

Preface

Dysfunction of motor, sensory, and cognitive aspects of speech and language forms a substantial component of the clinical presentation in neurological practice. It is frequently present in the most common neurological conditions such as stroke and Parkinson's disease, as well as many other neurodegenerative diseases, and neurodevelopmental conditions such as autism spectrum disorders. Primary speech and language disorders also constitute a significant burden to the well-being of our society. For example, developmental stuttering afflicts more than 1 % of the population, causing great emotional and social discomfort to people who suffer from it. There is a great need to find rational approaches to alleviate the suffering caused by all these conditions. Toward this end, scientific research is focused on discovering their underlying causal mechanisms in the brain. However, despite several decades of sustained effort, we are no closer to understanding these mechanisms, as they pertain specifically to speech and language pathology.

Experience from other areas of biomedical research suggests that, arguably, an important reason for this lack of progress is the perceived absence of elementary animal models of speech and language pathologies or a reluctance to recognize them. The latter circumstance results from the fact that speech and language have long been thought to be unique attributes of the human species. Psychological and neurological research in these areas has therefore been confined to human subjects and patients. However, other frontiers of biomedical research have shown us that animal models often pave the way to understanding a disorder at the causal and mechanistic level and thereby enable researchers and physicians to devise rational strategies toward therapy.

Basic research over the last 3 decades or so has uncovered similarities between speech, especially its sensorimotor aspects, and vocal communication in several nonhuman species. The most comprehensive studies so far have been conducted in songbirds. Songbirds offer us a model system to study the interactions between developmental or genetic predispositions and tutor-dependent influences, on the learning of vocal communication. Songbird research has elucidated cellular and molecular mechanisms underlying learning and production of vocal patterns,

auditory processing and perception of vocal sounds, vocal motor control, and vocal neuromotor plasticity. More recently, the entire genome of the songbird zebra finch has been sequenced. These discoveries, along with the identification of several genes implicated in familial human speech and language disorders, have made it possible to look for analogues of speech and language dysfunction in zebra finches, at least at the perceptual and sensorimotor levels. Two approaches in particular have led us closer to the development of animal models of human speech conditions, namely, developmental stuttering and a familial verbal dyspraxia associated with a mutation in the gene for the transcription factor FoxP2.

Work on other animals that show developmental sensorimotor learning of vocal sounds used for communication has also shown significant progress, leading to the possibility of development of models of speech and language dysfunction in them. In nonhuman primates, while vocal learning per se is not very prominent, investigations on their communicative abilities have thrown some light on the rudiments of language. As far as auditory processing is concerned, echolocation in bats has long served as a rich source of fundamental insights.

There is a great need for a synthesis of all observations and ideas that have emerged from basic and clinical research into the neuroscience of vocalization and auditory processing, in order to develop a rational animal model-based framework for understanding and management of speech and language pathologies. The ultimate goal of satisfying this need makes the publication of this book focused on animal models of speech and language disorders, detailing the overall investigative approach of neurobehavioral studies in animals capable of vocal communication and learned vocalizations, a much-needed and worthwhile project. This book is arguably the first of its kind. I believe it serves as a unifying review of research in a new multidisciplinary frontier, spanning the molecular to the behavioral, for clinicians and researchers, as well as a teaching resource for advanced speech pathology and neuroscience students.

The book covers a wide range of disciplines related to speech and language and vocal communication in animals. In Part I, the first chapter deals with the current state of understanding of the neurology of speech and language in terms of brain substrates, representation, and theoretical models. The second chapter is a review of what is known about the genetics of speech and language disorders with special emphasis of the FoxP2 gene mutations, on which there is the most amount of new information. In Part II, Chap. 3 introduces and discusses the behavioral and physiological aspects of the songbird model of vocal learning. It focuses on developmental time scales of changes in vocal sounds and sequences of sound, as well as motor control and the role of sleep in these processes. The auditory pathway for encoding and processing of vocal signals is discussed in Chap. 4. Chapter 5 describes the findings of the zebra finch genome research and its application to molecular biological studies on song learning. The latter task has been extended in Chap. 6 to include current and prospective ways to elucidate detailed molecular mechanisms with translational significance. Chapter 7 wraps up the section on songbird neurobiology by proposing an elementary birdsong-based model of stuttered speech in zebra finches and discusses the possible involvement of perceptual and synaptic plasticity and neuromodulatory influences in the underlying mechanisms.

The last section is concerned with vocal signaling in three different groups of mammals that have contributed substantially to our understanding of neurophysiological and/or cognitive aspects of social communication. In Chap. 8 the authors present a compilation of findings on the rich variety of calls used by bats for communication and echolocation and the manner in which they are processed at the neuronal level. Chapter 9 concentrates on social communication in New World monkeys and the extent to which the study of their complexity and cognitive role contributes to gleaning insights into the rudiments of grammar and meaning of vocal sounds. The final chapter is an examination of the accumulated knowledge on gestures and socially significant sounds produced by our closest evolutionary ancestors, the great apes, in terms of their relevance to evolution of speech and language and their shared brain substrates in man and ape.

I am fortunate to have an illustrious panel of experts graciously agree to write chapters on their respective areas of research and teaching for this book. I am deeply grateful to them for their painstaking efforts, as well as to other experts who have reviewed their chapters and offered valuable suggestions to make them better. This book would not have been possible without the kind assistance, guidance, and hard work of Melissa Higgs and Elektra McDermott of Springer. I hope the readers will find this joint endeavor of ours useful and informative.

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