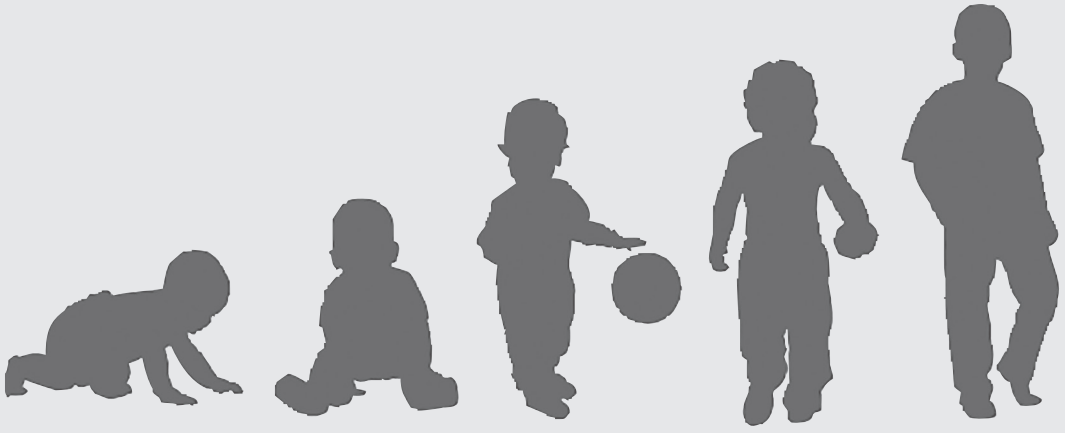
Handbook on Children's Speech

DEVELOPMENT, DISORDERS, AND VARIATIONS

Raymond D. Kent, PhD



Plural Publishing Inc.

PLURAL PUBLISHING
INC.

9177 Aero Drive, Suite B
San Diego, CA 92123

email: information@pluralpublishing.com
website: https://www.pluralpublishing.com

Copyright © 2024 by Plural Publishing, Inc.

Typeset in 10.5/13 Garamond by Flanagan's Publishing Services, Inc.
Printed in the United States of America by Integrated Books International

All rights, including that of translation, reserved. No part of this publication may be reproduced, stored in a retrieval system, or transmitted in any form or by any means, electronic, mechanical, recording, or otherwise, including photocopying, recording, taping, web distribution, or information storage and retrieval systems without the prior written consent of the publisher.

For permission to use material from this text, contact us by
Telephone: (866) 758-7251
Fax: (888) 758-7255
email: permissions@pluralpublishing.com

Every attempt has been made to contact the copyright holders for material originally printed in another source. If any have been inadvertently overlooked, the publisher will gladly make the necessary arrangements at the first opportunity.

Library of Congress Cataloging-in-Publication Data

Names: Kent, Raymond D., author.
Title: Handbook on children's speech : development, disorders, and variations / Raymond D. Kent.
Description: San Diego, CA : Plural Publishing, Inc., [2024] | Includes bibliographical references and index.
Identifiers: LCCN 2023024896 (print) | LCCN 2023024897 (ebook) | ISBN 9781635506204 (hardcover) | ISBN 1635506204 (hardcover) | ISBN 9781635504590 (ebook)
Subjects: MESH: Speech Disorders--diagnosis | Child | Speech Disorders--therapy | Speech Therapy--methods | Speech--physiology | Language Development
Classification: LCC RJ496.S7 (print) | LCC RJ496.S7 (ebook) | NLM WV 501 | DDC 618.92/855--dc23/eng/20230822
LC record available at https://lccn.loc.gov/2023024896
LC ebook record available at https://lccn.loc.gov/2023024897

