveri, G. Villa, and A. Caramazza. 1984. On the basis for the agrammatic's difficulty in producing main verbs. *Cortex* 20:207–220.

Miller, G. A., and C. Fellbaum. 1991. Semantic networks in English. *Cognition* 41:197–229.

Milman, L. H., M. W. Dickey, and C. K. Thompson. 2008. A psychometric analysis of functional category production in English agrammatic narratives. *Brain and Language* 2008:18–31.

Milner, B., M. Petrides, and M. L. Smith. 1985. Frontal lobes and temporal organization of memory. *Human Neurobiology* 4:137–142.

Mimouni, Z. A., and G. Jarema. 1997. Agrammatic aphasia in Arabic. *Aphasiology* 11:125–144.

Miozzo, M. 2003. On the processing of regular and irregular forms of verbs and nouns: evidence from neuropsychology. *Cognition* 87:101–127.

Miozzo, M., S. Fischer-Baum, and J. Postman. 2008. Knowing where but not what: impaired thematic roles and spatial language. *Cognitive Neuropsychology* 25:853–873.

Mishkin, M., L. G. Ungerleider, and K. A. Macko. 1983. Object vision and spatial vision: two cortical pathways. *Trends in Neurosciences* 6:414–417.

Mitchum, C. C., and R. S. Berndt. 2001. Cognitive neuropsychological approaches to diagnosing and treating language disorders. In *Language Intervention Strategies in Aphasia and Related Neurogenic Communication Disorders*, ed. R. Chapey, 551–571. Philadelphia: Lippincott Williams & Wilkins.

Mitchum, C. C., A. N. Haendiges, and R. S. Berndt. 2004. Response strategies in aphasic sentence comprehension: an analysis of two cases. *Aphasiology* 18:675–692.

Mohr, J. P., M. S. Pessin, S. Finkelstein, H. H. Funkestein, G. W. Duncan, and K. R. Davis. 1978. Broca aphasia: pathologic and clinical. *Neurology* 28:311–324.

Moran, J., and R. Desimone. 1985. Selective attention gates visual processing in extrastriate cortex. *Science* 229:782–784.

Moss, H. E., P. De Mornay Davies, C. Jeppeson, S. McLellan, and L. K. Tyler. 1998. The relationship between knowledge of nouns and verbs in a category-specific deficit for living things. *Brain and Language* 65:92–95.

Murray, R. C., P. Koenig, S. Antani, G. McCawley, and M. Grossman. 2007. Lexical acquisition in progressive aphasia and frontotemporal dementia. *Cognitive Neuropsychology* 24:48–69.

Nadeau, S. E. 1988. Impaired grammar with normal fluency and phonology: implications for Broca's aphasia. *Brain* 111:1111–1137.

Nadeau, S. E. 2001. Phonology: a review and proposals from a connectionist perspective. *Brain and Language* 79:511–579.

Nadeau, S. E., and B. Crosson. 1997. Subcortical aphasia. *Brain and Language* 58:355–402, 436–458.

Nadeau, S. E., and L. J. Gonzalez-Rothi. 1993. Morphologic agrammatism following a right hemisphere stroke in a dextral patient. *Brain and Language* 43:642–667.

Nadeau, S. E., and K. M. Heilman. 2007. Frontal mysteries revealed. *Neurology* 68:1450–1453.

Nadeau, S. E., and L. J. G. Rothi. 2008. Rehabilitation of subcortical aphasia. In *Language Intervention Strategies in Aphasia and Related Neurogenic Communication Disorders*, ed. R. Chapey, 530–542. Philadelphia: Lippincott Williams & Wilkins.

Nadeau, S. E., L. J. G. Rothi, and J. C. Rosenbek. 2008. Language rehabilitation from a neural perspective. In *Language Intervention Strategies in Aphasia and Related Neurogenic Communication Disorders*, ed. R. Chapey, 689–734. Philadelphia: Lippincott Williams & Wilkins.

