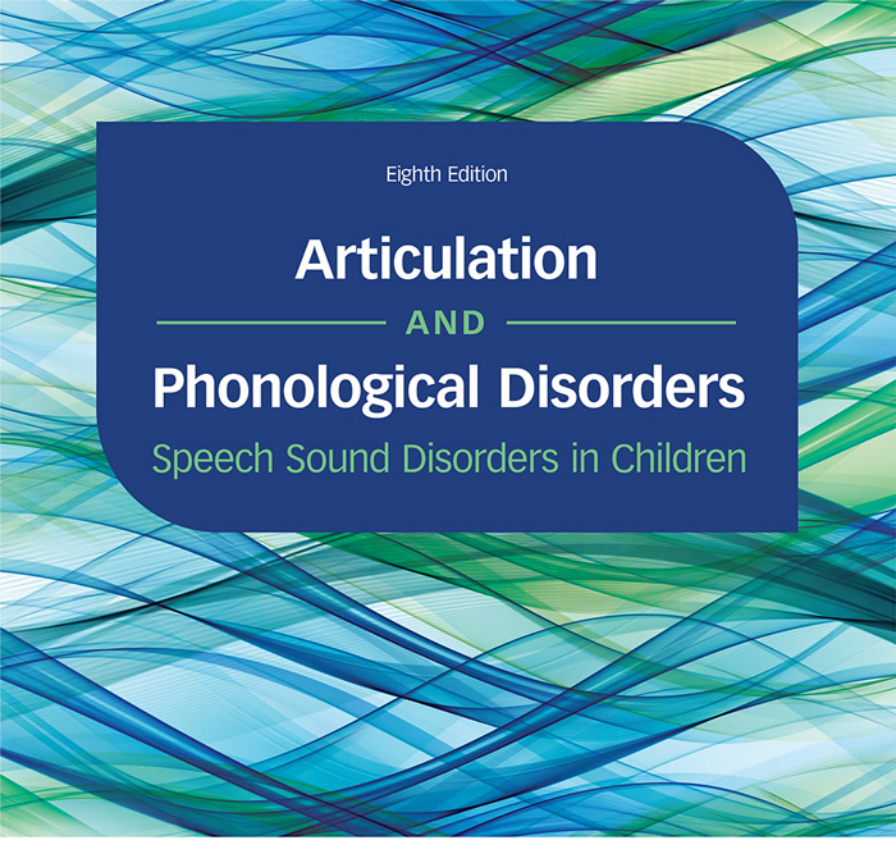

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Articulation and Phonological Disorders

Speech Sound Disorders in Children

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EIGHTH EDITION

Articulation and Phonological Disorders

Speech Sound Disorders in Children

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Library of Congress Cataloging-in-Publication Data
Names: Bernthal, John E., author. | Bankson, Nicholas W., author. | Flipsen, Peter, Jr., author.
Title: Articulation and phonological disorders : speech sound disorders in children / John E. Bernthal, University of Nebraska/Lincoln, Nicholas W. Bankson, James Madison University, Peter Flipsen Jr., Pacific University, Oregon.
Description: Eighth edition. | Boston : Pearson, 2016. | Includes bibliographical references and index.
Identifiers: LCCN 2016006776| ISBN 9780134170718 (alk. paper) | ISBN 0134170717 (alk. paper)
Subjects: LCSH: Articulation disorders.
Classification: LCC RC424.7 .B47 2016 | DDC 616.85/5—dc23 LC record available at http://lccn.loc.gov/2016006776

ISBN 10: 0-13-417071-7
ISBN 13: 978-0-13-417071-8

eText
ISBN 10: 0-13-417083-0
ISBN 13: 978-0-13-417083-1

PEARSON

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Preface

We are pleased to share with you the eighth edition of our speech sound disorders textbook. We continue to hear that this text is regarded as a "classic" tool for providing clinicians with an expansive knowledge base in the area of speech sound disorders. The first edition was published in 1981, and since then it has been utilized as a college textbook and resource by many aspiring and practicing speech-language pathologists. As in previous editions, we continue to endeavor to provide a comprehensive and timely summary of the literature in the area of speech sound disorders. There is no doubt that certain information and knowledge are retained over the years. However, there also continue to be changes and developments in contemporary clinical practice that we seek to incorporate in each new edition, including this eighth edition. We are pleased to share with you our reader what we hope will be a useful resource in your professional library.