CONTENTS

PREFACE

Speech is such a distinguishing feature of humans that Dennis Fry (1977) suggested we should be called *homo loquens* ("the talking animal"). For most people in the world, speech is the most used form of communication. It is estimated that on average we produce about 1000 words every waking hour, which makes speech one of our most highly practiced motor abilities. Development of speech in children is one of the most significant milestones observed by parents and specialists in child development. The word *infant* is derived from the Latin *infans*, meaning "unable to speak." There are many ways in which infants differ from adults, but the term given to this early phase of development pertains to only one—speech, or rather the lack of it. But, as discussed in this book, lack of speech in its adult form does not mean that children, at even the youngest ages, are not already on the path to spoken language. A great deal of research on infant vocalizations has produced what might be called "the book of babble," a collection of research articles that shows how cooing and babbling are foundations for speech development. Children produce their first words around their first birthday and then proceed on a course of rapid language development. Speech is a robust faculty that is acquired by most children despite large variations in language stimulation, socioeconomic level, and general health status. However, speech development can be disrupted or delayed in some children, with potentially profound consequences on quality of life. This book considers how speech develops in children, why speech disorders arise, and why variations such as dialect can occur in different populations. The book subtitle reflects this three-part goal: development, disorders, and variations.

The Facets of Speech

Speech in the general sense can be defined as the audible form of language expression. The systems of speech production convert an intended message to movements that generate an acoustic signal that is heard and decoded by listeners. Speech has several facets, as discussed in the following.

Language. The most obvious facet of speech is linguistic communication. Speech, along with gestures, is the earliest form of communication in childhood. It is also the primary means of human communication throughout the world. Speech offers several advantages as a means of communication. It is produced with our own body structures (therefore does not rely on tools or devices), can be transmitted by telephony, does not require visual cues, and contains different kinds of information in addition to the linguistic message (more on this below).

Gender and age. Speech provides cues as to a person's gender and age. When

we receive a telephone call from an unknown person, we can quickly form opinions on whether the caller is male or female, young or old. Speech is highly sexually dimorphic, meaning that it is quite different between the sexes. Speech also changes with age, especially during childhood and adolescence.

Culture and language. Speech patterns are specific to individual languages. The imprint of a first language can influence learning another language, so that the additional language usually has a nonnative accent. All speakers have a dialect that reflects geographic and social factors. The way we speak identifies us as part of a speech community that shares a language and a dialect.

Individual identity. We often can identify a familiar person just from the sound of his or her voice, as when the person says "hello" over a telephone. Speech is a personal identifier in which idiosyncratic features are combined with aspects of gender, age, and culture. Speech, like our faces, is individually distinctive. When we speak, we announce ourselves.

Emotion. Aside from facial expression, speech is the major way of expressing emotions. Children learn very early in life that vocalization can signal discomfort, pleasure, and other emotional states. Speech is nearly always imbued with emotion. Even the so-called neutral tone of voice is a type of emotion. This emotional component has both expressive and receptive domains. We learn how to express emotions in our own speech and to recognize them in others.

Health. Speech can be affected by state of health, as when a listener detects that a speaker is tired or has a cold. Speech can be disordered in various ways, as detailed in this book. Some speech disorders arise for unknown reasons, whereas others are associated with developmental conditions such as autism spectrum disorder or hearing loss.

Speech as Complexity

Even a simple utterance can combine these various facets. Speech also is a combination of skills related to audition, somatosensation, phonology, and motor control. It is one of the fastest and most precisely timed of human behaviors. Ordinary speech is extraordinary in many ways, and decades of research have been conducted to understand it. Although most six-year-old children are highly intelligible to strangers, the development of various aspects of speech continues into puberty and adolescence. But even in adulthood, speech undergoes continual refinement in an apparent effort to achieve optimal performance. The scientist Karl S. Lashley took speech as the prime example of serial ordering of behavior, and it is prowess in this domain that sets speech apart from other human skills and activities.

Contemporary understanding of speech in children is multidisciplinary, including the fields of developmental biology, developmental psychology, genetics, linguistics, medicine, neuroscience, and speech-language pathology. These and other fields are needed to create an account of how speech develops, how it can be disordered, and how it reflects cultural and individual experiences. A natural consequence of this synthesis is the emergence of new subdisciplines, such as the developmental neuroscience of speech disorders, which

enfolds speech development, speech disorders, and neuroscience to portray new methods of diagnosis and treatment.

Because speech draws on many body systems and processes, it is not surprising that many different conditions can imperil speech development. Many, but surely not all, of these conditions are outlined in this book. But for many speech disorders, the cause simply is not known. In medical parlance, these are idiopathic disorders (idiopathic denotes a disease or condition that arises spontaneously or for which the cause is unknown). Many different therapies have been developed to improve speech production, and this book describes more than 30 such treatments along with summaries of evidence for their effectiveness.

