FOURTH EDITION

SPEECH SOUND DISORDERS

For Class and Clinic

KEN M. BLEILE

PLURAL PUBLISHING INC.

Speech Sound Disorders

FOR CLASS AND CLINIC

Fourth Edition

Speech Sound Disorders

FOR CLASS AND CLINIC

Fourth Edition

Ken M. Bleile, PhD

Plural Publishing Inc.

PLURAL PUBLISHING
INC.

5521 Ruffin Road
San Diego, CA 92123

e-mail: information@pluralpublishing.com
Website: http://www.pluralpublishing.com

Typeset in 10.5/13 Times New Roman by Flanagan's Publishing Services, Inc.
Printed in the United States of America by McNaughton & Gunn, Inc.

Library of Congress Cataloging-in-Publication Data:

Names: Bleile, Ken Mitchell, author.
Title: Speech sound disorders : for class and clinic / Ken M. Bleile.
Other titles: Manual of speech sound disorders
Description: Fourth edition. | San Diego, CA : Plural Publishing, [2020] | Preceded by Manual of speech sound disorders / Ken M. Bleile. Third edition. 2015. | Includes bibliographical references and index.
Identifiers: LCCN 2018028733| ISBN 9781635501100 (alk. paper) | ISBN 1635501105 (alk. paper)
Subjects: | MESH: Speech Sound Disorder--diagnosis | Speech Sound Disorder--therapy | Child | Speech Perception--physiology | Phonetics | Speech Therapy
Classification: LCC RC424.7 | NLM WL 340.2 | DDC 616.85/5--dc23
LC record available at https://lccn.loc.gov/2018028733

Contents

Preface xi
Contributors xiii
Acknowledgments xiv

PART I. FOUNDATIONS

Chapter 1. Speech 3
Why Study Speech? 4
The Nature of Speech 7
A Final Thought: Giving Back 10
Conclusions 12
References 12

Chapter 2. Speech Sound Disorders 15
What Is a Speech Sound Disorder? 16
Why Study Speech Sound Disorders? 16
The Nature of Speech Sound Disorders 20
Will This Help Someone? 22
Conclusions 24
References 25

Chapter 3. Speech Production 29
Todd A. Bohnenkamp
Speech in the Brain 30
Speech in the Muscles 34
Conclusions 40
References 41

Chapter 4. Speech Reception and Perception 43
Jaimie L. Gilbert
Introduction 44
Sound in the Air 44

Sound in the Ear 47
Sound in the Brain 51
Conclusions 54
Recommended Readings 54
References 55

Chapter 5. Phonetics Warm-Up 57
Transcription 58
International Phonetic Alphabet 58
Notations 61
Exercises 63
Conclusions 72
References 72

PART II. SPEECH DEVELOPMENT

Chapter 6. Infants 75
Speech Perception 76
Vocal Production 77
Summary: In a Word 80
Sound Communication 81
Conclusions 84
References 85

Chapter 7. Toddlers 89
Speech Perception 90
Speech Production 90
Summary: Puzzle Pieces 94
Sound Communication 94
Conclusions 98
References 99

Chapter 8. Preschoolers 101
Speech Perception 102
Speech Production 102
Summary: A Challenge That Stretches 108
Sound Communication 108
Conclusions 111
References 111

Chapter 9. Students 113
Speech Perception 114
Speech Production 114
Summary: Speech Development in School 120
Sound Communication 120
Conclusions 124
References 124

Chapter 10. Speech Puzzles 127
Communication Strategies 128
Exercises 130
Conclusions 144
References 144

PART III. ASSESSMENT

Chapter 11. Speech Evaluation 149
Overview 150
Referral 151
History 151
Present Development 155
Clinical Decisions 158
Implementation 159
Conclusions 160
References 160
Appendix 11–A. Speech Evaluation Checklist 162
Appendix 11–B. Quick 11 Step Screener of Oral Structure and Function 164

Chapter 12. Assessing a Bilingual Child 167
Lindsey R. Squires
Introduction 168
Special Topics in Assessment 172
Conclusions 179
References 179
Appendix 12–A. Template for Evidence-Based Case History 183

Chapter 13. Hypothesis Testing 185
Optimal Settings and Otherwise 186
Testing Methods 187
Speech Samples 189

Transcription . . . 191
Conclusions . . . 195
References . . . 196
Appendix 13–A. Preventable Harm . . . 198
Appendix 13–B. Elicitation . . . 200

Chapter 14. Phonetic Inventories . . . 207
Consonant Inventories . . . 208
Exercises . . . 209
Conclusions . . . 219
References . . . 219

Chapter 15. Phonological Processes . . . 221
Definitions . . . 222
Exercises . . . 224
Conclusions . . . 237
References . . . 237

PART IV. TREATMENT

Chapter 16. Developmental Goals . . . 241
The Developmental Logic of Treatment . . . 242
Developmental Speech Goals . . . 243
Infants . . . 245
Toddlers . . . 249
Preschoolers . . . 252
Students . . . 255
Conclusions . . . 258
References . . . 259

Chapter 17. Treatment Sounds . . . 263
Selecting a Treatment Sound . . . 264
Establishing a Treatment Sound . . . 269
Perception Training . . . 272
Speech Practice . . . 275
Conclusions . . . 280
References . . . 281

Chapter 18. Talking with Children . . . 283
Motherese . . . 284

Facilitative Talk 286
Therapy Talk 291
Conclusions 295
References 296

Chapter 19. Talking about Speech 297
Metaphors 298
Touch Cues 300
Descriptions and Demonstrations 302
Phonetic Placement and Shaping 306
Conclusions 309
References 309

Chapter 20. Supporting Communication 311
Evette Edmister
What Is AAC? 312
Benefits of AAC 314
Treatment Strategies 317
Conclusions 320
References 321

Chapter 21. The Daily Researcher 323
Evaluating Treatment Approaches 324
Assessing Treatment Progress 326
Dynamic Assessment 331
Conclusions 332
References 333

Chapter 22. Sound Decisions 335
Definitions 336
Exercises 338
Conclusions 353
References 353

Appendix A. Special Symbols and Diacritics 355
Appendix B. Definitions 357
Appendix C. Dialect and Accent 371

Index *379*

Preface

Welcome to the fourth edition of *Speech Sound Disorders*! I hope you find this to be a useful resource.

Major features of this book include

- Readable and practical discussions of complex clinical topics
- Coverage from infants to adults
- Clear link between speech development and clinical decision making
- Emphasis on underlying principles and procedures
- Student friendly

Content revisions in this new edition include

- About 80% updated and revised
- More treatment chapters
- Every chapter has learning objectives, key words, and review questions
- "Learn by doing" chapters with speech exercises from real children
- Chapters written by invited contributors on AAC, bilingualism, speech production, and speech perception
- More downloadable clinic resources

I wrote this book to support people who help children learn to talk. Whether you are a student who reads the book from beginning to end or a clinician who jumps to the resources and skims through an occasional chapter, if the book ends up marked, dog-eared, and rolled up in your pocket, it will have served its purpose.

Best wishes!
Ken M. Bleile

Contributors

Todd A. Bohnenkamp, PhD, CCC-SLP
Associate Professor
Communication Sciences and Disorders
University of Northern Iowa
Cedar Falls, Iowa
Chapter 3. Speech Production

Evette Edmister, PhD, CCC-SLP
Associate Professor
Communication Sciences and Disorders
University of Northern Iowa
Cedar Falls, Iowa
Chapter 20. Supporting Communication

Jaimie L. Gilbert, PhD, CCC-A
Assistant Professor
Communication Sciences and Disorders
University of Northern Iowa
Cedar Falls, Iowa
Chapter 4. Speech Reception and Perception

Lindsey R. Squires, PhD
Assistant Professor
Communication Sciences and Disorders
University of Northern Iowa
Cedar Falls, Iowa
Chapter 12. Assessing a Bilingual Child

Acknowledgments

This book has come full circle—I began the first edition in Iowa and finished the fourth edition in the same state. In between, I worked on book editions in Maryland (Johns Hopkins), Pennsylvania (Children's Hospital of Philadelphia), Hawaii (University of Hawaii), and New Zealand (University of Canterbury). What an odd, wandering journey for a collection of words!

I thank the many people who helped put these words in order through the ideas and experiences they shared with me. I hope you recognize your influence in these pages and that what I wrote pleases you, at least in parts. Thanks especially to faculty, staff, and students at the University of Northern Iowa for your good company all these years. Lastly, I thank my brother and sisters, living and gone (Henry, Cheryl, and Judy), and my wonderful children (Jude and Zoe).

Dedicated to the memory of Sadanand Singh.
A visionary and a great humanist.

PART I

FOUNDATIONS

CHAPTER 1
SPEECH

The world is brimming with fascinating topics, from subatomic particles to supernovas, from Zen to the Zen of baking. Why devote time and energy to study short bursts of sound that pop from a person's mouth, one after another? Of course, one reason may be someone told you to, perhaps saying something like, "Please read Chapter 1." Since you want to pass the course, you read about speech. However, the "why" intended here is of a different sort, something you might paraphrase as, "Why am I learning this stuff when I could be studying ___?" (You fill in the blank.) This chapter addresses three topics:

- Why Study Speech?
- The Nature of Speech
- A Final Thought: Giving Back

Subsequent foundation chapters discuss speech sound disorders, speech production, and speech reception and perception. The section concludes with a "learn by doing" chapter to help brush up—possibly—rusty phonetic skills.

Learning Objectives

I hope on completing the chapter you will

- Appreciate the central role that speech plays in human culture
- Understand that speech has a dual nature
- Know that speech elements in phonology lack meaning
- Understand why phonology is a cornerstone of human communication
- Appreciate the complexity of the channel of communication

Key Words

Key words you will encounter in this chapter

Talk
Thought
Theory of mind
Group identity
Accent
Dialect
Sociolect
Code switching
Cultural transmission
Dual nature of speech
Phonology
Speech perception
Articulation

Why Study Speech?