NEW TO THIS EDITION

In this eighth edition, we have retained the overall organization of information from the previous edition, but we have also:

1. Reordered the background material in Chapters 4 and 5 so that the historical search for factors related to speech sound disorders is placed before the discussion of classification.
2. Added an expanded discussion in Chapter 9 of principles of learning that underlie motor approaches to speech sound intervention. This includes a discussion of the *challenge point* framework for maximizing treatment efficiency.
3. Expanded our discussion of evidence-based practice and consolidated that material into the end of Chapter 8.
4. Greatly updated and expanded the information related to childhood apraxia of speech both in terms of our understanding of the disorder itself (in Chapter 5) and the assessment and treatment of this challenging disorder (in Chapter 9).
5. Added more discussion of the most recent studies related to treatment using both motor and linguistic treatment methodologies.
6. Provided a new section on treating older children and adolescents. Included in this section is a newly organized presentation on instrumental applications for motor approaches to speech sound correction
7. Added a new appendix related to accent modification.

As with previous editions, in all chapters, we and our guest authors have attempted to synthesize the most up-to-date research and literature in the field while maintaining our "eclectic" perspective relative to the nature and treatment of speech sound disorders. In the assessment and treatment chapters, you will continue to see some of our biases regarding clinical management. We continue, however, to defer to clinician judgment in deciding which assessment and treatment procedures are most useful to them and the clients they serve.

We are indebted to several professionals who have once again contributed their knowledge and expertise in specialized areas to this text: Ray Kent, Sharynne McLeod, Brian Goldstein, Aquiles Iglesias, Brigid McNeill, Gail Gillon, Laura Justice, and Melanie Schuele. We also appreciate the contributions and suggestions that four anonymous reviewers of the seventh edition of the text provided to Pearson.

As authors, we assume all responsibility for errors, oversights, and misconceptions that may appear in this book. Our hope is that this edition will provide you with a comprehensive source of information on speech sounds disorders and that it will be a valuable resource as you learn about and practice clinical interventions for speech sound disorders.

CHAPTER 1

Introduction to the Study of Speech Sound Disorders

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Welcome to the world of *clinical* intervention for individuals with speech sound disorders! You are about to learn about one of the most frequently occurring communication disorders that speech-language pathologists (SLPs) encounter. We use the term *clinical* to indicate that this book is focused on how you, as a clinician, will assess and treat disorders related to speech sound production. This is in contrast to studying production of speech sounds from the standpoint of phonetics, linguistics, or acoustics—any one of which is often a course of study in and of itself. While knowledge from each of these areas is important background information in our study of speech sound disorders, the distinguishing characteristic of this text is that it is focused on individuals, primarily children, who have difficulty learning to produce and appropriately use the speech sounds of the language.

AN EVOLVING AREA OF PRACTICE

Concerns about speech sound production are certainly not a new area of study. An early work by Samuel Potter called *Speech and Its Defects*, for example, appeared in 1882. According to Moore and Kester (1953), formal studies of what was then called speech correction began to proliferate in the first decade of the 20th century. Organized efforts to address these problems in the public schools appear to have begun in the United States as early as 1910 in Chicago, Illinois, and 1916 in New York City. At about this same time, studies of the prevalence of speech problems in schoolchildren began to appear, with formal reports appearing from places such as St. Louis, Missouri (Wallin, 1916), and Madison, Wisconsin (Blanton, 1916). Growing concern for speech sound difficulties and other communication disorders resulted in the 1925 formation of the American Academy of Speech Correction, which was the predecessor to our current professional body, the American Speech-Language-Hearing Association (ASHA) (Moore and Kester, 1953).

Moving forward in time, documenting prevalence of communication disorders continued to be of interest (e.g., Burdin, 1940; Carhart, 1939; Louttit and Halls, 1936; Mills and Streit, 1942; Morley, 1952), but practitioners soon began to have a strong interest in also understanding the underlying nature of these problems. This probably motivated the initial publication of the *Journal of Speech Disorders* in 1936; the desire to have a scientific basis for this work also likely led to the publication of the first edition of the classic text *Speech Correction: Principles and Methods* (Van Riper, 1939). Numerous journals and texts would follow as the breadth of the

research related to these disorders expanded. The text you are currently reading follows in that tradition.