Speech as we usually think of it is directed to others for the purpose of communicating thoughts, feelings, and experiences. But speech takes two other common forms. One is private speech, that is, speech directed to oneself and not to others. The other form is inner or covert speech, which is not really spoken but nonetheless shares many properties with spoken speech. Inner speech has important functions of monitoring, self-regulation, and reflection. Textbooks on speech development and disorders usually pay little attention to inner speech. To be sure, inner speech is not easily studied, but the scientific literature attests to its importance. Sometimes we speak not to be heard but rather to reflect and self-direct.

Risk Factors in Speech Disorders

Although many different factors can pose risks for speech disorders in children, research shows that the most prominent risk factors in different countries are male sex, family history, and birth difficulties. Speech disorders also occur in many different diseases and conditions, including anatomic anomalies, neurodevelopmental disorders, genetic syndromes, hearing impairment, and socioeconomic disadvantage.

Adultcentrism

This book suffers from a limitation that is all too common in discussions of child development—it has an adultcentric point of view. Adultcentrism is the tendency of adults to view children and their experiences from a biased, adult perspective (Goode, 1986). As Petr (1992) points out, this perspective is evident in the formulation of stage theories of child development that lead to the implicit presumptions that children are incomplete and essentially incompetent. Adults, being on the far end of maturity on any such stage model, become the standard of completion and competence. Children, by definition, fall short. Stage models are presented several times in this book because they are convenient and economical in portraying development. Unfortunately, they tend to carry the misconceptions and distortions of adultcentrism. A consequence of adultcentrism is underestimation of children's abilities. At one time, it was proposed that human infants were basically subcortical in their neural processes and largely unaware of the complexities of human speech. But it is now clear that infants are capable of statistical learning, defined as the ability to detect statistical regularities in their environment. This kind of learning potentially

applies to virtually all levels of human language (Romberg & Saffran, 2010) and compels a new perspective on how even the youngest members of our species recognize structure in their environments and use this information to fuel the development of language and cognition. It has been shown that some language tracts in the brain are already formed at birth.

The author has no real remedy for adultcentrism in this book, but a remedy in practice is to try to see children at any point of development as being complete and competent within the circumstances of their lives. Words such as immature, undeveloped, unsophisticated, and simplistic should be used (if used at all) with due regard to the powerful phenomena that underlie lifelong development. Merrick and Roulstone (2011) wrote, "Children have the right to express their views and influence decisions in matters that affect them. Yet decisions regarding speech-language pathology are often made on their behalf, and research into the perspectives of children who receive speech-language pathology intervention is currently limited" (p. 281). Adult perspectives and opinions should be balanced by consideration of how children view themselves and their abilities. Children and their parents do not always share the same attitudes (McCormack, McLeod, & Crowe, 2019).

Intended Audience

This book may be of interest to anyone who seeks to understand speech development in children, but it is focused especially on disorders and variations. The challenge facing speech-language therapists and other professionals is illustrated by the example of a 6-year-old child who has a speech disorder accompanied by a mild hearing loss, a dental malocclusion, and a family history of communication disorder. As a further complication, this child is learning English as a second language that is not spoken at home.

References

Fry, D. (1977). *Homo loquens: Man as a talking animal*. Cambridge University Press.

Goode, D. (1986). Kids, cultures, and innocents. *Human Studies*, *9*, 85–106.

McCormack, J., McLeod, S., & Crowe, K. (2019, March). What do children with speech sound disorders think about their talking? *Seminars In Speech and Language*, *40*(02), 94–104.

Merrick, R., & Roulstone, S. (2011). Children's views of communication and speech-language pathology. *International Journal of Speech-Language Pathology*, *13*(4), 281–290. https://doi.org/10.3109/17549507.2011.577809

Petr, C. G. (1992). Adultcentrism in practice with children. *Families in Society*, *73*(7), 408–416.