Speech is a foundation of human culture (Caroll, 2008; Duranti, 2009; Gumperz, 1972; Hymes, 1974). To see this, think of all the things that either you could not accomplish, or you could only accomplish with much greater effort, if speech did not exist to convey language. As summarized in Table 1–1, things that speech facilitates include talking, thinking, being part of a group, and transmitting knowledge from generation to generation.

Talk (Interpersonal Communication)

Talk is how people typically communicate with each other (Carroll, 2008). Stand back and watch a conversation. The mouth of a person opens, emitting a volley of sound. Then the mouth of another person opens and returns a sound volley. As Fillmore (1975) described years ago, the volleys continue—back and forth, back and forth—conveying ideas, memories, and emotions.

Approximately 7,099 different languages exist in the world, a remarkably large number considering they all belong to a single species with the same cognitive system (Ethnologue, 2017). In each of these languages, the primary means of communication is the exchange of sound. Many languages have written systems in addition to spoken ones, allowing the translation of speech into graphic mediums. Modern inventions such as the telephone, computer, film, and television have extended the realm of speech to transmission through electricity.

Of course, speech is not the only form through which humans convey language. Other means include sign language, in which the volleys are gestures rather than sounds (Sacks, 1989; Stokoe, 2005). Although the gestural volleys of sign language are as fascinating to study as those of sound, that intriguing topic lies outside the purview of this book. Nor does this book address fascinating gestural communication systems such as eye gaze and stance, though those forms of communication are rich and increasingly well-researched topics (Burgoon, Guerrero, & Floyd, 2011).

TABLE 1–1. Four Types of Communication Facilitated by Speech

Type of Communication	Definition
Talk	Communication between persons
Thought	Communication with oneself
Groups	Communication within and between groups
Cultural transmission	Communication between generations

Thought (Intrapersonal Communication)

Speech turned inward conveys **thought (**Kozulin, 1990; Smith, 1973). Internal speech and images allow humans to regulate their own behavior, make plans, and reason (Huettig & Harsuiker, 2010). Indeed, sometimes a person does not turn their speech all the way inward and you can hear them muttering—sometimes in whole sentences, though more often in short snatches.

If you introspect, you can mentally overhear speech in your head, perhaps whispering dinner possibilities or planning what you will say to a friend this evening. Or, if you are preparing for an argument you expect with a significant other, the little whisper allows you to play both sides of the projected conflict; a sort of mental script:

Mental Script:

Me: You don't treat me well!

Significant other: I do too!

Me: We never go out to dinner anymore.

Significant other: We do too. We went to dinner on your birthday.

Oops. They're right. Revise the script.

Revised Mental Script:

Me: You don't treat me well!

Significant other: I do too.

Me: We never go out to dinner anymore, except on my birthday.

Significant other: Well, I don't have much money.

Me: That's no excuse.

Good! Much better outcome.

You may notice that inner speech requires some mind reading. In the above example, "me" not only plans their own utterances, but also mind reads what "significant other" likely will reply. The scientific name for this mind reading trick is **theory of mind**, which essentially means that we act on the assumption that other people have minds, thoughts, wishes, motivations, and so forth, just as we do (Firth & Firth, 2005). Theory of mind guides our use of language; difficulties with theory of mind is part of many different communication disorders, including autism spectrum disorder (Schmaafsma, Pfaff, Spunt, & Adolphs, 2015).

Lastly, you may notice that inner speech takes a person out of the moment in which they live and projects them elsewhere—in the example, "me" projects their self into the future. A goal of many meditation practices is to turn off the inner voice so a person may experience more of the now (Lazar, Bush, Gollub, Fricchione, Khalsa, & Benson, 2000). It is not easy! To experience this, try turning off your inner speech and look around the room in which you are reading. The voice disappears for a few moments but soon returns,

a little whisper. You can turn it off again, but for most people it soon returns, taking you from the moment to other places.

Groups (Intergroup Communication)

For both good and ill, people use speech to form groups as a means to foster a **group identity** (Gumperz, 1972; Wolfram, 2004). Being a native speaker of a language is a common way people view themselves as belonging to a group. For example, persons born in Spain may group themselves as native Spanish speakers, in contrast to those with foreign **accents** that show they are nonnative Spanish speakers.

Shared speech characteristics of a **dialect** offer another means through which people place themselves in groups. In addition to dialects based on regions, people also may share a dialect based on social relationships: called **sociolects** (Wolfram, 2004). Cockney English is a famous example of a dialect that is both regional and based on social class.

Race, ethnicity, sexual orientation, age, and gender all offer people other ways to build a group identity based on shared speech characteristics. To give just one example, teenagers with similar interests and outlooks may develop a slang (a temporary age- and interest-based dialect) to differentiate themselves from those outside their group. Persons within a dialect group may speak in their dialect with other members of their group and switch dialects when speaking to outsiders: called **code switching** (Wolfram, 2004).

Sharing a common language, dialect, or style of speaking facilitates cohesion within a group, evoking feelings of pride, shared history, and camaraderie (Trudgill, 1995). More negatively, a group may weaponize speech to exclude, mock, debase, or ridicule another group (Labov, 1972). When a group uses speech as a weapon, the attitude may be, "We are ___ (select a favorite adjective: good, superior, intelligent, moral, hip, etc.) because we speak this way, while you are ___ (select a negative stereotype: stupid, inferior, uneducated, ignorant, bad, etc.) because you speak that way."

CLIn IC Box: Do You Speak Bar Bar?

Judging people by their speech is not a recent cultural development. Greeks of antiquity divided the world into two groups: speakers of Greek and those unfortunate souls who spoke other languages. The Greek view was that the latter, because they are unable to speak Greek, were inherently inferior and largely incapable of rational thought. They considered speech of foreigners to be mere noise, a sound like *bar bar bar bar,* giving us the root of the word *barbarian*, or someone who speaks *bar bar* (Kitto, 1951).

Generations (Intergenerational Communication)

Speech and its written forms are primary mechanisms through which a **culture transmits** what it considers needful to know from one generation to the next, allowing a person to

learn without direct experience. To illustrate, a parent may tell a child not to touch a hot plate, enabling the child to learn about burns without receiving one. In a broader way, cultures do the same. A few of the multitude of things a culture may consider needful to pass on from one generation to the next include ideas about freedom, morality, and thousands of different technologies. Right this moment you are reading a book as a way of passing on accumulated knowledge of speech sound disorders.

Compared to instinct, speech permits change to occur much more quickly. To illustrate, imagine a terrible drought transforms a forest into desert. To survive in this new environment, an imaginary creature that lived entirely based on its instincts would likely need generations for genes mutations to adapt to the new circumstance. For a species that relies on speech and its written forms to transmit information between generations, all it must do is develop new words to describe what is needful to know in the new environment.

The Nature of Speech

Speech has a **dual nature**, being both an aspect of language and a channel of communication (Hockett, 1960). The dual nature of speech is the basis of the conceptual distinction between phonology and articulation, and, as we shall see in Chapter 2, the basis of the difference between phonological and articulation disorders.

Language

In this book, **phonology** is the knowledge of language rules that underlie speech. Examples of phonological elements include distinctive features, phonemes, syllables, stress, and intonation. The essential characteristic of these and other elements in the phonological system is that they lack meaning. To illustrate, *s*, *t*, and *m* have no meaning in themselves, but other language systems recruit them to create meaning. For example, combined with other consonants and vowels they make words such as *sun*, *see*, *tea*, *toe*, *me*, and *myth*.

Consonants, vowels, syllables, and intonation may seem mundane, relatively insignificant aspects of language, but they are what make the rest of language possible. Because the foundation of our language is meaningless sounds that represent nothing, we can express a nearly infinite number of different meanings, allowing us to express whatever meanings are important in our social and physical environments. To appreciate the role phonology plays in human language, imagine it organized differently. For example, pretend that each consonant and vowel, instead of being meaningless, is associated with a meaning. For example, *s* represents *anger*, *w* represents *sadness*, and *t* represents *touch*. If this were so, *s* could not appear in *sweet* or *sun* or other words, since *s* always represents *anger*.

If phonology had a similar organization, humans could express very few different meanings. In fact, the world of different things to talk about would closely equal the number of sounds we could produce. To illustrate, if our vocal tracts could pronounce

120 different sounds, we could talk about approximately 120 different things, one thing per sound.

In no small measure, human adaptability depends on possessing a language system that allows the expression of an almost infinite number of meanings using a small set of sounds. This allows humans to enter a new environment and create vocabulary to describe the place in which they find themselves. This has allowed humans to spread out across the world and flourish in such diverse places as deserts, mountains, forests, and tundra. Just as easily, phonology would allow us to live on a satellite, the moon, or a distant planet.

Indeed, phonology is so critical to language and so uniquely human that we could define ourselves in the following way:

Humanity is the species whose cornerstone of communication means nothing.

That is, humanity is the species whose language includes phonology.

Channel of Communication

This book follows established practice in dividing the channel of communication into two domains: **articulation** (the motor part of the channel) and **speech perception** (the perceptual part of the channel).

Myths and Otherwise

A myth you sometimes hear about speech is that it is simple. The idea is, "How could speech *not* be simple, since a young child learns to talk and people of all ages chat from morning to night, the sounds and syllables tumbling out, virtually without effort?" Rather than being simple, it is more accurate to say that speech, like many neurological functions, is invisible, occurring automatically or semiautomatically, freeing our attention to focus on the world around us (Fodor, 1993).

In truth, speech is incredibly complex. On average, every second of speech entails producing and perceiving 12 to 14 different sounds (Ostry & Munhall, 1985). Researchers estimate that 140,000 neuromotor commands are required *per one second of speech*, requiring coordination of muscles across half the body, from the diaphragm through the lower half of the face. Chapters 3 and 4 describe this channel. For the present, let's discuss it at a nontechnical level to illustrate this complex and astonishing feat of biology.

The Long Journey of One Short Word

It's easy to think of articulation and perception as being about the mouth and ear, since those are visible structures—the former occupying the lower part of our face and the latter stuck on the side of our head. However, mouths and ears are just the beginning and

end of a much more complex, unseen process. To make this process visible, imagine that for some reason you decide to say one little word, *green*.