As our knowledge base grew, so too did our focus related to speech sounds. As an aside, until the 1960s, the area of language disorders in children was barely recognized as something within the province of the speech therapist. In fact, there were many discussions as to whether the profession should be engaged in studying and working with language disorders in children. Interest in adult language disorders had, however, already emerged. Brain injuries sustained by soldiers in World War II had resulted in an increasing prevalence of adult aphasia and motor speech disorders. For many years, however, we were most concerned with speech sound production errors in school-age children and adults.

A desire for better outcomes led to many developments, including a focus on younger children. The idea was to intervene early; work with children at younger ages to avoid the development of strongly ingrained bad habits. This focus was also driven by the passage of several pieces of federal legislation (e.g., the *Education of all Handicapped Children Act* in 1975 and the *Education of the Handicapped Amendments* in 1986), which mandated the availability of services first to preschoolers (those aged 3 – 5 years) and then to infants and toddlers (birth to 3 years of age). No longer was it sufficient for SLPs to focus on how to correct a distorted /s/ or /r/ sound in a school-aged child. We now had to think about children who produced errors on many sounds and were often very difficult to understand. Along with our interest in child language disorders, we then started to think about the relationship between spoken and written language as we saw that children with speech sound disorders may be at increased risk for reading difficulties and other significant challenges with classroom learning. Practitioners also began to report about children with co-existing (or comorbid) difficulties with other aspects of communication. They might, for example, have a speech sound disorder and a voice disorder, a speech sound disorder and an expressive language disorder, or a speech sound disorder and a fluency disorder (i.e., be someone who stuttered).

The field of speech-language pathology also had to deal with a changing perspective on what constitutes "normal" speech. Publications like sociolinguist William Labov's 1969 paper entitled "The Logic of Non-standard English" forced us to think very differently about notions of difference and disorder. If dialects are rule-governed variations of a language that are accepted as normal by a community of speakers, who are we to label them as speech disorders that need to be fixed? On the other hand, each dialect community likely includes similar percentages of individuals who struggle to learn to effectively communicate. Sorting out whether a particular speaker is demonstrating the normal features of a dialect other than our own or a disorder that must be attended to is often a challenge.

Dialects evolve within cultural contexts. Related to discussions of such contexts are considerations of second-language learners. As immigration patterns and population demographics continue to change, SLPs increasingly find themselves being asked to work with non-native speakers of the language. While we are not usually qualified as English teachers, we may have a role to play in such cases. In this case, like with speakers of unfamiliar dialects, it would be reasonable to expect that some small percentage of second-language learners may also have speech or language-learning challenges, and we may be asked to help determine whether there is a disorder present. In addition, some of the clinical skills we have for working with speech sound disorders can be helpful in accent reduction.

A WORKING FRAMEWORK

The term presently recommended by the American Speech-Language-Hearing Association (ASHA) to identify people who have disorders related to producing the sounds of the language is *speech sound disorders.* Historically, these disorders were referred to as *articulation disorders*—a term still in widespread use. From the time the profession of speech-language pathology came into existence in the 1920s until the 1970s, the prevailing viewpoint related to speech sound disorders was that they reflected a client's inability to either auditorally perceive or discriminate

a particular sound or sounds, and/or to motorically produce these sounds. The role of the speech clinician was to first teach a client to discriminate a sound auditorally and then teach him or her to say it correctly by having him or her practice it until the new (correct) motor behavior became habitual. When the first edition of this text was published in 1981, *Articulation Disorders* was used as the title of the book because that was still the prevailing term used to identify speech sound disorders. Beginning in the 1970s, as the first edition of this book was being written and federal mandates began to emerge, the field of linguistics began to influence how our profession viewed speech sound disorders. Linguists, who study how speech sounds are used in various languages, pointed out that speech sound disorders should not be viewed only from a motor production perspective but also from the perspective that such difficulties may reflect a child's lack of knowledge regarding where to appropriately use sounds that he or she can produce. Said another way, the child might be having difficulty acquiring the phonological rules of the language. For example, he or she may have difficulty learning to use sounds contrastively (e.g., /s/ and /z/ are contrasted in *sue* versus *zoo*) or in learning that certain sounds need to be placed at the beginning or ends of words to communicate effectively (e.g., *at* versus *hat; go* versus *goat*). Disorders related to learning the phonological rules of the language then began to be referred to as *phonological disorders*; thus, the term *phonology* was the second term (in addition to *articulation*) that moved into our vocabulary to identify speech sound disorders.