Romberg, A. R., & Saffran, J. R. (2010). Statistical learning and language acquisition. *Wiley Interdisciplinary Reviews: Cognitive Science, 1*(6), 906–914. https://doi:10.1002/wcs.78

1

INTRODUCTION

This book considers the various processes underlying speech development and speech disorders in children. Speech is defined as movements or movement plans that produce acoustic patterns that accord with the phonetic structure of a language. This definition implies that speech should be understood as a motor activity, an acoustic signal, an encoding of a linguistic message, and reception of that message in a listener's brain. But that is not all. Speech is a primary means of individual recognition and emotional expression. Even a simple utterance can carry information on the intended linguistic message, the speaker's identity and cultural background, and the speaker's emotional state. Speech is a motor act that is learned and maintained through sensory information, primarily but not exclusively from the auditory and somatosensory (kinesthetic and tactile) channels. The intimate connections between motor and sensory aspects compels use of the term *sensorimotor*.

A major part of learning to speak is learning the sensorimotor skills of what is very likely the most highly coordinated motor behavior that most humans possess. The task is complicated by the large number of muscles involved (100 or so different muscles in the oral, laryngeal, and respiratory organs), the precise control of spatial and temporal parameters, and the essential linkage to cognition and language. It should be emphasized that a focus on sensorimotor processes does not mean that this book pertains only to children's motor speech disorders as typically defined. Rather, the effort is to examine how sensorimotor and other processes factor into the general experience of learning to produce intelligible speech and how these processes are disrupted in children's speech disorders, of which there are several kinds.

It is well to note that speech is a distinctive feature of humans, so much so that it has been argued that our species may as well be called *homo loquens* ("talking animal") as *homo sapiens* ("wise man") (Fry, 1977; Pulgram, 1970). The uniqueness of speech to humans is relevant to this book because it implies specialties that underlie the development and use of speech as a tool of communication and cognition. Perhaps chief among these specialties are the neural connections between the cerebral cortex, cerebellum, and the vocal organs. Interestingly, the word *infant* is from the Latin for "unable to speak" or "speechless." There are many things that

infants cannot do, but inability to speak is a common label for this stage of life and signals the importance attached to the faculty of speech.

> "Speech, as the preferred output modality for human language, is an unusual feature of our species that depends upon a complex but well-understood set of mechanisms, including vocal/motor, auditory/perceptual, and central neural mechanisms. The capacity for speech clearly differentiates humans from other primates . . . " (Fitch, 2018, p. 256)

Coverage of the book's topic includes two major interrelated domains: (1) speech development and (2) pediatric speech disorders focusing on the ages of birth to puberty. Because speech disorders in children occur against a complex developmental background, the understanding of these disorders requires knowledge about how speech develops and how it is affected in children with disorders. These topics are introduced in the following two sections.

Speech Development

Speech development can be defined as the continuous, age-related process of change in speech patterns over the lifespan. The process of change is influenced by both maturation and experience. Motor control is adapted to anatomic, physiologic, and cognitive changes that occur over the lifespan, even into advanced age. Understanding speech development requires consideration of developmental changes in the anatomy and physiology of the speech production system, the maturation of sensory and cognitive capabilities, the refinement of language skills and abilities, and the social experience of communication. This book concentrates on the early part of the process of speech development (when speech and language are largely developing) but many of the principles can be extended to later phases such as adolescence and adulthood. A child's journey to intelligible speech begins with infant vocalizations such as coos and babble. Most infants utter their first words at about one year of age, produce about 50 to 200 different words at two years of age, and learn about 21 words each day in early childhood.

> "That every child learns to talk is such a commonplace observation that we have to stop and think about it to appreciate what a miracle of development it really is. And once it is appreciated, it is almost impossible to suppress your curiosity. I find it one of the most challenging mysteries on the agenda of psychological science." (G. Miller [1977] *Spontaneous apprentices: Children and language* [pp. 19–20]. Seabury Press.)

Speech production is malleable to some degree in both children and adults, probably more so in the former, as discussed in Chapter 10, which deals with the issues of bilingualism and dialect. It is commonly believed that malleability is limited, especially in adults, which could explain the difficulty that adult speakers have in acquiring another language (L2) that is free from the influences of

the first language (L1). It has been proposed that L2 learning is limited by maturational constraints. According to Lenneberg (1969, p. 639), " . . . the maturation of the brain marks the end of regulation and locks certain functions into place." Scovel (1988) suggested that a critical period for L2 speech learning closes at about 12 years owing to decreased brain plasticity that accompanies neural maturation. Patkowski (1980, 1990) concluded that a critical period for the learning of both L2 speech and morphosyntax closes at about 15 years of age. However, other authors assert that plasticity can be observed in both language and the brain. Even in adults, L1 is not rigid and permanent but rather dynamic and fluid. Research reviewed by Chang (2012) has shown restructuring of sound patterns in L1 through the influence of L2 (a phenomenon known as **phonetic drift**), and significant, sometimes rapid, adjustments to L1 speech in response to a variety of environmental factors. The concept of life-long plasticity is discussed in detail by de Leeuw and Celata (2019) and other articles in a special issue of the *Journal of Phonetics*. The topic of a critical period (or several critical periods) is examined more fully in Chapter 10.

