Cognitive and Communication Interventions

Neuroscience Applications for Speech-Language Pathologists

Martha S. Burns, PhD

PLURAL PUBLISHING INC.

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5521 Ruffin Road
San Diego, CA 92123

e-mail: information@pluralpublishing.com
Web site: https://www.pluralpublishing.com

Typeset in 10.5/13 Minion Pro by Achorn International
Printed in the United States of America by Integrated Books International

Library of Congress Cataloging-in-Publication Data:

Names: Burns, Martha S., author.
Title: Cognitive and communication interventions : neuroscience applications for speech-language pathologists / Martha S. Burns.
Description: San Diego, CA : Plural Publishing, Inc., [2021] | Includes bibliographical references and index.
Identifiers: LCCN 2020027165 | ISBN 9781635502923 (paperback) | ISBN 1635502926 (paperback) | ISBN 9781635506662 (ebook)
Subjects: MESH: Language Disorders—therapy | Speech-Language Pathology—methods | Cognitive Neuroscience—methods
Classification: LCC RC428.8 | NLM WL 340.2 | DDC 616.85/506—dc23
LC record available at https://lccn.loc.gov/2020027165

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Preface

One of the most significant scientific developments in the past several decades for clinical therapeutic professionals working with neurodevelopmental and neurogenic disorders has been the emergence, in the late 1950s and early 1960s, of neuroscience as a distinct discipline (Cowan, Harter, & Kandel, 2000). Eric Kandel, who was awarded the 2000 Nobel Prize for Physiology or Medicine, noted that, "the emergence of neuroscience is but one of several examples . . . in which inspired rearrangements of scientific disciplines provided opportunities for novel interactions—interactions which substantially changed the perspective, the technical power, and the excitement of a field" (Kandel, 1982). The intent of this text is to explain and expand the broadened neuroscience perspective within the speech-language community.

Most in the profession of speech and language pathology have studied neuroanatomy or neurology, and some have specialized in neurogenic disorders in children and/or adults, but the field is very broad. Just a cursory overview of our specialty groups provides a glimpse of our professional diversity: fluency, swallowing, voice, alternate and augmentative communication, language, cultural and linguistic diversity, auditory processing disorders, sensorineural hearing loss, and orofacial disorders. Yet, one overriding facet of each of these areas is a wealth of contributions from the neuroscience through research community. From a neuroscience perspective, research focused on the "bilingual brain," auditory processing system, brain organization of gestural versus oral language, neurogenic basis of fluency disorders, swallowing disorders, cochlear implant algorithms, and neurological comorbidity in orofacial disorders, we discover exciting new insights into our specialty fields. Speech, language, and hearing are, after all, core neurological capacities. Kandel's (1982) observation, that the power of neuroscience research is that it is a shared component of all of our specialties, thereby provides all of us a powerful opportunity for intra- and interdisciplinary interaction and broadened perspectives.

Take, for example, the newest neuroscience research on therapeutic effects on brain recovery after stroke. Even those who specialize in pediatric language learning, for example, and do not work with stroke, per se, can still benefit from the neuroscience research on mechanisms shown to drive neuroplastic recovery processes (i.e., how therapy changes the brain). Those specializing in speech and language disorders in pediatrics can also apply the new neurolinguistics research studies of aphasia or social and perceptual problems associated with right hemisphere lesions. Conversely, neuroscience research in pediatric disorders like apraxia of speech and autism spectrum disorders has led to increased understanding of the neurogenetic components of a range of cognitive and communication disorders like dyslexia in children as well as adult-onset speech and cognitive

disorders associated with Parkinson's disease, multiple sclerosis, and Alzheimer's disease, to name just a few. Through neuroscience, each of us, within our diverse specialties, can share a more unified perspective and revel in the power and the excitement associated with the new neuroscience research as it applies to speech-language pathology intervention.