It Starts in the Brain

The journey of *green* begins when you decide to say *green*. At this point, *green* is not a series of sounds, but rather electricity and brain chemicals. The brain electricity is the same as the electricity that moves through wires in the walls of your home. The brain chemicals are like the light switches on your wall that control the flow of electricity.

At this point, *green* exists only in pieces in various parts of your brain—color in one location and the pronunciation of the word in another. Still, other parts of the brain may contain associations with the word, including perhaps that *green* sometimes means environmentally friendly and other times means a person beginning a new endeavor.

Next, the various parts of *green* assemble in the front part of your brain in preparation for pronunciation. Once assembled, the electrical current that is *green* travels from the front of your brain in several bundles of energy, the biological equivalent of electrical wires. One bundle travels directly to your muscles, and the other circles through the brain to check and correct possible speech errors before they happen. Both bundles meet at your muscles.

Muscle Power

Muscles are cells specialized to contract. The electrical current of *green* causes muscle cell contractions across half your body, from your stomach to your nose. Your diaphragm pushes your lungs, your lungs contract, and your articulators assume shapes for speech.

Air Travel

The muscle contractions push and shape air. *Green* now is air movement flowing from your lungs toward your throat. But the air moves too slowly, so the tube of your throat narrows midway, at your voice box, causing the air to energize—much like how the water in a broad river energizes when the river bed narrows, becoming rapids. The energized air travels through your mouth and nose, where muscle contractions have moved your articulators, so that, like pebbles and boulders in a stream, they shape and configure the energized air.

Green now is a wave of air emitted from your mouth. The air ripples like a stone dropped in a lake causes water to ripple. The rippling air moves away from your mouth and soon encounters a rather strange cauliflower-shaped thing on the side of your head. The cauliflower is the outer part of your ear. It exists there to capture rippling air—not unlike cupping your hand on your ear to create an extra ear when you have difficulty hearing something.

An Earful

The rippling air of *green* pushes on the membranes, ligaments, and muscles of your ear. *Green* is now vibrating flesh. Vibrations rattle your eardrum, travel through the smallest bones of your body, and push against a membrane, which in turn pushes on the water in the inner most part of your ear. *Green* is now rippling, salty, chemical-laden water.

Green ripples along as water, and the water in turn presses down on a membrane lining the inner most part of your ear. Under the membrane are thousands of hair cells. The membrane pushes on the hair cells. *Green* now is a pattern of pressure on thousands upon thousands of hair cells. Attached to the hair cells are nerves of the brain specialized to carry electricity.

Electricity and Chemicals Again

The hair cells press on the nerve fibers and *green* is electricity again. The electricity moves in a bundle from your ear, up the brain, crossing over from one side of the brain to the other. It reaches the upper part of your brain, moves along through several places until it finally reaches a location where your brain reads the electrical current, and translates it into a word: *green.*

And so *green,* slightly less than one half second of speech, is articulated and perceived.

CLIn IC Box: The Speech Chain

Like many students in my generation, *The Speech Chain* (Denes & Pinson, 1993) is the book that first sparked my fascination with the topic that eventually resulted in The Long Journey of One Short Word. I still have a dog-eared copy of *The Speech Chain* on my bookshelves—an early edition, quite old now, but still a fun, readable account of the basic physics of speech.

A Final Thought: Giving Back

Understanding speech disorders begins with the study of speech—it's nature, how it is perceived and produced, and how it is learned.

This chapter explored the role of speech in human society as well as its functions in communication between people, with oneself, between groups, and across generations. We found that speech has a dual nature and discovered that the lack of meaning in speech elements lets our species create a near infinite number of words, allowing us to enter and describe any new environment. We saw how the miracle of speech production and speech perception transforms a word from electricity, to muscle contractions, to rippling air, to vibrating membranes, to rippling water, and back to electricity again. And in the case of *green*, all within half a second.

These ideas, many developed by investigators in other disciplines, are a foundation of speech disorders. To illustrate, speech disorders are important largely because of the central role of speech in human society, and articulation and phonological disorders reflect the dual nature of speech. The following chapters in Part I, "Foundations," deepen our understanding of speech. The discussion of how a child acquires speech is sufficiently large enough to be a section of its own. The concepts and knowledge in Part II, "Speech Development," form the basis for the assessment and treatment of speech disorders.

Importantly, our profession is both a giver and receiver of speech knowledge. Of all the many fields that study speech—linguistics, psychology, anthropology, neuroscience, medicine, and so forth—ours is the one that uses it to achieve a very special purpose: helping a child learn to talk. Researchers in our field "give back" to the study of speech from the unique perspective of attempting to help a child who may struggle with learning it. Questions studied scientifically within our profession are too diverse to catalog, but some general areas include

- Where is speech in the brain?
- How does a child learn to talk?
- Why do some children have difficulty learning speech?

The questions may give the impression—a false one, I believe—that the scientific study of speech is solely the province of university researchers. Clinicians are researchers as much as academicians, are far more numerous than professors, and conduct research far more often. Their research laboratories include the classroom, the preschool, the retirement home, and hospital bedside. Their daily research questions include, "What aspect of communication should I treat?"; "How can I best assess this communication disorder?"; and "What is the research evidence for the best way to treat this speech error?" Their answers are unique "give backs" to the study of speech, offering a perspective on this complex and fascinating topic that others cannot provide. And the best part is if a clinician answers their questions well, a child improves.

CLIn IC Box: Hunting for Treasure

If you'd like a clinical treasure hunt, see if you can uncover the answers to the following questions by the time you finish the book:

- Why don't you want a neonate in your phonetics class if the instructor is grading on a curve?
- How do you do the bilingual dance?
- Why is a speech sound disorder not an illness and speech treatment not a pill?
- What does doing the wave at a football game have to do with hearing?
- Why is augmentative and alternative communication (AAC) like riding a bike?
- Why won't pumping iron help you learn speech?
- Why do students fall down the wabbit hole?

Suggestion: If you are a student, consider asking for extra credit for answering all the questions by the completion of the course.

Conclusions

These are major points in this chapter:

1. Speech plays a central role in human society, facilitating four types of communication: between persons (talking), with oneself (thinking), between groups (group identity), and between generations (cultural transmission).
2. Speech has a dual nature, being both a part of language and a channel of communication, which is the conceptual basis of the distinction between *phonology* and *articulation*.
3. Our profession contributes to speech research both in our universities and as part of clinical work.

Review Questions

1. What roles does speech play in human culture?
2. What is speech turned inward?
3. Explain the idea of intergenerational communication in your own words.
4. What are the two parts of the dual nature of speech?
5. What is the common characteristic of all speech elements in phonology?
6. Explain in your own words what it means that humanity is the species whose cornerstone of communication means nothing.
7. Approximately how many speech sounds does a person say in one second?
8. What are muscle cells specialized to do?
9. Why is it important to narrow the channel of air from your lungs? Where in the throat does this happen?
10. What is the purpose of having a cauliflower shaped thing on the side of your head?

References

Burgoon, J., Guerrero, L., & Floyd, K. (2011). *Nonverbal communication.* Boston, MA: Allyn & Bacon.

Carroll, D. (2008). *The psychology of language* (5th ed.). Belmont, CA: Tomson Delmar.

Denes, P. B., & Pinson, N. (1993). *The speech chain: The physics and biology of spoken language.* Bell Telephone Laboratores. New York, NY: Williams and Wilkins.

Duranti, A. (2009). *Linguistic anthropology: A reader* (2nd ed.). Oxford, UK: Blackwell.

Ethnologue. (2017). Retrieved from http://www.ethnologue.com

Fillmore, C. (1975). *Santa Cruz lectures on deixis: 1971*. Bloomington, IN: Indiana University Linguistics Club.

Firth, C., & Firth, U. (2005). Theory of mind. *Current Biology*, *17*, 644–645.

Fodor, J. (1993). *The modularity of mind: An essay on faculty psychology*. Boston, MA: The MIT Press.

Gumperz, J. (1972). *Language and social identity.* New York, NY: Cambridge University Press.

Hockett, C. (1960). The origin of speech. *Scientific American*, *203*, 88–111.

Huettig, F., & Harsuiker, R. (2010). Listening to yourself is like listening to others: External, but not internal, verbal self-monitoring is based on speech perception. *Language and Cognitive Processes*, *25*, 347–374.

Hymes, D. (1974). *Foundations in sociolinguistics: An ethnographic approach.* Philadelphia, PA: University of Pennsylvania Press.

Kitto, H. D. F. (1951). *The Greeks*. London, UK: Penguin Books.

Kozulin, A. (1990). *Vygotsky's psychology: A biography of ideas*. Cambridge, MA: Harvard University Press.

Labov, W. (1972). *Language in the inner city: Studies in the black English vernacular*. Philadelphia, PA: University of Pennsylvania Press.

Lazar, S., Bush, G., Gollub, R. Fricchione, G., Khalsa, G., & Benson, H. (2000). Functional brain mapping of the relaxation response and meditation. *Neuroreport*, *15*, 1581–1585.

Ostry, D., & Munhall, K. (1985). Control of rate and duration of speech movements. *Journal of the Acoustical Society of America*, *77*(2), 640–648.

Sacks, O. (1989). *Seeing voices: A journey into the world of the deaf*. Berkeley, CA: University of California Press.

Schmaafsma, S., Pfaff, D., Spunt, R., & Adolphs, R. (2015). Deconstructing and reconstructing theory of mind. *Trends in Cognitive Sciences*, *19*, 65–72.

Smith, N. (1973). *The acquisition of phonology.* Boston,, MA: Cambridge University Press.

Stokoe, W. (2005). Sign language structure: An outline of the visual communication systems of the American deaf. *Journal of Deaf Studies and Deaf Education*, *10*, 3–37.

Trudgill, P. (1995). *Sociolinguistics: An introduction to language and society* (3rd ed.). New York, NY: Penguin.

Wolfram, W. (2004). Social varieties of American English. In E. Finegan & J. R. Rickford (Eds.), *Language in the USA: Themes for the twenty-first century* (pp 58–73). New York, NY: Cambridge University Press.