Nanousi, V., J. Masterson, J. Druks, and M. Atkinson. 2006. Interpretable vs. uninterpretable features: evidence from six Greek-speaking agrammatic patients. *Journal of Neurolinguistics* 19:209–238.

Nespoulous, J.-L., M. Dordain, C. Perron, B. Ska, D. Bub, D. Caplan, J. Mehler, and A. R. Lecours. 1988. Agrammatism in sentence production without comprehension deficits: reduced availability of syntactic structures and/or of grammatical morphemes? A case study. *Brain and Language* 33:273–295.

Niemi, J., M. Laine, R. Hänninen, and P. Koivvuselkä-Sallinen. 1990. Agrammatism in Finnish: two case studies. In *Agrammatic Aphasia: A Cross-Language Narrative Sourcebook*, ed. L. Menn and L. K. Obler, 1013–1085. Philadelphia: John Benjamins Publishing Company.

O'Connor, C. M., G. S. Cree, and K. McRae. 2009. Conceptual hierarchies in a flat attractor network: dynamics of learning and computations. *Cognitive Science* 33:665–708.

O'Grady, W., and M. Lee. 2005. A mapping theory off agammatic comprehension deficits. *Brain and Language* 92:91–100.

Ojemann, G. A. 1991. Cortical organization of language. *Journal of Neuroscience* 11:2281–2287.

Osmán-Sági, J. 1987. Action naming in Hungarian aphasic patients. *Neuroscience: Abstracts of the Second World Congress of Neuroscience IBBO* 22:S509.

Paivio, A., J. C. Yuille, and S. A. Madigan. 1968. Concreteness, imagery and meaningfulness values for 925 nouns. *Journal of Experimental Psychology* 76:1–25.

Papagno, C., R. Capasso, and G. Miceli. 2009. Reversed concreteness effect for nouns in a subject with semantic dementia. *Neuropsychologia* 47:1138–1148.

Paresi, D. 1987. Grammatical disturbances of speech production. In *The Cognitive Neuropsychology of Language*, ed. M. Coltheart, G. Sartori, and R. Job, 201–219. Hillsdale, NJ: Lawrence Erlbaum Associates.

Patterson, K. 2007. The reign of typicality in semantic memory. *Philosophical Transactions of the Royal Society, B* 362:813–821.

Patterson, K., M. A. Lambon Ralph, J. R. Hodges, and J. L. McClelland. 2001. Deficits in irregular past-tense verb morphology associated with degraded semantic knowledge. *Neuropsychologia* 39:709–724.

Patterson, K., M. A. Lambon Ralph, E. Jefferies, A. M. Woollams, R. Jones, J. R. Hodges, and T. T. Rogers. 2006. "Presemantic" cognition in semantic dementia: six deficits in search of an explanation. *Journal of Cognitive Neuroscience* 18:169–183.

Paulesu, E., C. D. Frith, and R. S. J. Frackowiak. 1993. The neural correlates of the verbal component of working memory. *Nature* 362:342–345.

Penke, M., U. Janssen, and M. Krause. 1999. The representation of inflectional morphology: evidence from Broca's aphasia. *Brain and Language* 68:225–232.

Penke, M., and G. Westermann. 2006. Broca's area and inflectional morphology: evidence from Broca's aphasia and computer modeling. *Cortex* 42:563–576.

Percy, E. J., S. J. Sherman, L. Garcia-Marques, A. Mata, and T. Garcia-Marques. 2009. Cognition and native-language grammar: the organizational role of adjective–noun word order in information representation. *Psychonomic Bulletin & Review* 16:1037–1042.

Petrides, M. 1991. Functional specialization within the dorsolateral frontal cortex for serial order memory. *Proceedings in Biology and Medicine* 246:299–306.

Petrides, M. 1995. Impairments on nonspatial self ordered and externally ordered working memory tasks after lesions of the mid-dorsal part of the lateral frontal cortex in the monkey. *Journal of Neuroscience* 15:359–375.