Languages have their own phonetic systems, with different repertoires of vowels and consonants, different melodies, and different rhythms. It has been proposed that languages even have their own **phonetic settings**, that is, a tendency for the speech production system to return to a language-specific habitual configuration (Honikman, 1964). Mennen et al. (2010) wrote of this configuration as follows, "For example, languages may differ in their degree of lip-rounding, tension of the lips and tongue, jaw position, phonation types, pitch range and register" (p. 13). Perhaps speakers adopt phonetic settings to facilitate the demanding sensorimotor functions in speech production that are keyed to the phonetic and phonological features of a language. If so, learning a second language is not just a matter of learning its phonemes or other segments but a matter of learning the optimal settings of the speech production system.

Information relating to typical speech development (covered in Chapter 4) is essential to understanding speech itself and the nature of speech disorders. The process begins in utero, given that the fetal auditory system is capable of processing aspects of the speech signal, such as the mother's voice and the overall prosody. Newborns typically announce their arrival with a robust cry, which is evidence of a healthy respiratory system and the beginning of vocal behavior. Thereafter, vocal development proceeds from cooing and babbling vocalizations to first words and eventually to multisyllabic utterances with syntactic structure. Understanding typical patterns of development is essential to clinical assessment and treatment. Chapter 4 summarizes how speech takes form as the consequence of processes of maturation and experience. The developmental process draws on several capabilities and resources, including sensory function, motor control, and phonological acquisition.

Pediatric Speech Disorders and Variations

The second component of this book, pediatric speech disorders and other speech variations, pertains to aspects of impaired (or atypical) speech development and

to speech development in bilingualism. These two broad categories are sometimes labeled disorders and differences. The disorders are not easily defined and are not well understood with respect to their prevalence and incidence. MedlinePlus (n.d.), an information source of the National Library of Medicine, defines **speech disorder** as "a condition in which a person has problems creating or forming the speech sounds needed to communicate with others. This can make the child's speech difficult to understand" (https://medlineplus.gov/ency/article/001430.htm#:~:text=A%20speech%20disorder%20is%20a,Articulation%20disorders). This source goes on to identify the common speech disorders to include articulation disorders, phonological disorders, disfluency, voice disorders, and resonance disorders. But this is only a partial list—one that is expanded in this book, especially in Chapter 11. A further complication is that a specific speech disorder may co-occur with other disorders, such as another type of speech disorder (e.g., articulation disorder accompanied by developmental stuttering), as well as language and hearing disorders. For present purposes, a **speech disorder** is defined as any impaired, habitual pattern of speech production that members of the speaker's sociolinguistic community regard as atypical or significantly inappropriate. A **speech difference**, for lack of a better term, is the effect of bilingual or multilingual experience on a child's speech development. This effect is not a disorder. but it can co-occur with a disorder, and that poses challenges to clinical assessment. Much more is said about this in Chapter 10.

Unfortunately, it is not always straightforward to differentiate speech disorders from language disorders, and this difficulty has complicated efforts to determine the incidence and prevalence of these disorders. Raghavan et al. (2018) concluded from a review of studies on this topic that, "existing data sources do not capture the condition [speech and language disorders] in a reliable, uniform, or systematically valid manner, which poses a barrier to population level ascertainment of the condition. Current survey data also do not sufficiently permit the separation of speech and language disorders into speech, language, and other communication disorders" (p. 11).

A further complication is that speech disorders often are comorbid with various health and socioeconomic factors (Keating et al., 2001), a point that recurs throughout this book. But whatever the exact percentage of affected children may be, a significant number of children have a speech disorder that affects their quality of life, and, in some individuals, the disorder can have lifelong consequences.