From the second edition of this book (1988) through the current edition, the terms *articulation* and *phonological* have been used in the title of the book (i.e., *Articulation and Phonological Disorders*). Some SLPs have differentiated these two terms for purposes of assessment and treatment of speech sound disorders. *Articulation* refers to production-based (or motor-based) speech sound disorders, and *phonological* denotes speech sound errors that are rule based (or linguistically based). However, in reality, it may be difficult to determine which of these concepts is most appropriate to describe a particular client's error productions. We must also recognize that there may be variables beyond motor production and rule acquisition that we need to attend to when we try to understand speech sound disorders.

ASHA, in its clinical portal (a website designed to assist clinicians) has defined *speech sound disorders* as "an umbrella term referring to any combination of difficulties with perception, motor production, and/or the phonological representation of speech sounds and speech segments…that impact speech intelligibility" (ASHA, n.d.). In this book we use the terms *articulation, phonology,* and *speech sound disorders* somewhat interchangeably but will hold to the traditional differentiation we have referred to between *articulation* and *phonology* when we talk about assessment and treatment.

THE SCOPE OF THE PROBLEM

Speech sound disorders may be described as ranging from something as "mild" as a lisp (interdentalizing the /s/ sounds; sometimes identified as substituting a voiceless *th* sound for an /s/) to a disorder as significant as that found in an individual who is completely unintelligible. The terms *delay* and *deviant* are concepts that are often used to describe the nature of the sound errors produced by children. *Delay* refers to speech sound errors that are often noted as "normal" errors found in young children as they learn the proper use of sounds (e.g., lisps, misarticulations of /r/ or the affricates) but which persist in some children. *Deviant* refers to errors not typically observed in young children's development (e.g., lateralization of sibilants, backing of alveolars, vowel errors). It should be noted that some scholars argue that the terms *delay* and *deviance* are not particularly useful because, in terms of overall language development (including speech sounds), delay often leads to deviance. This progression occurs because of the high degree of coordination involved in the development of all aspects of language (e.g., speech sounds, vocabulary, syntax). If one area is slow (i.e., delayed), it may lead to difficulties across several areas of development, which results in errors that we might then describe as deviant.

Typically, speech sound disorders are found in children, and the pediatric population is the focus of this text. As discussed earlier there have been many estimates and studies of how

common these disorders are (i.e., their prevalence). In 2003, Campbell and colleagues presented data suggesting that speech sound disorders occur in approximately 15.6 percent of 3-year-old children. Findings reported by Shriberg, Tomblin, and McSweeny (1999) suggest that by age 6 years, up to 3.8 percent of that age group continues to have difficulty with speech sound production. The difference in prevalence between these two percentages indicates that many of these problems are resolved in the preschool period. Although a positive trend, it does not remove the need for intervention for some children in order to learn accurate production of speech sounds. This is seen most obviously in the report of Mullen and Schooling (2010), who reported in a national study, among prekindergarten children referred for possible communication difficulties, that approximately 75 percent were identified as having articulation/intelligibility difficulties (the most frequently identified disorders category). In addition, up to 56 percent of the overall caseloads of school-based clinicians may involve work on speech sound production problems. And as mentioned previously, many of these disorders often co-exist with disorders in comprehension or production of language (something we discuss in more detail later in this text). Most speech sound disorders occur in children under the age of 8 years, but speech sound production errors may persist past that point and occur in adults. Information contained in this book is relevant to the treatment of any client who faces difficulties producing speech sounds; however, adult speech sound disorders are often related to organic conditions, and thus you will need to review other materials when planning treatment for most adult clients.

THE CAUSE OF THE PROBLEM

As we begin our discussion of speech sound disorders, it is important to recognize that for most children, the cause of the disorder is unknown. Often it is assumed that many children do not say their sounds properly because of difficulty in their language development that is reflected in learning speech sounds. In some instances, the problem may be related to difficulty with other aspects of language (e.g., vocabulary, syntax). As will be discussed in a later chapter, a number of variables have been studied as they relate to such learning problems (e.g., familial history, tongue thrust, speech sound discrimination). Research evidence that would give a better understanding of causality related to speech sound disorders has been difficult to establish but is ongoing. Certainly, efforts to categorize or classify various types of speech sound disorders (e.g., speech delay related to otitis media with effusion, motor speech involvement, genetic factors) is a step in the direction of helping us better understand children with speech sound disorders of unknown origin. For some children, the cause of their disorder may be more obvious (e.g., hearing loss, cleft palate); however, even then, the impact of an organic condition does not necessarily determine the type of speech sound disorder a client may have, nor how he or she will respond to treatment.