Pinker, S. 1991. Rules of language. *Science* 253:530–535.

Pinker, S., and A. Prince. 1988. On language and connectionism: analysis of a parallel distributed processing model of language acquisition. *Cognition* 28:73–193.

Pinker, S., and M. T. Ullman. 2002. The past and future of the past tense. *Trends in Cognitive Sciences* 6:456–463.

Plaut, D. C. 1996. Relearning after damage in connectionist networks: toward a theory of rehabilitation. *Brain and Language* 52:25–82.

Plaut, D. C., J. L. McClelland, M. S. Seidenberg, and K. Patterson. 1996. Understanding normal and impaired word reading: computational principles in quasi-regular domains. *Psychological Review* 103:56–115.

Plunkett, K., and P. Juola. 1999. A connectionist model of English past tense and plural morphology. *Cognitive Science* 23:463–490.

Plunkett, K., and V. Marchman. 1991. U-shaped learning and frequency effects in a multi-layered perceptron: implications for child language acquisition. 38:43–102.

Plunkett, K., and V. Marchman. 1993. From rote learning to system building: acquiring verb morphology in children and connectionist nets. *Cognition* 48:21–69.

Porter, R., and R. Lemon. 1993. *Corticospinal Function and Voluntary Movement., Monographs of the Physiological Society*. Oxford: Clarendon Press.

Prasada, S., and S. Pinker. 1993. Generalization of regular and irregular morphological patterns. *Language and Cognitive Processes* 8:1–56.

Prather, P., E. Zurif, C. Stern, and T. J. Rosen. 1992. Slowed lexical access in nonfluent aphasia: a case study. *Brain and Language* 43:336–348.

Pulvermüller, F. 2002. *The Neuroscience of Language*. Cambridge: Cambridge University Press.

Rajkowska, G., and P. S. Goldman-Rakic. 1995. Cytoarchitectonic definition of prefrontal areas in the normal human cortex: 2. Variability in locations of areas 9 and 46 and relationship to the Talairach coordinate system. *Cerebral Cortex* 5:323–337.

Ramscar, M. 2002. The role of meaning in inflection: why the past tense doesn't require a rule. *Cognitive Psychology* 45:45–94.

Raos, V., M. N. Evangeliou, and H. E. Savaki. 2007. Mental simulation of action in the service of action perception. *Journal of Neuroscience* 27:12675–12683.

Raposo, A., H. E. Moss, E. A. Stamatakis, and L. K. Tyler. 2009. Modulation of motor and premotor cortices by actions, action words and action sentences. *Neuropsychologia* 47:388–396.

Rapp, B., and A. Caramazza. 2002. Selective difficulties with spoken nouns and written verbs: a single case study. *Journal of Neurolinguistics* 15:373–402.

Raymer, A. M., A. L. Foundas, L. M. Maher, M. L. Greenwald, M. Morris, L. J. Rothi, and K. M. Heilman. 1997. Cognitive neuropsychological analysis and neuroanatomic correlates in a case of acute anomia. *Brain and Language* 58:137–156.

Rhee, J., P. Antiquena, and M. Grossman. 2001. Verb comprehension in frontotemporal degeneration: the role of grammatical, semantic and executive components. *Neurocase* 7:173–184.

Richardson, D., and T. Matlock. 2007. The integration of figurative language and static depictions: an eye movement study of fictive motion. *Cognition* 102:129–138.

Rigalleau, F., and D. Caplan. 2000. Effects of gender marking on pronominal coindexation. *Quarterly Journal of Experimental Psychology* 53A:23–52.

Rigalleau, F., and D. Caplan. 2004. A deficit of automatic pronominal coindexation in aphasic patients. *Journal of Neurolinguistics* 17:181–213.

Rizzolatti, G., and L. Craighero. 2004. The mirror-neuron system. *Annual Review of Neuroscience* 27:169–192.