CHAPTER 2

SPEECH SOUND DISORDERS

This book is about helping people with speech sound disorders. This chapter addresses foundation topics such as:

- What Is a Speech Sound Disorder?
- Why Study Speech Sound Disorders?
- The Nature of Speech Sound Disorders
- Will This Help Someone?

Learning Objectives

I hope on completing the chapter you will

- Know the definition of a speech sound disorder
- Recognize that speech sound disorders may negatively affect people's lives
- Recognize health care disparities around the world
- Appreciate the difference between articulation and phonological disorders
- Understand the need for additional research to support clinical decisions

Key Words

Key words you will encounter in this chapter

Speech sound disorder
Phonological disorder
Articulation disorder
Evidence-based practice (EBP)

What Is a Speech Sound Disorder?

A **speech sound disorder** is a type of speech difference. Of course, not all speech differences are speech problems, nor is every speech problem a speech sound disorder. A dialect, for example, is a speech difference, but not a speech problem, and a laryngeal anomaly may result in significant speech challenges, but those challenges are not a speech sound disorder.

A speech difference must meet three criteria to be a speech sound disorder:

1. The speech disorder arises during childhood and is not directly attributable to damage to the speech mechanism, sensory systems, peripheral nervous system, or central nervous system.
2. The speech is not the result of dialect or accent.
3. The child or members of the child's community consider it a speech problem.

A Little More Detail

1. *The speech disorder arises during childhood and is not directly attributable to damage to the speech mechanism, sensory systems, peripheral nervous system, or central nervous system.*
   Explanation: Speech sound disorders are different from speech problems arising directly from physical difficulties such as cranial nerve damage, unrepaired cleft palate, laryngeal anomalies, dysarthria, or difficulties in respiratory control. Of course, children with such physical difficulties may also have a speech sound disorder in addition to other speech problems.

2. *The speech is not the result of dialect or accent.*
   Explanation: Speech sound disorders differ from speech variations attributable to dialect and accent. While a speech sound disorder is a learning difficulty, dialect arises from normal language variation and accent represents a learning accomplishment.

3. *The child or members of the child's community consider it a speech problem.*
   Explanation: Individuals, communities, cultures, and ethnic groups may differ both in what they identify as disordered and in what they assign as a priority to remediate. That is, we are not "speech police" who decide for a person or a community what is and is not a speech sound disorder (McCormack, McLeod, McAllister & Harrison, 2010; Taylor & Peters-Johnson, 1986).

Why Study Speech Sound Disorders?

The first chapter discussed the central role of speech in human society. The implication is that speech disorders matter because they interfere with those essential cultural functions. While true, this is not why most of us assess and treat speech sound disorders. What motivates us is that such disorders negatively affect people's lives.

CLIn IC Box: Did You Know?

Within the United States, federal laws provide an overarching legal umbrella to protect children with communication disorders, but access and eligibility for services vary by state and health insurer . As a result, on one side of a state border a child may be diagnosed with a speech sound disorder (and be eligible for treatment), but, if the family drives over the state line or changes health insurance, the child may suddenly be deemed not to have a problem and be ineligible for services.

Children's Lives

No matter where you go in the world, nearly everyone understands that to lead a rich and full life a child needs to communicate. Speech typically is the preferred form of communication, because it allows a person to live most widely in their community. A family in a developing country residing under a tin roof in a dirt-floor shack, cooking from a smoky wood-burning fire, understands this as clearly as a wealthy family in a luxury penthouse in Manhattan, Dubai, or Singapore (Bleile, 2009).

The following five examples of real children provide a "close up" of the many ways a problem in speech may impact a person's life.

Jose

Jose's mother immigrated to the United States from Latin America as a young woman, seeking a better life for herself while sending money home to her family. She found work in restaurants, married, had a son (Jose), divorced, and afterward lived with her son.

Jose grew to be a teenager with a mild to moderate speech disorder affecting **[l]**, **[s]**, and **[r]**. Because he believed his speech kept girls from going out with him, Jose enrolled in his school's speech treatment program, where he worked hard and had good attendance, except when treatment conflicted with his great passion—playing basketball on the school team.

One summer night when Jose was 15, police raided the restaurant where Jose's mother worked. Jose's mother was in the country illegally and the court began deportation proceedings. Returning to her home country would place them with her family, who lived in a rural area where unemployment was over 90%, electricity was intermittent, and health and education facilities were almost nonexistent. She wondered, *in such a place what will become of my son who sounds so different than his friends?*

Joni

Joni was 5 when she started kindergarten. She was a bright child with a minor speech difficulty that changed "y" into "l" in words such as *yesterday*, which she said as *lesterday*. On the first day of kindergarten, Joni made several new friends. On the second day, as Joni approached her new friends, one said, "Look, it's the *lesterday* girl." Joni felt crushed.

Margaret

Margaret was 5 years old and she had severe cerebral palsy and intellectual impairments. She lived in a developing country with her mother in a dirt floor home. Margaret's mother supported the family by selling trinkets and cigarettes on the street, typically earning less than a dollar a day, often less than twenty dollars monthly.

The most important thing in the world to Margaret's mother was her daughter. For that reason, when she heard that a clinic in the neighborhood provided evaluation services to children with communication disorders, she carried Margaret in her arms to the clinic. Her question to the evaluators was, "Will Margaret ever speak?"

Martin

Martin was 2 years old and spoke four to five different words. The children of his mother's friends spoke several hundred different words at that age, and their pronunciations were much clearer.

At the end of a diagnostic session with a speech-language pathologist, the clinician explained that Martin had something called an expressive language disorder, and that he had a 50% chance of catching up to his peers by the time he was 3 years old (Paul, 1991). However, if he did not catch up, Martin was at risk for speech and language disorders during the preschool years and, possibly, for reading and language difficulties in school (Rice, Taylor, & Zubrick, 2008).

From the parents' perspective, if treatment might reduce the chance of a future speech, language, and reading problems, they were all in for treatment. However, their health insurer denied coverage, explaining, "Why provide speech services when Martin has a 50% chance of recovery without receiving any services at all?"

CLIn IC Box: An Uneven Playing Field

The world is an uneven playing field for a person with a disability, including one in speech (World Report on Disability, 2011). To illustrate, in the world's poorer regions, a family in poverty may only be able to afford to send those children with "the best potential" to school (World Report on Disability, 2011). A child with a communication disorder, even one as mild as pronouncing a few late acquired sounds, is not typically one judged to possess "the best potential." Worldwide, 100 million children remain out of primary school, almost 60% of them girls (World Bank Group, 2005).

Many people around the world believe disability is a stigma created as a punishment from God or from a curse from someone who possesses supernatural powers (Human Rights Watch, 2010). If a culture associates disability with shame or believes it results from God's punishment or a shaman's curse, it is more likely to shut away a child with a communication disorder than to develop laws that mandate clinical services.

Andrea

Andrea's mother consumed narcotics heavily during her pregnancy, and Andrea was born addicted to crack cocaine. Drug withdrawal for Andrea began at birth. The hospital's social worker recommended Andrea immediately begin to receive developmental services, including those for communication.

The Big Picture in Nine Statistics

The children in the previous examples—Jose, Joni, Margaret, Martin, and Andrea—offer a close-up view of speech sound disorders. The following nine statistics provide "the big picture":

1. A speech sound disorder is the world's most common type of communication disorder, affecting approximately 10% to 15% of preschoolers and 6% of students (American Speech-Language-Hearing Association, 2006; Campbell et al., 2003; Law, Boyle, Harris, Harkness, & Nye, 2000; Shriberg & Tomblin, 1999; Slater, 1992).

   What This May Mean: If you choose to work in pediatric settings, expect your caseload to include many children with speech sound disorders.

2. Speech sound disorders are sufficiently severe that nearly four out of five children require treatment (Gierut, 1998).

   What This May Mean: Don't expect most children with speech sound disorders to "get over it" without professional assistance.

3. At least three quarters of preschoolers with speech sound disorders also have language difficulties (Paul & Shriberg, 1982; Ruscello, St. Louis, & Mason, 1991; Shriberg & Kwiatkowski, 1988).

   What This May Mean: Most preschoolers you see for speech sound disorders also need your help in language.

4. A toddler or a preschooler with a speech sound disorder is at increased risk for later academic difficulties during the school years (Anthony et al., 2011; Bird, Bishop, & Freeman, 1995; Felsenfeld, Broen, & McGue, 1994; Shriberg and Kwiatkowski, 1982; Shriberg et al., 2005; Van Dyke & Holte, 2003).

   What This May Mean: Consider a speech sound disorder in a preschooler to be a red flag for possible future academic difficulties.

5. Preschoolers with speech sound disorders have a higher risk for school challenges if they also have language problems, lower nonverbal intelligence, and social disadvantages (Lewis et al., 2015).

   What This May Mean: Your clinical alarm bells for future school challenges should go off loudly if a preschooler with a speech sound disorder also has either language problems, lower nonverbal intelligence, or comes from a deeply impoverished or neglectful environment.

6. Approximately 11% to 15% of 6-year-old students with speech sound disorders also experience specific language impairment (Shriberg & Tomblin, 1999).

   What This May Mean: Evaluate language along with speech, because a first grader referred to you for speech may also have language difficulties.

7. Half or more of students with speech sound disorders struggle academically all the way through high school (Felsenfeld et al., 1994; Gierut, 1998; Lewis, Freebairn, & Taylor, 2000; Pennington & Bishop, 2009; Shriberg & Austin, 1998).

   What This May Mean: Plan that your students with speech sound disorders will probably need academic assistance throughout school to reach their best potential.

8. Even when a student with reduced intelligibility does well in school, one third of grade school teachers perceive them as having less overall academic potential than their classmates (Overby, Carrell, & Bernthal, 2007).

   What This May Mean: The self-image of your student may be "bruised" by the fact that many people falsely believe that their speech difficulties reflect "lack of intelligence."

9. A student with a speech sound disorder is at risk for being bullied, struggling with friendships, and enjoying school less (McCormack, Harrison, McLeod, & McAllister, 2011).

   What This May Mean: Keep your eyes open to the possibility that your student with a speech sound disorder is being ostracized, is socially isolated, or is being bullied.