Introduction and Text Organization

The human brain is an experience-dependent organ. As such, it is continually changing from early stages in neonatal development until the day we die. That is why and how our therapy effectively alters brain function. Unless an individual has a neurological illness or injury, most of the experience-dependent changes are constructive, permitting each individual to adapt to the specific contingencies of their own external environment and internal needs. Therapy of any kind is designed to maximize this natural experience-dependent capacity for constructive change. Especially when typical neurological maturation and/or function is altered by genetics, illness, or injury, the aim of therapy is to enable the brain to reorganize for more effective and efficient processing of information. Chapter 1 begins with a review of the newest research on brain organization, specifically focusing on anatomical regions that support language, reading, and cognition and that specifically correlate to speech and language therapy. This is followed by the new research from the Human Connectome Project and other neurodevelopmental research on brain maturation and intercommunication among these cortical and subcortical cerebral structures from gestation through adulthood. A focus of Chapter 1 is the early "setup" period of brain maturation from birth to 5 years of age, but continuing maturation changes, now known to occur through adulthood, is also reviewed. The organization/maturation section of Chapter 1 also reviews the current research on brain chemistry, as chemical changes in the brain connections and environment are major drivers of the brain's adaptive architecture (i.e., neuroplastic brain changes associated with experience). The remaining sections of Chapter 1 provide more detail on neuroplasticity, specifically, what we know about how the therapy drives neuroplastic change, the effects of genetics on brain maturation, as well as the response to illness and injury. The adolescent brain has been a focus of much international research over the past several years, with newer research looking at individual differences in adolescent brain maturation and effects of poverty on that age group. Chapter 1 concludes with a summary of this new research, highlighting the special challenges associated with adolescent brain changes. Chapter 2 reviews the current neuroscience research on organization of oral, written and gestural language networks in the human brain based on results from structural and functional neuroimaging studies.

Chapter 3 provides an introduction to connectomics, which has enabled more precise understanding of brain organization and variability in typical children and adults as well as those with neurocognitive disorders. Chapter 4 reviews major human dynamics that drive the development of the brain from fetus to adult: genetics, experience and recovery functions after brain injury.

Chapters 5 through 9 focus on recent neuroscience investigations of factors that can affect typical cognitive and communication development in the brain as well as

those that can disrupt connectomics. The initial and primary human brain adaptation processes are survival based. Above all, the human must be able to procure food, find adequate shelter to maintain body temperature, and protect the body from external threats. It is important to remember this as we work with children and adults who have cognitive or communication disorders, since environmental stresses like poverty or fear of injury or impact of illness will take precedence, brain-wise, over non-survival-based cognition. Chapter 5 reviews the research on the effects of environmental stressors like poverty and family adversity on brain maturation and function. When a person is hungry, anxious, or in pain, the human brain is directing and enabling the individual to focus on those survival problems, thereby effectively "shorting out" higher level cognitive functions. We all are familiar with how a traumatic event, like an auto accident, or even something less immediately impactful, like a major argument with a loved one, can impair our reasoning and ability to accomplish even routine tasks. For some of our clients and patients, stressors like poverty, abuse in the home, fear of inability to return to work after a stroke, to name just a few, will dramatically interfere with the individual's ability to benefit from a therapeutic session. Since cognition and communication take a back seat to survival needs, therapists need to understand, consider, and accommodate for primary stressors in each therapeutic session. Chapter 5 provides a discussion about the therapist's role in identifying and accommodating for the effects of trauma and stress in the treatment session.

Chapter 6 reviews recent clinical descriptions and neuroscientific investigations of neurodevelopmental disorders including autism spectrum disorders, developmental language disorders, and childhood apraxia of speech. Chapter 7 reviews acquired neurocognitive disorders including aphasia, right hemisphere disorders, and dementias. Chapters 8 and 9 provide an overview of neuroscience considerations for interventions including research on the what, how, and when of therapy reviewed in Chapter 8 and other factors important for individualizing and maximizing outcomes in Chapter 9.

Many of the chapters also provide case studies to provide examples of practical application of the neuroscience research. Finally, new neuroscience research (see, especially, Siler & Benjamin, 2019) supports the time-validated process of testing during study to improve memory and inference. To this purpose, study questions are provided periodically for review and group discussion.

Reference

Siler, J., & Benjamin, A. S. (2019). Long-term inference and memory following retrieval practice. *Memory and Cognition*, 1–10. doi:10.3758/s13421-019-00997-3