Robinson, J., J. Druks, J. R. Hodges, and P. Garrard. 2008. The treatment of object naming, definition, and object use in semantic dementia: the effectiveness of errorless learning. *Aphasiology* 22:1–27.

Robinson, K. M., M. Grossman, T. White-Devine, and M. D'Esposito. 1996. Category-specific difficulty naming with verbs in Alzheimer's disease. *Neurology* 47:178–182.

Rogers, T. T., M. A. Lambon Ralph, P. Garrard, S. Bozeat, J. L. McClelland, J. R. Hodges, and K. Patterson. 2004. Structure and deterioration of semantic memory: a neuropsychological and computational investigation. *Psychological Review* 111:205–235.

Rogers, T. T., and J. L. McClelland. 2004. *Semantic Cognition: A Parallel Distributed Processing Approach*. Cambridge, MA: MIT Press.

Roland, D., J. L. Elman, and V. S. Ferreira. 2006. Why is that? Structural prediction and ambiguity resolution in a very large corpus of English sentences. *Cognition* 98:245–272.

Rolls, E. T., and G. Deco. 2002. *Computational Neuroscience of Vision*. Oxford: Oxford University Press.

Rolls, E. T., and A. Treves. 1998. *Neural Networks and Brain Function*. New York: Oxford University Press.

Roth, H. L., S. E. Nadeau, A. L. Hollingsworth, A. M. Cimino-Knight, and K. M. Heilman. 2006. Naming concepts: evidence of two routes. *Neurocase* 12:61–70.

Ruigendijk, E., and N. Friedmann. 2008. On the relation between structural case, determiners, and verbs in agrammatism: a study of Hebrew and Dutch. *Aphasiology* 22:948–969.

Rumelhart, D. E., and J. L. McClelland. 1986. On learning the past tenses of English verbs. In *Parallel Distributed Processing*, ed. J. L. McClelland, D. E. Rumelhart, and the PDP Research Group, 216–271. Cambridge, MA: MIT Press.

Rumelhart, D. E., P. Smolensky, J. L. McClelland, and G. E. Hinton. 1986. Schemata and sequential thought processes in PDP models. In *Parallel Distributed Processing*, ed. J. L. McClelland, D. E. Rumelhart and the PDP Research Group, 7–57. Cambridge, MA: MIT Press.

Saffran, E. M., R. S. Berndt, and M. F. Schwartz. 1989. The quantitative analysis of agrammatic production: procedure and data. *Brain and Language* 37:440–479.

Saffran, E. M., and O. S. M. Marin. 1975. Immediate memory for word lists in a patient with deficient auditory short-term memory. *Brain and Language* 2:420–433.

Saffran, E. M., M. F. Schwartz, and M. Linebarger. 1998. Semantic influences on thematic role assignment: evidence from normals and aphasics. *Brain and Language* 62:255–297.

Saffran, E. M., M. F. Schwartz, and O. Marin. 1980a. The word order problem in agrammatism: production. *Brain and Language* 10:263–280.

Saffran, E. M., M. F. Schwartz, and O. S. M. Marin. 1980b. Evidence from aphasia: isolating the components of a production model. In *Language Production*, ed. B. Butterworth, 221–241. London: Academic Press.

Sandra, D. 2010. Homophone dominance at the whole-word and sub-word levels: spelling errors suggest full-form storage of regularly inflected verb forms. *Language and Speech* 53:405–444.

Schwartz, M. F., E. M. Saffran, and O. S. M. Marin. 1980. The word order problem in agrammatism. 1. Comprehension. *Brain and Language* 10:249–262.

Seidenberg, M. S., and J. L. McClelland. 1989. A distributed, developmental model of word recognition and naming. *Psychological Review* 96:523–568.

Shallice, T. 1988. *From Neuropsychology to Mental Structure*. Cambridge: Cambridge University Press.

Shapiro, K., and A. Caramazza. 2003. Grammatical processing of nouns and verbs in left frontal cortex? *Neuropsychologia* 41:1189–1198.