The Nature of Speech Sound Disorders

Reflecting the nature of speech, speech sound disorders have a dual nature. Persons with **phonological disorders** have knowledge-based difficulties with language rules that underlie speech, while persons with **articulation disorders** have difficulty producing speech. To illustrate, a child with a phonological disorder might not know that **[st]** is a possible word initial consonant cluster (as in *stop*), whereas a child with an articulation disorder have difficulty shaping the articulators to pronounce **[st]**.

The conceptual distinction between knowing (phonology) and doing (speaking/articulation) is important because it suggests that seemingly similar difficulties may result from different causes. Possibly, a child with phonological problems may also show difficulties learning other aspects of language, including syntax and reading, while a child whose problem involves more "doing" than "knowing" may have difficulties restricted to pronunciation.

Which Matters Most?

Dodd and McIntosh (2010) assessed the relative contributions of phonology and articulation to speech production. The subjects were 62 two-year-old children who were developing typically. The researchers assessed children in articulation (oral motor skills,

speech perception abilities) and phonology (rule abstraction abilities). The researchers then measured the accuracy of their spoken words. The researchers discovered that phonological ability and articulation ability both contributed to speech accuracy, but that the greatest contribution came from a child's phonological abilities.

A Long Discussion

The Dodd & McIntosh study (2010) is part of a long 70-year discussion within the profession regarding the nature of speech disorders.

Articulation Pioneers

The pioneers of our profession largely believed that speech problems arose because a person could not configure the mouth appropriately to produce speech sounds. This idea was reasonable at that time because the primary candidates for treatment were students with good cognition who had pronunciation problems affecting individual late acquired sounds containing notoriously difficult tongue configurations.

The Rise of the Phonologists

Articulation approaches, which dominated the care of speech disorders for two-thirds of the 20th century, began to lose their appeal for many clinicians in the 1970s. The reason was that the primary tenets of articulation treatment (emphasis on individual sounds, phonetic drills, treatment of sounds in isolation and in nonsense syllables, improvements in small increments of change) proved far less successful with newer populations just appearing on the clinical horizon, many of whom were preschoolers with speech problems affecting sound classes. Phonological approaches gained popularity largely because focusing on speech as an aspect of language offered a means to treat newer, more involved populations.

The Present Compromise

Here is a question you may have already asked yourself: what if you do not know if a speech problem arises from a problem with knowledge or doing? Or, what if you suspect that a speech problem arises from difficulties in both phonology *and* articulation? Or, what if you do not really care how a speech problem arises?

In all these situations, you may want a cover term that does not commit you to saying where a problem arises. The name of the cover term you are seeking is speech sound disorder. Though the term seems somewhat dull, it has gained currency in the profession because it is neutral to the disorder's cause (Bowen, 2009; Williams, 2010). In the future, speech sound disorder may develop its own theoretical baggage, but for the present time it seems useful. Some authors, noting that children with speech sound disorders often speak similarly to younger children without speech problems, prefer to use the term delay rather than disorder (Curtiss, Katz, & Tallal, 1992).

CLIn IC Box: Other Terms, Similar Meanings

Disorders of articulation and phonology go by an impressive number of different names, including

- articulation disorder (for both articulation and phonological disorders);
- phonological disorder (for both articulation and phonological disorders);
- developmental ___ (speech, articulation, or phonology) disorder;
- functional speech disorder;
- phonomotor disorder;
- speech disorder;
- functional articulation disorder; and
- idiopathic speech disorder.

Studies: Bauman-Waengler, 2000; Bernhardt & Stemberger, 1998; Bernthal, Bankson, & Flipsen, 2009; Creaghead, Newman, & Secord, 1989; Fey, 1992; Hodson, 1994; Hoffman, Schuckers, & Daniloff, 1989; Locke, 1983; Lowe, 1994; Rvachew & Brosseau-Lapre, 2017; Shelton & McReynolds, 1979; Shriberg & Kwiatkowski, 1982; Smit, 2003; Weiss, Gordon, & Lillywhite, 1987; Williams, 2003; Winitz, 1984.

The Future?

Though articulation and phonology are the dominant perspectives in our profession, they are not necessary ways to consider speech sound disorders. In fact, established ideas have a bad tendency to become blinders, blocking newer perspectives from taking hold. For example, as we learn more about the workings of the brain, perhaps speech treatment will add neurological viewpoints. Or, as we learn more about cognition, perhaps clinicians will say, in effect, "Why describe speech sound disorders in terms of articulation and phonology? Scrap them both. What matters is memory, representation, speech planning, execution, and feedback" (Anthony et al., 2011). Alternately, perhaps a more social perspective will arise and clinicians will say, "No, no: while articulation, phonology, neurology, and cognition matter, what matters most in speech learning is social relations."

My own vote for the future is all the above. One perspective does not preclude insights from other viewpoints. For example, social psychology may offer insights about the social nature of learning, while neurology may help explain how the brain makes speech possible. I suspect the best ideas probably are those we haven't thought of yet. Perhaps the only certain thing about the future study of speech and its disorders is that humans will remain too complex and diverse to fit entirely into the box of any single theoretical framework.

Will This Help Someone?

Most students who study speech sound disorders want to know if learning this will help someone.

CLIn IC Box: Would a Pill Help?

It's tempting to think of a speech sound disorder as an illness and speech treatment as a pill. To illustrate, within the pill perspective you might diagnose a child with an articulation problem and then give an articulation approach pill to correct the condition. The trouble is the analogy becomes stretched very fast. Illnesses tend to be recognized as such regardless of where they occur, while a speech characteristic may be considered a disorder in one community and a normal speech variation in another. As for speech treatment being a pill, a child with an articulation problem may not respond to an articulation approach, but may improve through language activities, or because they want to impress the clinician (or maybe a girl/boy), or they may feel ready to work on speech issues. Perhaps the lesson is that the avenue you follow to helping a child often entails far greater creativity and insight than administering an articulation or phonology pill.

The Short Answer

The short answer: yes. Literally hundreds of studies document the positive effects of speech treatment (Baker & McLeod, 2011). Knowledge of speech sound disorders can help you

- promote vocal development in an infant with medical needs;
- assist a toddler with a developmental disability learn to speak;
- lead a preschooler to unravel the mysteries of speaking in sentences;
- support a student to succeed socially and academically; and
- help persons without communication disorders to learn English as a second language.

A Slightly Less Short Answer

A slightly less short answer: everyone recognizes the need for additional and more rigorous research to support clinical decisions. **Evidence-based practice (EBP)** (the use of research evidence to guide clinical practice) is a major goal of the clinicians in our profession (Apel & Self, 2003).

You may wonder why this area needs more research support. One reason is the subject matter: speaking is astonishingly complex and the people who have speech disorders are far more complex than their speech, and both variables—speech and person—combine in successful treatment. With such complexity, the more we learn about speech and about speech learners, the more our treatments change and the more we need new research to support our work.

Another reason is that the study of speech sound disorders changes in response to evolution of culture, health care, and education. Just a few of the many possible illustrations:

- **Preschoolers:** Forty years ago, the profession debated—sometimes furiously—whether preschoolers should receive treatment for speech sound disorders. The logic was let kids be kids and wait until they reached school to begin treatment. Today, preschoolers regularly receive speech services, and some ask, why not infants and toddlers as well? (Claessen et al., 2016; Williams & Stoel-Gammon, 2016)
- **Diversity:** The world—and our caseloads—are increasingly diverse. To paraphrase a leader in the field: today, if you want to work internationally, just open your front door (Battle, 2012). These welcome cultural changes challenge us to improve our knowledge base and clinical skills.
- **Relooking at students:** Our profession sometimes relooks at familiar populations. Students from kindergarten through high school have been a mainstay of clinicians for so long that you would think there was nothing left to research (American Speech-Language-Hearing Association, 2006, 2010; Shewan, 1988). Then came inclusion of speech as part of a school's curriculum, causing clinicians to rethink basic ways to treat speech sound disorders (Farquharson, 2015; Nathan, Stackhouse, Goulandris, & Snowling, 2004).

In summary, we know a great deal about how to help a child learn to talk, but you can expect the field to change as new theories of speech and human behavior appear and as society changes. Why go through all the effort to learn this topic and to keep updated? Probably everyone who studies speech sound disorders would answer this question differently. My own answer is speech is a fascinating topic and helping a child to communicate is a wonderful use for speech knowledge.

Conclusions

These are the major ideas in this chapter

1. Speech disorders matter because they may negatively affect a person's life.
2. Persons with a speech sound disorder may also have difficulties in school, social relations, and employment.
3. Articulation and phonological disorders reflect the dual nature of speech.
4. Speech sound disorder is a widely accepted cover term for articulation and phonological disorders.
5. Help exists for a person with a speech sound disorder.

Review Questions

1. What are the reasons for the second and third parts of the definition of a speech sound disorder?
2. Do (or did) you know anyone with a speech sound disorder or other type of communication disorder? How does (or did) it affect them?

3. In the example about Andrea, why do you think the social worker recommended developmental services so soon after birth? Why didn't she wait for a developmental problem to arise before making her recommendation?
4. What are the names of the two speech disorders that reflect the dual nature of speech?
5. Why did the pioneers of our profession gravitate toward articulation perspectives?
6. How did treatment of preschoolers lead to the rise of phonological perspectives?
7. What is the name of the cover term for articulation and phonological disorders?

References

American Speech-Language-Hearing Association. (2006). *2006 schools survey report: Caseload characteristics*. Rockville, MD: Author.

American Speech-Language-Hearing Association. (2010). *2010 schools summary report: Number and type of responses, SLPs.* Rockville, MD: Author.

Anthony, J. L., Aghara, R. G., Dunkelberger, M. J, Anthony, T. I., Williams, T. I., & Zhang, Z. (2011). What factors place children with speech sound disorders at risk for reading problems? *American Journal of Speech-Language Pathology*, *20*(2), 146–160.

Apel, K., & Self, T. (2003). Evidence-based practice: The marriage of research and clinical services. *ASHA Leader*, *8*, 6-7.