In thinking about causes and treatment, it is also important to put speech sounds into their broader context. As we have already mentioned, speech sounds are but one component of language (i.e., the phonology). Other aspects of language include semantics, which refers to meaning attached to words as reflected in vocabulary; morphology, which is defined as minimum meaningful units in the language that include words, and attachments to words such as plural markers (e.g., /s/ in *dogs*) and tense markers (e.g., *ed* in *walked*, indicating past tense), or parts of words (e.g., *doghouse* has two minimum meaningful units); syntax, that is, grammatical rules for putting words together in phrases and sentences; pragmatics, which refers to using language appropriately in a social context; and discourse, the ability to string sentences together in a meaningful manner while communicating with others. Each of these areas of language is acquired gradually and simultaneously by young children. Initially, we are concerned that children learn to use meaningful utterances to express themselves, but soon thereafter, we become concerned about accurate sound usage because it is largely through correct production of speech sounds that the child is understood by the listener, or, in other words, becomes intelligible. To recap, SLPs are initially concerned with a young child's acquisition of semantics and vocabulary, then phonology, and then grammatical rules (morphology and syntax), although these areas are

being acquired all at the same time. Concern over pragmatics and discourse come later because they are based on vocabulary and syntax. Thus, it is often older children for whom pragmatics and discourse may be targeted for instruction.

THE IMPORTANCE OF THE PROBLEM

As mentioned earlier, our understanding of speech sound disorders has changed dramatically over the years. Such problems are often about more than just being able to say individual sounds. Fundamentally, the issue is about being able to connect with others through communication—to make ourselves understood. And increasingly, it is being recognized that a normal sound system is important in terms of literacy, or, in other words, learning to read and spell. Children's phonological awareness skills (or their ability to mentally manipulate the sounds and syllables in words) have been shown to impact literacy skills, and children with speech sound disorders are at risk for inappropriate development of phonological awareness and later literacy. For this reason, clinicians have been drawn into using their knowledge of phonology as a way to understand a child's literacy development.

Before we decide that there actually is a problem, however, we need to recall some of our earlier discussion. We must recognize that some children use different speech sounds than those found in their environment because perhaps their first language is different from English, or maybe they are a part of a regional or cultural group that uses a less common dialect of English. Certainly, the increasing cultural diversity, the number of second-language learners, and other languages spoken in the United States make us acutely aware of the fact that linguistic differences are a part of everyday communication. As speech-language pathologists, we are primarily focused on disorders that individuals may have in their speech sound productions. When the clinician does not speak the language or dialect of a client, it is sometimes very challenging to determine what constitutes a disorder and what is a language or dialectal difference. Although there are some guidelines to help us, the reality is that there is a need for clinicians who are bilingual and/or represent different language/dialect groups. All sound systems, whether they are a part of a separate language or dialect, are legitimate and deserve acceptance. In some instances, the clinician may, however, help an individual learn an alternative sound system in order to fit in with speakers of other dialects of English when a client elects to do this, often for educational, business, or social reasons.

APPROACHING THE PROBLEM WITH EVIDENCE

A final note in laying the groundwork for our study of speech sound disorders is to place it in its most current context. The dawn of the current millennium brought with it a new era of accountability. Those who pay for our services, whether taxpayers, school or hospital administrators, insurance executives, or our clients and their families, have begun to ask that we as a profession demonstrate that the services we provide are both effective (i.e., that they actually work) and efficient (i.e., that they do so in the most cost-effective way). No longer is it sufficient for us to simply say, "Trust us; we know what we're doing." We need to provide scientific evidence; put another way, we need to demonstrate that we are engaging in *evidence-based practice (EBP)*. This book is a step in that direction. In her 2007 book on EBP, Christine Dollaghan suggests that EBP requires

> the conscientious, explicit, and judicious integration of 1) best available *external* evidence from systematic research, 2) best available evidence *internal* to clinical practice, and 3) best available evidence concerning the preferences of a fully informed patient. (p. 2, italics in original)

Relative to external evidence, this book has, since its first edition, been about presenting the best of the available scientific studies related to working with children who have speech

sound disorders. This edition is no different. We will also discuss how the conscientious clinician can and should generate his or her own internal evidence about whether what he or she is doing with each client is in fact resulting in meaningful change. Finally, relative to patient preferences, the past 20 years have yielded a long and varied menu of treatment approaches, which we will highlight. It is no longer a matter of clinicians simply telling parents that we will "do artic therapy." Rather, parents of children with speech sound disorders need to be made aware of available treatment options, and EBP mandates that they be partners in determining which approach or instructional format may be best prescribed for their child.