Shapiro, K., J. R. Shelton, and A. Caramazza. 2000. Grammatical class in lexical production and morphological processing: evidence from a case of fluent aphasia. *Cognitive Neuropsychology* 17:665–682.

Shapiro, K. A., A. Pascual-Leone, F. M. Mottaghy, M. Gangitano, and A. Caramazza. 2001. Grammatical distinctions in the left frontal cortex. *Journal of Cognitive Neuroscience* 13:713–720.

Shrager, Y., D. A. Levy, R. O. Hopkins, and L. R. Squire. 2008. Working memory and the organization of brain systems. *Journal of Neuroscience* 28:4818–4822.

Sibley, D. E., C. T. Kello, D. C. Plaut, and J. L. Elman. 2008. Large-scale modeling of wordform learning and representation. *Cognitive Science* 32:741–754.

Slobin, D. I. 1991. Aphasia in Turkish: speech production in Broca's and Wernicke's patients. *Brain and Language* 41:149–164.

Smith, S., and E. Bates. 1987. Accessibility of case and gender contrasts for agent-object assignment in Broca's aphasics and fluent anomics. *Brain and Language* 30:8–32.

Smith, S. D., and I. Mimica. 1984. Agrammatism in a case-inflected language: comprehension of agent–object relations. *Brain and Language* 21:274–290.

Speedie, L. J., E. Wertman, J. Ta'ir, and K. M. Heilman. 1993. Disruption of automatic speech following a right basal ganglia lesion. *Neurology* 43:1768–1774.

Spivey, M. 2007. *The Continuity of Mind*. Oxford: Oxford University Press.

Squire, L. R., and S. Zola-Morgan. 1991. The medial temporal lobe memory system. *Science* 253:1380–1386.

St. John, M. F., and M. A. Gernsbacher. 1998. Learning and losing syntax: practice makes perfect and frequency builds fortitude. In *Foreign Language Learning: Psycholinguistic Studies on Training and Retention*, ed. A. F. Healy and L. E. Bourne, 231–255. Hillsdale, NJ: Lawrence Erlbaum Associates.

Stadie, N., A. Schröder, J. Postler, A. Lorenz, M. Swoboda-Moll, F. Burchert, and R. De Bleser. 2008. Unambiguous generalization effects after treatment of non-canonical sentence production in German agrammatism. *Brain and Language* 104:211–229.

Stark, M., H. B. Coslett, and E. M. Saffran. 1996. Impairment of an egocentric map of locations: implications for perception and action. *Cognitive Neuropsychology* 13:481–523.

Stavrakaki, S., and S. Kouvava. 2003. Functional categories in agrammatism: evidence from Greek. *Brain and Language* 86:129–141.

Stemberger, J. P. 1984. Structural errors in normal and agrammatic speech. *Cognitive Neuropsychology* 4:281–313.

Strauss, K. A., E. G. Puffenberger, M. J. Huentelman, S. Gottlieb, S. E. Dobrin, J. M. Parod, D. A. Stephan, and D. H. Morton. 2006. Recessive symptomatic focal epilepsy and mutant contactin-associated protein-like 2. *New England Journal of Medicine* 354:1370–1377.

Taylor, L. J., and R. A. Zwaan. 2008. Motor resonance and linguistic focus. *Quarterly Journal of Experimental Psychology* 61:896–904.

Thompson, C. K. 2003. Unaccusative verb production in agrammatic aphasia: the argument structure complexity hypothesis. *Journal of Neurolinguistics* 16:151–167.

Thompson, C. K., K. L. Lange, S. L. Schneider, and L. P. Shapiro. 1997. Agrammatic and non-brain damaged subjects' verb and verb argument structure production. *Aphasiology* 11:473–490.

Thompson, C. K., and M. Lee. 2009. Psych verb production and comprehension in agrammatic Broca's aphasia. *Journal of Neurolinguistics* 22:354–369.