Baker, E., & McLeod, S. (2011). Evidence-based practice for children with speech sound disorders: Part 1 narrative review. *Language, Speech, and Hearing Services in Schools*, *42*, 102–139.

Battle, D. (2012). *Communication disorders in multicultural and international populations*. St. Louis, MO: Elsevier.

Bauman-Waengler, J. (2000). *Articulatory and phonological impairments: A clinical focus*. Boston, MA: Allyn and Bacon.

Bernhardt, B., & Stemberger, J. (1998). *Handbook of phonological development from the perspective of constraint-based nonlinear phonology*. San Diego, CA: Academic Press.

Bernthal, J., Bankson, N., & Flipsen, P. (Eds.). (2009). *Articulation and phonological disorders: Speech sound disorders in children* (5th ed.). Boston, MA: Allyn & Bacon.

Bird, J., Bishop, D., & Freeman, N. (1995). Phonological awareness and literacy development in children with expressive phonological impairments. *Journal of Speech and Hearing Research*, *38*, 446–462.

Bleile, K. (2009). A Nicaraguan experience. In C. Bowen (Ed.), *Children's speech sound disorders*. (pp. 157–160). Oxford, UK: Wiley-Blackwell.

Bowen, C. (2009). *Children's speech sound disorders*. Oxford, UK: Wiley-Blackwell.

Campbell, T., Dollaghan, C., Rockette, H., Paradise, J., Feldman, H., Shriberg, L., . . . Kurs-Lasky, M. (2003). Risk factors for speech delay of unknown origin in 3-year-old children. *Child Development*, *74*(2), 346–357.

Claessen, M., Beattie, T., Roberts, R., Leitao, S., Whitworth, A., & Dodd, B. (2017). Is two too early? Assessing toddlers' phonology. *Speech, Language and Hearing*, *20*(2), 91–101.

Creaghead, N., Newman, P., & Secord, W. (1989). *Assessment and remediation of articulatory and phonological disorders*. Columbus, OH: Charles E. Merrill.

Curtiss, S., Katz, W., & Tallal, P. (1992). Delay versus deviance in the language acquisition of language-impaired children. *Journal of Speech and Hearing Research*, *35*, 373–383.

Dodd, B., & McIntosh, B. (2010). Two-year-old phonology: Impact of input, motor and cognitive abilities on development. *Journal of Child Language*, *37*(5), 1027–1046.

Farquharson, K. (2015). After dismissal: Examining the language, literacy, and cognitive skills of children with remediated speech sound disorders. *Perspectives in School Based Issues*, *16*(2), 50–59.

Felsenfeld, S., Broen, P., & McGue, M. (1994). A 28-year follow-up of adults with a history of moderate phonological disorder: Educational and functional results. *Journal of Speech and Hearing Research*, *37*(6), 1341–1353.

Fey, M. (1992). Articulation and phonology: Inextricable constructs in speech pathology. *Language, Speech, and Hearing Services in Schools*, *23*, 225–232.

Gierut, J. A. (1998). Treatment efficacy: Functional phonological disorders in children. *Journal of Speech, Language, and Hearing Research*, *41*, S85–S100.

Hodson, B. (1994). Foreword. *Topics in Language Disorders*, *14*, vi–viii.

Hoffman, P., Schuckers, G., & Daniloff, R. (1989). *Children's phonetic disorders: Theory and treatment*. Boston, MA: Little, Brown.

Human Rights Watch. (2010). *"As if we weren't human:" Discrimination and violence against women with disabilities in northern Uganda.* New York, NY: Author.

Law, J., Boyle, J., Harris, F., Harkness, A., & Nye, C. (2000). Prevalence and natural history of primary speech and language delay: Findings from a systematic review of the literature. *International Journal of Language and Communication Disorders*, *35*(2), 165–188.

Lewis, B., Freebairn, L., Tag, J., Ciesla, A., Iyengar, S., Stein, C., & Taylor, H. (2015). Adolescent outcomes of children with early speech sound disorders with and without language impairment. *American Journal of Speech Language Pathology*, *24*, 150–163.

Lewis, B., Freebairn, L., & Taylor, H. (2000). Academic outcomes in children with histories of speech sound disorders. *Journal of Communication Disorders*, *33*, 11–30.

Locke, J. (1983). Clinical phonology: The explanation and treatment of speech sound disorders. *Journal of Speech and Hearing Disorders*, *48*, 339–341.

Lowe, R. (1994). *Phonology: Assessment and intervention applications*. Baltimore, MD: Williams & Wilkins.

McCormack, J., Harrison, L., McLeod, S., & McAllister, L. (2011). A nationally representative study of the association between communication impairment at 4–5 years and children's life activities at 7–9 years. *Journal of Speech, Language, and Hearing Research*, *54*, 1328–1348.

McCormack, J., McLeod, S., McAllister, L., & Harrison, L. J. (2010). My speech problem, your listening problem, and my frustration: The experience of living with childhood speech impairment. *Language, Speech, and Hearing Services in Schools*, *41*(4), 379–392.

Nathan, L., Stackhouse, J., Goulandris, N., & Snowling, M. J. (2004). Educational consequences of developmental speech disorder: Key Stage 1 National Curriculum assessment results in English and mathematics. *British Journal of Educational Psychology*, *74*, 173-186.

Overby, M., Carrell, T., & Bernthal, J. (2007). Teachers' perceptions of students of students with speech sound disorders: A quantitative and qualitative analysis. *Language, Speech, and Hearing in the Schools*, *38*(4), 327–341.

Paul, R. (1991). Profiles of toddlers with slow expressive language. *Topics in Language Disorders*, *11*, 1–13.

Paul, R., & Shriberg, L. (1982). Associations between phonology and syntax in speech-delayed children. *Journal of Speech and Hearing Research*, *25*, 536–547.

Pennington, B., & Bishop, D. (2009). Relations among speech, language, and reading disorders. *Annual Review of Psychology*, *60*, 283–306.

Rice, M. L., Taylor, C. L., & Zubrick, S. R. (2008). Language outcomes of 7-year-old children with or without a history of late language emergence at 24 months. *Journal of Speech, Language and Hearing Research*, *51*, 394–407.

Ruscello, D. M., St. Louis, K., & Mason, N. (1991). School-aged children with phonologic disorders: Coexistence with other speech/language disorders. *Journal of Speech and Hearing Research*, *34*, 236–242.

Rvachew, S., & Brosseau-Lapre, F. (2017). *Developmental phonological disorders* (2nd ed.). San Diego, CA: Plural.

Shelton, R., & McReynolds, L. (1979). Functional articulation disorders: Preliminaries to treatment. In N. Lass (Ed.), *Introduction to communication disorders* (pp. 263–310). Englewood Cliffs, NJ: Prentice-Hall.

Shewan, C. (1988). 1988 omnibus survey: Adaptation and progress in times of change. *Asha*, *30*, 27–30.

Shriberg, L., & Kwiatkowski, J. (1982). Phonological disorders III: A procedure for assessing severity of involvement. *Journal of Speech and Hearing Disorders*, *47*, 256–270.

Shriberg, L., & Kwiatkowski, J. (1988). A follow-up study of children with phonologic disorders of unknown origin. *Journal of Speech and Hearing Disorders*, *53*, 144–155.

Shriberg, L., & Tomblin, B. (1999). Prevalence of speech delay in 6-year-old children and comorbidity with language impairment. *Journal of Speech, Language, and Hearing Research*, *42*, 1461–1481.

Shriberg, L. D., & Austin, D. (1998). Co-morbidity of speech-language disorder: Implications for a phenotype marker of speech delay. In R. Paul (Ed.), *The speech-language connection* (pp. 73–117). Baltimore, MD: Paul H. Brookes.

Shriberg, L. D., Lewis, B. A., Tomblin, J. B., McSweeny, J. L., Karlsson, H. B., & Scheer, A. R. (2005). Toward diagnostic and phenotype markers for genetically transmitted speech delay. *Journal of Speech, Language, and Hearing Research*, *48*(4), 834–852.

Slater, S. (1992). Portrait of the professions. *Asha*, *34*, 61–65.

Smit, A. (2003). *Articulation and phonology resource guide for school-age children and adults*. New York, NY: Thomson Delmar Learning.

Taylor, O. L., & Peters-Johnson, C. A. (1986). Speech, language, and hearing disorders in Black populations. In O. L. Taylor, *Nature of communication disorders in culturally and linguistically diverse populations.* San Diego, CA: College-Hill Press.

Van Dyke, D. C., & Holte, L. (2003). Communication disorders in children. *Pediatric Annals*, *32*(7), 436–437.

Weiss, C., Gordon, M., & Lillywhite, H. (1987). *Clinical management of articulatory and phonologic disorders*. Baltimore, MD: Williams & Wilkins.

Williams, A. (2010). Multiple oppositions intervention. In A. Williams, S. McLeod & R. McCauley (Eds.), *Interventions for speech sound disorders in children* (pp. 73–94). Baltimore, MA: Brookes.

Williams, L. (2003). *Speech disorders resource guide for preschool children*. New York, NY: Thomson Delmar Learning.

Williams, L., & Stoel-Gammon, C. (2016, November). *Identification of speech sound disorders in toddlers*. Seminar session presented at the Annual Convention of the American Speech-Language-Hearing Association, Philadelphia, PA.

Winitz, H. (1984). *Treating articulation disorders*. Baltimore, MD: University Park Press.