Each of the chapters that follow was developed with the thought of providing the latest information and research in clinical phonology. The breadth and depth of information presented is designed to provide a broad-based perspective of how SLP can go about helping children who face difficulties producing the sounds of the language.

CHAPTER 2

Normal Aspects of Articulation

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This book is focused on the ability of humans to produce sounds that are used to convey a message. The act of producing such sounds is identified as *articulation*, and this activity is a major component of *speech* as distinguished from the term *language*. *Speech* consists of an organized set or system of sounds that are used to convey meaning. Meaning itself is based in *language*, which includes the collection of words that are used in phrases and sentences and the grammar or rules of the language that we use to create those phrases and sentences. More formally, *language* may be described as an arbitrary system of signs or symbols used according to prescribed rules to convey meaning within a linguistic community. Of course, once an arbitrary association of symbol with meaning has been developed, the users of that language must learn and use this association of symbols if they want to communicate with one another. The word *dog* has a certain meaning in the English language, and this word can be communicated to other users of English through speaking, writing, or signing it with symbols used by people who are deaf.

Speech is but one modality for the expression of language; however, speech has special importance because it is the primary, first-learned modality for hearing language users. Speech is a system in the sense that it consistently and usefully relates the meanings of a language with the sounds by which the language is communicated.

Not all sound variations in speech are related to meaning. When a person suffers from a cold, he or she has a different way of talking, but so long as the cold is not so severe as to make speech unintelligible, the relation of sound to meaning is basically the same as when the person is healthy. The acoustic signal of speech—that is, the vibrations of air molecules in response to the energy source of human speech—carries more information than just the expression of meaning. As we listen to a speaker, we often make judgments not only about the intended meaning but also about the speaker's age and sex (if the speaker isn't visible), the speaker's mood, the speaker's state of health, and perhaps even the speaker's dialectal background. Thus, on hearing a simple question—"Could you tell me the time, please?"—we might deduce that the speaker is a young southern woman in a hurry, an elderly British gentleman in a cheerful mood, or a young boy quite out of breath.

STRUCTURE OF LANGUAGE

Speech sounds, then, may be viewed from two perspectives: (1) as motor production (speech) and (2) as units that facilitate the expression of meaning (language). When sounds are studied as part of the language system, they are called *phonemes*.

To derive a speaker's meaning, the listener is basically concerned with the phonemes in the speech message. From a linguistic perspective, phonemes are sound units related to decisions about meaning. In the list *cat hat mat bat sat fat that chat,* each word rhymes with every

other word because all end with the same sounds (the vowel /æ/ and the consonant /t/). However, the words differ in their initial sounds, and these differences can change the meaning of the syllables. In fact, the linguist identifies the phonemes in a given language by assembling lists of words and then determining the sound differences that form units of meaning. The layperson usually thinks of words as the units of meaning, but the linguist recognizes a smaller form called the *morpheme*. For example, the linguist describes the words *walked* and *books* as having two morphemes: *walk* + *past tense* for *walked*, and *book* + *plural* for *books*. If two sounds can be interchanged without changing word meaning, or if they never occur in exactly the same combination with other sounds, then they are not different phonemes. Hence, phonemes are the minimal sound elements that represent and distinguish language units (words or morphemes).

A *phonemic transcription* (which is always enclosed in virgules / /) is less detailed than a *phonetic transcription* (which is enclosed in brackets [ ]). A phonetic transcription is sensitive to sound variations within a phoneme class. An individual variant of this kind is called an *allophone*. Thus, a phoneme is a family of allophones. Phonemes are the minimal set of sound classes needed to specify the meaningful units (words or morphemes) of the language. Allophones are a more numerous set of distinct sounds, some of which may belong to the same phoneme family. As a very simple example, the word *pop* begins and ends with the same phoneme but often begins and ends with a different allophone. If the final /p/ is produced by holding the lips together after they close, then this sound is the unreleased allophone of the /p/ phoneme. However, the initial /p/ must be released before the vowel is formed, so this sound is the released allophone of the /p/ phoneme. The /p/ phoneme also includes a number of other allophones, though perhaps not as obvious as these two.