Thompson, C. K., L. P. Shapiro, K. J. Ballard, B. J. Jacobs, S. L. Schneider, and M. E. Tait. 1997. Training and generalized production of wh- and NP- movement structures in agrammatic aphasia. *Journal of Speech and Hearing Research* 40:228–244.

Thompson, C. K., L. P. Shapiro, S. Kiran, and J. Sobecks. 2003. The role of syntactic complexity in treatment of sentence deficits in agrammatic aphasia: the complexity account of treatment efficacy (CATE). *Journal of Speech, Language, and Hearing Research: JSLHR* 46:591–607.

Thompson, C. K., L. P. Shapiro, and M. M. Roberts. 1993. Treatment of sentence production deficits in aphasia: a linguistic-specific approach to wh- interrogative training and generalization. *Aphasiology* 7:111–133.

Tissot, R., G. Mounin, and F. Lhermitte. 1973. *L'Agrammatisme*. Paris: Dessart.

Tranel, D., R. Adolphs, H. Damasio, and A. R. Damasio. 2001. A neural basis for the retrieval of words for actions. *Cognitive Neuropsychology* 18:655–670.

Tranel, D., and D. Kemmerer. 2004. Neuroanatomical correlates of locative prepositions. *Cognitive Neuropsychology* 21:719–749.

Tranel, D., K. Manzel, E. Asp, and D. Kemmerer. 2008. Naming dynamic and static actions: neuropsychological evidence. *Journal of Physiology* 102:80–94.

Tsapkini, K., G. Jarema, and E. Kehayia. 2002. A morphological processing deficit in verbs but not in nouns: a case study in a highly inflected language. *Journal of Neurolinguistics* 15:265–288.

Tyler, L. K., P. deMornay-Davies, R. Anokhina, C. Longworth, B. Randall, and W. D. Marslen-Wilson. 2002. Dissociations in processing past tense morphology: neuropathology and behavioral studies. *Journal of Cognitive Neuroscience* 14:79–94.

Tyler, L. K., B. Randall, and W. D. Marslen-Wilson. 2002. Phonology and neuropsychology of the English past tense. *Neuropsychologia* 40:1154–1166.

Tyler, L. K., E. A. Stamatakis, R. W. Jones, P. Bright, K. Acres, and W. D. Marslen-Wilson. 2004. Deficits for semantics and the irregular past tense: a causal relationship? *Journal of Cognitive Neuroscience* 16:1159–1172.

Tzeng, O. J. L., S. Chen, and D. L. Hung. 1991. The classifier problem in Chinese aphasia. *Brain and Language* 41:184–202.

Ullman, M. T. 1999. Acceptability ratings of regular and irregular past tense forms: evidence for a dual-system model of language from word frequency and phonological neighborhood effects. *Language and Cognitive Processes* 14:47–67.

Ullman, M. T. 2001. The declarative/procedural model of lexicon and grammar. *Journal of Psycholinguistic Research* 30:37–69.

Ullman, M. T., S. Corkin, M. Coppola, G. Hickok, J. H. Growdon, W. J. Koroshetz, and S. Pinker. 1997. A neural dissociation within language: evidence that the mental dictionary in part of declarative memory, and that grammatical rules are processed by the procedural system. *Journal of Cognitive Neuroscience* 9:266–276.

Ullman, M. T., R. Pancheva, T. Love, E. Yee, D. Swinney, and G. Hickok. 2005. Neural correlates of lexicon and grammar: evidence from the production, reading, and judgment of inflection in aphasia. *Brain and Language* 93:185–238.

Varlokosta, S., N. Valeonti, M. Kakavoulia, M. Lazaridou, A. Economou, and A. Protopapas. 2006. The breakdown of functional categories in Greek aphasia: evidence from agreement, tense, and aspect. 20:723–743.

Vernes, S. C., D. F. Newbury, B. S. Abrahams, L. Winchester, J. Nicod, M. Groszer, M. Alarcón, et al. 2008. A functional genetic link between distinct developmental language disorders. *New England Journal of Medicine* 359:2337–2345.