World Bank Group. (2005). Retrieved from http://www.worldbank.org

World Report on Disability. (2011). Retrieved from http://www.who.int/disabilities/world_report/en/index

CHAPTER 3

SPEECH PRODUCTION

Todd A. Bohnenkamp

The journey of speech begins in the brain and then arrives in the muscles, which move, channel, and shape air to create sound. This chapter introduces the systems involved in speech production. The nervous system is responsible for high-level functioning as well as the activation and monitoring of the speech production systems. The respiratory system provides the driving force for phonation, which downstream allows articulators to shape sounds for communication. Topics in this chapter include:

- Speech in the Brain
- Speech in the Muscles

Learning Objectives

I hope on completing the chapter you will

- Appreciate the complicated nature of neural control of speech production
- Explain how speakers manipulate the respiratory system to produce speech
- Describe the difference between phonation and speech
- Explain the difference between articulator function for chewing and swallowing and for speech

Key Words

Key words you will encounter in this chapter

Neurons
Action potential
Motor neurons
Sensory neurons
Interneurons
Glial cells
Cell body
Grey matter
Dendrites
White matter
Axons
Neurotransmitters
Synapse
Myelin
Central nervous system
Peripheral nervous system
Corpus callosum
Cortex
Lobes
Broca's area
Primary motor cortex
Wernicke's area
Basal ganglia
Thalamus
Cerebellum
Brain stem
Lower respiratory system
Alveoli
Pleural linkage
Larynx
Phonation
Epiglottis
Vestibular (false) vocal folds
True vocal folds
Glottis
Adduction
Abduction
Bernoulli Effect
Lamina propria
Frequency
Pitch
Speech articulation
Mandible
Tongue
Soft palate (velum)
Velopharyngeal port
Hypernasal
Hyponasal
Hard palate (maxilla)
Upper jaw (palatine bone)

Speech in the Brain

Speech begins in the brain as an electrochemical event. Our discussion begins with the neuron before going on to gross anatomy.

Neurons

Your **neurons** are specialized nerve cells that transmit information through an electrochemical process (**action potential**). Neurons are the basic structure within the neural system. Your brain contains approximately 100 billion neurons (Herculano-Houzel, 2009); there are three basic categories: motor, sensory, and interneurons.

Motor Neurons

Motor neurons bring efferent information out to the body from the brain and spinal cord (central nervous system; CNS) and the spinal cord and cranial nerves (peripheral nervous system; PNS).

Sensory Neurons

Sensory neurons bring sensation from the receptors within the PNS and body into the central nervous system.

Interneurons

Interneurons filter and fine-tune the efferent and afferent information. They greatly outnumber motor and sensory neurons.

Components of Neurons

Although neurons are present in many shapes and sizes, they each have the same core components: cell body, dendrites, axon, and axon terminals (called telodendria). In addition, support cells within the nervous system, or **glial cells**, are responsible for cellular health, maintaining the blood brain barrier, and carrying away metabolic by-products.

Cell Bodies

Each neuron has a **cell body** that is responsible for basic cellular functions. The cell bodies compose the **grey matter** within the nervous system. Large groups of cell bodies are often part of a functionally similar, larger functional system.

Dendrites

These structures are branchlike projections specific to neurons that communicate with the cell body and axons. **Dendrites** are necessary for communication with other neurons through the electrochemical communication of the action potential.

Axons

White matter is a collection of large numbers of **axons**, which are responsible for transmitting impulses throughout the central nervous system. Each neurons has a singular axon that eventually communicates with other neurons via numerous axon terminals (telodendria).

Communication between Neurons

Communication between neurons is dependent upon the release of **neurotransmitters** across the junction between the neurons (**synapse**). Neurotransmitters release from the terminal end buttons and bind on the postsynaptic neuron. The response of the postsynaptic neuron is dependent upon whether the neurotransmitter is excitatory or inhibitory in nature. An excitatory neurotransmitter results in an action potential in the postsynaptic neuron, whereas an inhibitory neurotransmitter will make it less likely to produce an action potential in the postsynaptic neuron. The speed of the electrical current of the action potential accelerates when a **myelin** sheath surrounds the neuronal axon, which also protects and insulates the axon.

Gross Anatomy

Your **central nervous system** (CNS) consists of your brain and spinal cord at its basic level, whereas **the peripheral nervous system** (PNS) consists of the cranial nerves (numbered I–XII) and spinal nerves (31 pairs). Your CNS has a left and right cerebral hemisphere, cerebellum, brain stem, and spinal cord. Meningeal linings surround your two cerebral hemispheres and are there to protect your brain. They are arranged in three levels, from deep (closest to the brain) to superficial (closest to the skin). Cerebrospinal fluid and blood supply run through these layers to nourish and protect the brain and CNS.

Functions of Hemispheres

The functions of your cerebral hemispheres vary considerably. The two hemispheres communicate via commissural fibers called the **corpus callosum**.

Left Hemisphere

Your left hemisphere is responsible for speech, language, sequencing, planning, mathematics, and integration as well as providing cortical control of innervating the spinal nerves to control the right side of the body.

Right Hemisphere

Your right hemisphere is the location for prosody, music, visuospatial recognition (including facial recognition), and creativity as well as controlling the left side of the body.

Cortex

The **cortex** is a 2 to 4 mm thick layer of cells that covers the cerebral hemispheres. Your cortex is the location of the highest-level functions of your brain, including reasoning, executive functioning, voluntary control of structures, memory, vision, hearing, and language and speech production. The cortex of each hemisphere divides into four functional areas called **lobes**.

Frontal Lobe

The largest lobe is the frontal lobe, with a cortical area that composes approximately a third of your entire cortex. It is the location for major cognitive functions, personality, motivation, inhibition, language production, speech production, motor programming, motor sequencing, and executive functioning.

Speech Functions. Speech-related functions in the frontal lobe include planning, sequencing, and motivation prior to the initiation of speech. Cortical locations important for voluntary speech in the frontal lobe include your premotor area, supplementary motor area, and the expressive language center oftentimes referred to as **Broca's area**. Your frontal lobe also contains the **primary motor cortex**, which is responsible for voluntary movement. As you would expect, this is an essential location for speech production.

Parietal, Temporal, and Occipital Lobes

The parietal, temporal, and occipital lobes are instrumental in integrating sensory information for both speech production and perception.

Parietal Lobe. The parietal lobe is the primary cortical area for sensory information, memory, cognition, and perception.

Temporal Lobe. The temporal lobe is an essential component in speech and language production—codifying language, making memories, and integrating with visual input. Language comprehension is located at the juncture of the temporal and parietal lobes at **Wernicke's area**. The lateral surface of the temporal lobe is the location for the primary auditory cortex, responsible for hearing and frequency representation. Connections to your hippocampus, which are essential for converting short-term to long-term memory, are in the temporal lobe.

Occipital Lobe. Your occipital lobe is responsible for visual input and integration of visual material, and contributes to speech and language development.

Subcortical Structures

Your subcortical structures are essential for communication between brain structures and monitoring of background activities. Interaction of the basal ganglia, thalamus, and

cerebellum results in fine-tuning of planned voluntary motor movements based on results of previous activity. These structures work together to serve as the quality control system for your CNS.

Basal Ganglia

The **basal ganglia** of your subcortex are responsible for graceful motor movement, essentially functioning as a "filter" that eliminates unwanted voluntary movements and suppresses involuntary movements. A disruption in the basal ganglia can result in disruption to motor control. An example of a motor plan that is "over-filtered," would be Parkinson's disease, whereas Huntington's chorea would be an example of "under-filtering."

Thalamus

The structures of the basal ganglia are part of a larger and complex circuit that includes the cortex and thalamus. Your **thalamus** integrates motor activity with sensory feedback. It receives sensory feedback, particularly the results of previous motor movements, and relays that information to the corresponding portion of the cortex.

Cerebellum

The **cerebellum**, or "little brain," shares information with the thalamus and CNS regarding the location of structures in space (proprioception), the speed or sensation of movement (kinesthesia), and predicting the location of structures as they move (Pellionisz & Llinás, 1979).

Brain Stem

Your **brain stem** is a hub of autonomic involuntary control and integrates with large amounts of efferent and afferent information communicating through the CNS to the PNS. Your brain stem contains large numbers of cell bodies in a structure called the reticular formation, which is responsible for basic life functions such as respiration, digestion, and maintenance of homeostasis.

Cranial Nerves

Your corticobulbar (cranial nerves) and corticospinal (spinal nerves) tracts provide CNS control of the cranial nerves and spinal nerves within the PNS. These tracts decussate, or cross the midline, within the brain stem for contralateral control of the body. Corticobulbar fibers innervate the cell nuclei for 10 of the 12 cranial nerves, whereas corticospinal tract fibers continue to the spinal cord. A short description of each of your cranial nerves and its function in speech production appears in Table 3–1.

Table 3–1. Cranial Nerves

Cranial nerve	Category	General Function(s)
I Olfactory	Sensory	Smell
II Optic	Sensory	Vision
III Oculomotor	Motor	Medial eye movement
IV Trochlear	Motor	Eye movement
V Trigeminal	Mixed	*M*—Muscles for chewing *S*—Sensory from face, touch from anterior tongue
VI Abducens	Motor	Lateral eye movement
VII Facial	Mixed	*M*—Muscles of the face *S*—Taste from anterior tongue
VIII Vestibulocochlear	Mixed	*M*—Damping of hair cells in cochlea *S*—Hearing and balance
IX Glossopharyngeal	Mixed	*M*—Elevates pharynx *S*—Touch and taste posterior tongue
X Vagus	Mixed	*M*—Larynx and pharynx, velum *S*—Larynx and pharynx, velum
XI Spinal Accessory	Motor	Move head, lift shoulders
XII Hypoglossal	Motor	Tongue movement

Speech in the Muscles

Speech next becomes the movement of muscles. Whereas brain cells are specialized to carry nervous system impulses, muscle cells are specialized to contract. Muscle contractions function to move, channel, and shape air for speech. Speech breathing requires you to make quick inspirations followed by controlled expirations while reducing the number and duration of interruptions to balance gas exchange. This section describes the lower respiratory system, larynx, and speech articulators.

Your **lower respiratory system** within the rib cage includes the lungs, the soft tissues of the trachea, sections of bronchi and smaller airways, and **alveoli**. The alveoli are air sacs within the lung and the location of oxygen and carbon dioxide gas exchange. We use this system to provide the driving pressures for voice and speech via manipulation of the lungs by the inspiratory and expiratory muscles.

Inspiration and expiration are possible because of the interaction of the inherent properties of the rib cage and lungs. Your rib cage, if allowed, would open and move

outward if not connected at the sternum, which places the ribs under constant tension. In contrast, your lung tissue would move inward or collapse due to the elasticity of the soft tissues. These forces create a constant negative pressure between the lungs and rib cage resulting in a system that moves in unison. This is called **pleural linkage**.