Clinical conditions can be described in terms of several aspects, as follows:

1. **Phenomenology** is the systematic description and classification of phenomena without efforts at explanation or interpretation. A phenomenological description pertains to the observed signs and symptoms of a disorder (e.g., a listing of misarticulations in a child's speech without interpretation as to cause). Such descriptions are useful in determining the presence and/or severity of a disorder.
2. **Etiology** is the cause or causes of a disease or abnormal condition (e.g., identifying hearing loss as contributing to a child's speech disorder). Speech disorders in children are linked to several different etiologies,

and a significant proportion are considered **idiopathic** (meaning "unknown cause"). Some disorders are thought to have a **multifactorial etiology** in which two or more factors play a role in causing or exacerbating the condition. Frequently occurring etiologies, either alone or in combination, include hearing impairment, structural anomaly such as cleft palate, motor disorder, genetic influences, and sociocultural factors.

3. **Epidemiology** is the study of the distribution and determinants of health-related states or events in specified populations. Epidemiologic studies tell us how often diseases, disorders, or other conditions occur in different groups of people and why (e.g., showing that speech disorders occur more frequently in boys than girls).
4. **Pathogenesis** is the course of an illness or condition, from its origin to manifestation and outbreak (e.g., showing that a speech disorder in early childhood may be linked to a later disorder of reading). A similar concept is the **natural history** of a disorder or condition (i.e., how it changes over time). Speech disorders often have a developmental profile that reflects general processes of maturation as well as a child's social interactions.
5. **Treatment** is intervention to normalize a disorder, provide compensations if normalization is not possible, or to prevent worsening (e.g., initiate therapy to correct misarticulations and improve speech intelligibility). Across clinical specialties, treatments are increasingly studied with the principles of evidence-based practice, in which outcomes are evaluated with standardized tools.
6. **Prevention** is any course of action that decreases the likelihood that a person will have a disease or other condition (e.g., identify and modify conditions that put a child at risk for a communication disorder). As explained in Chapter 12, prevention takes several different forms.

Many speech disorders can be associated with atypical motor patterns of speech production, and it is important to distinguish motor speech disorders from general motor processes in speech development. Discussions of **motor speech disorder (MSD)** in children usually identify three or four disorders: **childhood apraxia of speech (CAS)**, **dysarthria**, **motor speech delay (MSD)**, and perhaps a yet-to-be defined disorder (let's call it Disorder X, which may not be a single disorder at all but rather a group of disorders). CAS has attracted a great deal of clinical attention and substantial progress has been made in its diagnosis, treatment, and etiology, although differing views persist about its nature and treatment. Childhood dysarthria, unlike adult dysarthria, has no widely recognized classification of types, although some progress has been made in identifying the responsible neural lesions. It does not appear that classifications used in acquired dysarthria in adults align with the speech disorder in children (Morgan & Liégeois, 2010; Schölderle, Haas, & Ziegler, 2021). Motor speech delay was described by Shriberg et al. (2019) as a pediatric motor speech disorder distinct from childhood dysarthria and CAS, and it was proposed as an addition to the Speech Disorders Classification System (SDCS; Shriberg et al.,

1997). The 10 signs of speech motor delay found in more than 50% of the children who were positive on the sign included age-inappropriate precision and stability behaviors in speech, prosody, and voice domains, with the most frequently occurring signs involving speech production.

The hypothetical Disorder X mentioned earlier is not established as a clinical entity, but the reason for its mention is to recognize growing evidence that motor factors contribute to speech disorders that are not confidently categorized as CAS, dysarthria, or speech motor delay. Vermiglio (2014) wrote that a clinical entity is defined by the Sydenham-Guttentag criteria (Guttentag, 1949), namely that it must (1) have an unambiguous definition, (2) represent a homogenous group with a perceived limitation, and (3) facilitate a diagnosis and intervention. Defining a clinical entity is important for many reasons, including effective diagnosis, treatment, and reimbursement for clinical services. Naming a disorder is an important step because it distinguishes the disorder from others and leads to clinical descriptions relevant to assessment and treatment.