Vitevitch, M. S. 1997. The neighborhood characteristics of malapropisms. *Language and Speech* 40:211–228.

Walmsley, A. R., and A. K. Mir. 2007. Targeting the Nogo-A signaling pathway to promote recovery following acute CNS injury. *Current Pharmaceutical Design* 13:2470–2484.

Warrington, E. K. 1975. The selective impairment of semantic memory. *Quarterly Journal of Experimental Psychology* 27:635–657.

Warrington, E. K., and T. Shallice. 1969. The selective impairment of auditory verbal short-term memory. *Brain* 92:885–896.

Warrington, E. K., and T. Shallice. 1984. Category specific semantic impairments. *Brain* 107:829–854.

Wenzlaff, M., and H. Clahsen. 2004. Tense and agreement in German agrammatism. *Brain and Language* 89:57–68.

Whatmough, C., H. Chertkow, S. Murtha, and K. Hanratty. 2002. Dissociable brain regions process object meaning and object structure during picture naming. *Neuropsychologia* 40:174–186.

White-Devine, T., M. Grossman, K. M. Robinson, K. Onishi, N. Biassou, and M. D'Esposito. 1996. Verb confrontation naming and word–picture matching in Alzheimer's disease. *Neuropsychology* 10:495–503.

Willems, R. M., P. Hagoort, and D. Casasanto. 2010. Body-specific representations of action verbs: neural evidence from right- and left-handers. *Psychological Science* 21:67–74.

Wilson, M. P., and S. M. Garnsey. 2009. Making simple sentences hard: verb bias efffects in simple direct object sentences. *Journal of Memory and Language* 60:368–392.

Woollams, A. M., E. Cooper-Pye, J. R. Hodges, and K. Patterson. 2008. Anomia: a doubly typical signature of semantic dementia. *Neuropsychologia* 46:2503–2514.

Woollams, A. M., M. F. Joanisse, and K. Patterson. 2009. Past-tense generation from form versus meaning: behavioural data and simulation evidence. *Journal of Memory and Language* 61:55–76.

Wu, D. H., A. Morganti, and A. Chatterjee. 2008. Neural substrates of processing path and manner information of a moving event. *Neuropsychologia* 46:704–713.

Wu, D. H., S. Waller, and A. Chatterjee. 2007. The functional neuroanatomy of thematic role and locative relational knowledge. *Journal of Cognitive Neuroscience* 19:1542–1555.

Wulfeck, B. 1988. Grammaticality judgments and sentence comprehension in agrammatic aphasia. *Journal of Speech and Hearing Research* 31:72–81.

Wulfeck, B., E. Bates, and R. Capasso. 1991. A crosslinguistic study of grammaticality judgments in Broca's aphasia. *Brain and Language* 41:311–336.

Zaidel, E., M. Iacoboni, D. W. Zaidel, and J. Bogen. 2003. The callosal syndromes. In *Clinical Neuropsychology*, ed. K. M. Heilman and E. Valenstein, 347–403. New York: Oxford University Press.

Zeki, S. 1991. Cerebral akinetopsia (visual motion blindness). *Brain* 114:811–824.

Zihl, J., D. Y. Von Cramon, and N. Mai. 1983. Selective disturbance of movement vision after bilateral brain damage. *Brain* 106:313–340.

Zingeser, L. B., and R. S. Berndt. 1990. Retrieval of nouns and verbs in agrammatism and anomia. *Brain and Language* 39:14–32.

Zurif, E. G., A. Caramazza, and R. Myerson. 1972. Grammatical judgments of agrammatic aphasics. *Neuropsychologia* 10:405–417.

Zwaan, R. A., C. J. Madden, R. H. Yaxley, and M. E. Aveyard. 2004. Moving words: dynamic representations in language comprehension. *Cognitive Science* 28:611–619.