Inspiration

Inspiration is an active process. The two primary muscles of inspiration are the diaphragm and external intercostals.

Diaphragm

The diaphragm is a large sheet of muscle that separates your thorax from your abdomen. It is mainly active during deep inspirations, pulling the lungs downward as it contracts. The diaphragm is in contact with the 25% of the lung surface. Your diaphragm moves down and forward, resulting in displacement of the incompressible mass of the abdominal viscera to make room for lung movement. You can demonstrate this easily by placing one hand on your rib cage and the other on your stomach. When you take a deep breath, you feel the outward movement of the abdomen. This is the diaphragm forcing the abdominal contents forward. Your diaphragm is active only during inspiratory movements, and any contribution to expiration happens because the passive response of abdominal muscles during speech production force it superiorly.

External Intercostals

Your external intercostals are located between each rib and pull the ribcage up. They work to increase the volume of the lungs, which results in air rushing into the lungs for inspiration. The manipulation of the rib cage by the external intercostals provides volume change due to its contact with 75% of the lung surface area.

Expiration

Expiration can be a passive or forced process. Passive expiration relies on gravity, elasticity of the lungs, and recoil within the rib cage to return the lungs to an equilibrium state following inspiration. However, speech expiration is an active process and requires activity in the many muscles responsible for forced expiration.

Internal Intercostals

The internal intercostal muscles are also located between each rib. In contrast to the externals, this group of muscles is responsible for compressing the rib cage and lungs by pulling the ribs downward. This results in air rushing out of the lungs. These are

the muscles responsible for making the subtle airflow and pressure changes necessary for speech.

Abdominal Muscles

The abdominal muscles are not involved in inspiration but are essential muscles for speech production. These four muscles, from deep to superficial, are transversus abdominus, internal oblique abdominus, external oblique abdominus, and rectus abdominus. When contracted, these muscles will force the abdominal contents posteriorly and superiorly. This superior movement will force the diaphragm upward and result in compression of the lungs.

Abdominal activity combines with the activity of the internal intercostal muscles to result in speech expiration. To improve overall speech efficiency, the abdominal muscles are active throughout all speech expirations, but they are not likely to make subtle pressure changes. The rib cage provides the force necessary to indicate stress and emphasis during speech. The abdomen serves a specific role in speech by maintaining activity throughout the expiratory phase, indicating a "speech-specific" posturing of the chestwall as compared to rest breathing.

CLIn IC Box: The Bucket Handle

Think of movement of air as a "bucket handle." Like a line of bucket handles, each of your ribs is pulled up and out away from the midline to create volume change. As a result, your ribcage is also elevated at the sternum, essentially lifting the entire rib cage out and up in the anterior-posterior plane (Zemlin, 1998). Expiration from this point is passive in nature and a result of the relaxation forces of elasticity in the lungs, recoil in the rib cage, and the effects of gravity.

The Larynx

The biological function of your **larynx** is to protect the airway. It also is the organ for voice production. **Phonation** is a component of speech, but is defined only as the vibration produced by the true vocal folds within the larynx; it is an overlaid function of the larynx. Speech articulators then shape those vibrations into sounds.

Laryngeal Structures

The larynx is located medially within the neck. Your laryngeal structures are primarily cartilaginous. The only bone is the hyoid bone, which forms the upper border of your larynx. It is free-floating and suspended within the body. The hyoid bone connects through membranes, and it articulates with the largest and most pronounced cartilage in the larynx—the thyroid cartilage. The lower border of the larynx is the cricoid cartilage, which articulates with the trachea.

Levels

Three levels, from top to bottom, help protect your airway: **epiglottis**, **vestibular (false) folds**, and **true vocal folds**.

Epiglottis. The function of the epiglottis is to protect the airway during swallow and is not essential for phonation, though it plays a role in the resonance and complexity of the resulting sound.

Vestibular Folds. These thick folds of mucous membrane serve as a layer of airway protection. These are not typically involved in phonation, though they find use in various chanting and singing styles in areas around the world.

True Vocal Folds. Of the three levels, only your true vocal folds are involved in phonation. The space between the true vocal folds is called the **glottis**; closing of the vocal folds is **adduction** and opening is **abduction**. Your true vocal folds perform the many functions essential for phonation.

CLInIC Box: The Bernoulli Effect

As the velocity of airflow increases through the constriction of your larynx, the pressure perpendicular to that flow will become negative in relation and will result in your vocal folds coming back together. This is the **Bernoulli Effect**. This, in conjunction with the physical properties (e.g., momentum, inertia) of the true vocal folds when forced open, maintains the continued vocal fold vibration needed for phonation.

Pitch

Many muscles in your larynx are involved in glottal configuration, or pitch change. To illustrate, muscles that elevate your larynx during swallow can also activate during phonation to make subtle and discreet changes in the length of the vocal tract to influence resonance. Contraction of the thyroarytenoid muscle decreases your pitch, whereas the cricothyroid muscle elevates pitch. Interaction between the cricothyroid muscle and thyroarytenoid muscle allows pitch changes during phonation, stretching and shortening the covering of connective and mucosal tissue (called the **lamina propria**) that lines each vocal fold.

Voicing

Adduction of the arytenoid cartilages brings your vocal folds together for phonation. The muscles involved include the lateral cricothyroid, the oblique interarytenoid, and transverse interarytenoid. To make an unvoiced sound, the posterior cricoarytenoid muscle opens your vocal folds by rotating the arytenoids open (abduction).

CLIn IC Box: Frequency and Pitch

Frequency and **pitch** are not interchangeable terms. Frequency is the measurement of vibratory cycles per second (Hertz; Hz) and can be objectively measured, whereas pitch is a perceptual correlate to frequency. Frequency is dependent on the amount of the vocal fold mass that is vibrating, which arises from the interaction of the cricothyroid muscle and thyroarytenoid muscle. The greater the mass, the lower the frequency; the lesser the mass, the higher the frequency. This explains why female speakers have a mean speaking fundamental frequency of approximately 210 Hz, whereas males have a mean fundamental frequency nearer 120 Hz (Baken & Orlikoff, 2000). In contrast to frequency, an individual can perceive an increase or decrease in pitch, but it is not quantifiable.

The Speech Articulators

Articulation is the process of joining two structures (Zemlin, 1998). Our topic, **speech articulation**, is the process of shaping of mobile and immobile structures in your vocal tract to produce speech. The overlaid function of speech integrates with the biological functions of airway protection, chewing (mastication), and swallowing (deglutition), requiring the complex coordination of the same structures under entirely different motor programs.

Mobile Structures

Your mobile articulators are the mandible, tongue, velum (soft palate), lips, cheeks, pharynx, and larynx (see previous section).

Larynx. The larynx is the sound source for speech (see previous section).

Mandible. The **mandible** is a mobile articulator that influences the interactions of the teeth, tongue, and lower lip. The function of the mandible varies considerably depending upon the activity. For example, your mandible moves in a rotary direction during mastication to ensure adequate grinding and breakdown of the food or drink (bolus) you manipulate. In contrast, during speech production your mandibular movements are almost exclusively up and down, without the side-to-side movement.

Tongue. Consonant production requires quick and accurate movements of the **tongue**. The tongue lacks a skeletal framework and it completes all shape configurations using its intrinsic muscles. Those intrinsic muscles are responsible for tongue tip elevation (superior longitudinal muscles), tongue tip depression (inferior longitudinal muscles), tongue flattening (vertical muscles), and tongue narrowing (transverse muscles). The variable configurations of these four muscles provide you the ability to produce varied shapes. That ability to reach articulatory targets is in concert with the extrinsic muscles of the tongue, which contribute to protrusion, retraction, and side-to-side movement.

CLIn IC Box: Speech and Swallowing Differences

Speech and swallowing use similar structures in very different ways. Your ability to shape the tongue allows you to produce numerous speech sounds and requires very quick and precise movement of a large structure. Whereas swallowing requires greater amounts of strength, speech requires speed and timing. These differences in strength requirements is one reason why therapy approaches for speech are different from those for swallowing.

To give another illustration of the difference between speech and swallowing, you need much less strength to close the velopharyngeal port during speech than during swallowing. Additionally, during swallowing, the velum elevates and closes during the duration of the oral transit stage of swallowing. This increased closure force ensures you do not have nasal regurgitation during swallow due to the high-pressure buildup in the oral cavity and pharynx. In contrast, speech does not require the same amount of force and its behavior is analogous to a fluttering movement during continuous speech.

Velum (Soft Palate). The **velum** (**soft palate**) is a slinglike structure that separates the nasal cavity from the oral cavity and pharynx. The velum is one portion of the **velopharyngeal (VP) port** that functions to close the nasal cavity for either speech or swallowing. You do not achieve VP closure by velar movement alone, but rather through a combination of velar elevation with posterior and lateral pharyngeal wall closure. Speech requires rapid and timed movements for you to be able to elevate the velum to close the VP port for oral sounds and to depress it for nasal sounds.

CLIn IC Box: Disorders of Speech

Disorders of speech related to the velum most often occur in craniofacial disorders, but can be present in neurological disorders, motor speech disorders, and oral/head and neck cancer. Craniofacial disorders may or may not result in a cleft of the velum. Typically, if the velum is affected, people perceive affected individuals as **hypernasal** (too much nasal resonance) due to difficulty building up oral pressure for oral sounds. Less often, people perceive affected individuals as **hyponasal** (too little nasal resonance).

Lips and Face. Speech articulation and communication would not be complete without discussion of the muscles of the face. Your lips depend on a surprisingly large number of muscles. The orbicularis is the major muscle of lip rounding; it maintains lip seal during swallowing and when you build up intraoral air pressure during speech. The buccinators and risorius muscles help you retract the corners of your mouth. The speech function of the buccinator is to pull the corners of your lips posteriorly (e.g., producing "eeee"); its biological function is to push your food and drink back into the oral cavity to maintain a cohesive bolus. Your smile comes from the muscles levator anguli oris and zygomatic major, pulling up your lip corners.