To understand more clearly the difference between phonemes and allophones, say the following word-pairs to yourself as you try to detect a difference in the production of the italicized sounds.

*k*eep – *c*oop	(phoneme /k/)
m*a*n – b*a*t	(phoneme /æ/)
te*n* – te*n*th	(phoneme /n/)

In the first pair of words, the phoneme /k/ is articulated toward the front of the mouth in the first word and toward the back of the mouth in the second. Despite the differences in the place of tongue contact, the two sounds are heard by speakers of English to be the same phoneme. Speakers of other languages, such as Arabic, may hear the two sounds as different phonemes. The tongue-front and tongue-back versions are allophones of the /k/ phoneme in English.

In the next pair of words, *man* and *bat*, the pertinent difference might be more easily heard than felt through articulation. In the word *man*, the vowel is nasalized (produced with sound transmission through the nose) owing to the influence of the surrounding nasal consonants. But in the word *bat*, the vowel /æ/ is not normally nasalized. The phonetic environment of the vowel—that is, its surrounding sounds—determines whether the vowel is nasalized. The nasal and nonnasal versions of the vowel are allophones of the /æ/ phoneme.

Finally, in comparing /n/ in the words *ten* and *tenth*, you might notice that your tongue is more toward the front (just behind the upper front teeth) in the word *tenth*. The final *th* sound exerts an articulatory influence on the preceding /n/, causing it to be dentalized or produced at the teeth. Again, the two types of /n/ are simply allophones of the /n/ phoneme.

Allophonic variation is of two types: complementary distribution and free variation. In *complementary distribution*, two (or more) allophones never occur in exactly the same phonetic environment, so the occurrence of one is complementary (nonoverlapping) to the occurrence of the other. For example, the front and back /k/ discussed above are in complementary distribution. The front /k/ occurs in the environment of vowels made in the front of the mouth, and the back /k/ occurs in the environment of vowels made in the back of the mouth. Similarly, the nasal and nonnasal allophones of /æ/ are in complementary distribution, determined by the presence

or absence of nasals in the phonetic environment. The nasalized /æ/ occurs only when this vowel is preceded or followed by nasal sounds. Allophones are said to be in *free variation* when they can occur in the same phonetic context. For example, the released /p/ and the unreleased /p/ are in free variation in word-final position in words like *pop* or *map*. As previously indicated, the final /p/ can be released audibly with a small burst as the lips open, or it can be unreleased if the lip closure is maintained.

The discipline of linguistics is concerned primarily with the structure of language. The disciplines of psychology and speech-language pathology are concerned primarily with the processing of language—with its formulation and its reception. The linguistic study of language structure has influenced the study of language processing, and, to some degree, the reverse is true as well. Descriptions of language processing often use terms such as *syntax, semantics, phonology*, and *phonetics* that denote traditional areas of linguistic study. These terms have come to have a dual usage, one referring to structure and another to processing.

To briefly round out our discussion of the structure of language, we need to mention phonemes and morphemes. *Phonemes* are combined to produce meaningful units, called *morphemes*, which we usually identify as words. However, it should be recognized that a given word, such as *walked*, may actually be composed of two or more morphemes—in the case of *walked*, the morphemes are the verb *walk* and the past tense marker *ed. Morphemes* are combined into phrases and sentences according to the grammatical rules of the language, and these combinations are referred to as the *syntax* of the language. Thus, language includes a set of phonemes and morphemes that are combined according to certain rules to reflect the syntax of the language. Meaning that is ascribed to individual words is identified as the *semantics* of the language. In a sense, the components of language (phonology, morphology, syntax) are one side of the coin, with semantics being the other side.