Aside from the commonly recognized MSDs, motor issues are important to understanding speech sound disorders in the general sense, including **articulatory/phonological disorder**, which is a general term for speech sound disorders of nonspecific origin. The terms **articulatory disorder** and **phonological disorder** are used in research and clinical practice, but the distinction between them is not clearly specified. For this reason, the term articulatory/phonological disorder (or phonological/articulatory disorder) is used to encompass a broad range of speech sound disorders. However, the more neutral term **speech sound disorder (SSD)** appears to be gaining favor, partly because it is not always clear how to distinguish articulatory from phonological components for an individual child. Namasivayam et al. (2020) wrote,

> The present definition describes SSD as a range of difficulties producing speech sounds in children that can be due to a variety of limitations related to perceptual, speech motor, or linguistic processes (or a combination) of known (e.g., Down syndrome, cleft lip and palate) and unknown origin. (p. 2)

The term **speech sound** is frequently used without definition. When a definition is offered, it may be something like *individual units of speech production* (which could be phonetic segments, phonemes, or perhaps some other element). Lindblom (1990) wrote, "What is a speech sound? Although phonetics is the study of speech sounds, textbooks do not normally present a standard definition" (p. 137). Lindblom goes on to note that definitions often have a circular nature, in that the term being defined becomes part of the definition. Defining a speech sound as a unit carries the risk of reducing speech production to a sequence of units, rather like keys on a keyboard. But, as discussed in Chapters 6 and 7, speech is more than a sequence of elements. Rather, speech is organized at several different levels that are integrated into a rhythmic and melodic pattern in which segments are very difficult to identify because speech movements are context-adaptive, overlapping with one another in their segmental affiliation, and subject to a variety of influences including speaking rate and speaking style.

The segmental assumption (i.e., speech sounds are units) runs through dis-

cussions of development (acquisition of speech sounds, which typically is a chronology of phoneme mastery in childhood) and disorder (speech sound errors, which usually focuses on phonemes). The American Speech-Language-Hearing Association (n.d.) defines speech sound disorders as "an umbrella term referring to any difficulty or combination of difficulties with perception, motor production, or phonological representation of speech sounds and speech segments—including phonotactic rules governing permissible speech sound sequences in a language" (first paragraph of https://www.asha.org/practice-portal/clinical-topics/articulation-and-phonology/). This definition mentions both speech sounds and speech segments but does not explain how these terms differ and why both should be recognized. The subsequent mention of *speech sound sequences* in the definition also lacks clarity. The definition of speech sound disorder conflates three critical terms: speech sounds, speech segments, and speech sound sequences (none of which is defined).

Given the ambiguity of the term *speech sound*, it is understandable why so many books, articles, and online sources on speech sound disorders simply do not define it. But it is necessary to define it to give an understanding of related terms such as *speech sound disorders* and *speech sound acquisition*. Simply put, the concept of speech sound is central to the study of speech, much as the concept of an element is central to chemistry. This book uses the following definition: a **speech sound** is a unit in the acoustic signal of speech, with the duration of the unit ranging from a phonetic segment to a larger prosodic unit, depending on the purpose of the analysis. By this definition, speech sounds include units such as phonetic segments, phonemes, syllables, and intonational patterns, whether produced by people or machines. Although this book is concerned primarily with speech produced by humans, machine speech has clinical relevance in systems such as a **voice output communication aid (VOCA)**, also known as a **speech generating device (SGD)**, which is any device producing intelligible speech that allows a person who is nonvocal (or who has great difficulty in producing speech) to communicate with another person or with some electromechanical system. A speech sound is an acoustic entity; however, this entity may be produced—by a human, a robot, or a computer using synthetic speech. Technological advances have taken speech from a purely human activity to one that is adapted to a world of artificial intelligence.

Accordingly, a speech sound disorder is an atypical production of a specified unit in the acoustic signal of speech. The units that are commonly recognized are phonetic segments or phonemes, but these are not the exclusive domain of the disorders, which can extend to larger units such as syllables, words, or intonational phrases. The rationale and implications of this definition are discussed more fully in Chapter 11. In comparing different systems for the classification of speech sound disorders, Waring and Knight (2013) concluded that there is general agreement on three major subgroups: an articulation-based subgroup, a motor planning subgroup, and a phonological subgroup. However, the means to identify the subgroups are not necessarily consistent across the major classification systems. Chapter 11 discusses the possibility that each of these subgroups can be understood in part through consideration of sensorimotor factors. The chapter also considers the possibility that " . . . children