Figure 2.1 is a diagram of an information-processing model of verbal formulation and utterance production. The diagram attempts to show how different types of information are

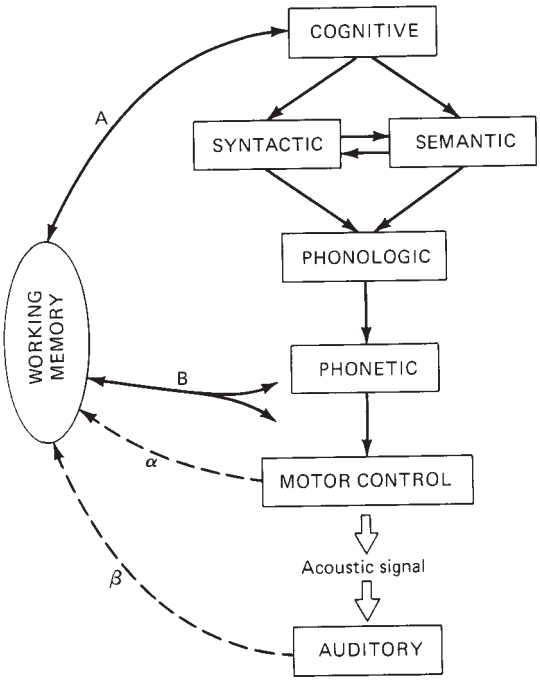

FIGURE 2.1 Information-processing model of verbal formulation production.

Source: Adapted from Bock (1982).

processed in the act of speaking. The cognitive level is where a thought is initiated. This is a prelinguistic, propositional level that involves decisions such as the identification of participants and actions. For example, the cognitive processing that preceded formulation of the sentence, *The dog chased the cat*, involved the identification of a dog and a cat as participants and chasing or pursuit as an action. However, the specific words *dog*, *cat*, and *chased* were not actually selected. Rather, concepts that later lead to the identification of these words at the semantic level are established.

Information from the cognitive level is used to make decisions at the syntactic and semantic levels. Syntax involves the ordering of words in a sentence, and semantics involves the selection of words. Research on verbal formulation indicates that syntactic and semantic processing is interactive (hence, the arrows between them in the diagram). Deciding on a particular syntactic structure for a sentence can influence word selection, and selection of particular words can limit or direct syntactic decisions. The semantic level is sometimes called *lexicalization*, or the choice of lexical units. Lexicalization appears to be a two-stage process. The first stage is selection of a lexical concept, not a phonologically complete word. Phonologic specification—that is, specification of the word's sound pattern—is accomplished in the second stage of the process. The phonologic level in Figure 2.1 is the level at which the evolving sentence comes to have phonologic structure. Various decisions are made at this level to ensure that a sound pattern accurately represents the syntactic and semantic decisions made earlier. The phonologic information then directs decisions at the phonetic level, where the details of the sound pattern are worked out. We might think of the phonetic level as producing a detailed phonetic representation of the utterance.

The output of the phonetic level is sufficient to specify the phonetic goals to be satisfied in speech production. Actual motor instructions are determined by a motor control level. This level selects the muscles to be activated and controls the timing and strength of the muscle contractions. This is no small task. Speech requires rapid changes in the activation of about 100 muscles, which are controlled to meet exacting spatiotemporal goals. Once the muscles have done their work, the acoustic speech signal is produced. This signal is then processed by the speaker and the listener(s) as auditory information. For the speaker, the auditory processing completes a feedback loop.

One component that remains to be explained in Figure 2.1 is working memory and its connections to other parts of the diagram. Working memory is a speaker's operational memory, the memory that is used to keep track of the information involved in sentence production. But this memory is limited, so it is in the interest of efficient processing to minimize demands on it. Therefore, the theory goes, two kinds of processing are involved in utterance production. One is *controlled processing*; this kind makes demands on working memory. The other is *automatic processing*, which does not require allocation of working memory. Verbal formulation is performed with both controlled processing and automatic processing. Controlled processing can be identified in Figure 2.1 by the arrows labeled A and B. Note that syntactic, semantic, and phonologic processing are automatic; that is, the speaker does not have direct access to these operations. It is for this reason that slips of the tongue are not detected until they are actually spoken.

Feedback is provided by two channels, labeled α and β in Figure 2.1. Channel α represents information from touch and movement. Channel β represents auditory feedback.

Researchers have concluded that when a person ordinarily produces a sentence, he or she doesn't make all of the syntactic, semantic, and phonologic decisions before beginning to speak. Rather, it is likely that the individual will utter a few words and then formulate the remainder of the utterance.

According to this view of verbal formulation, producing a sentence involves highly interactive levels of processing and a complex time pattern for this processing. It would not be surprising, then, to discover that articulation is affected by syntactic, semantic, and phonologic variables.

The following discussion of articulatory phonetics presents basic information on speech sound production. For the student who has had a course in phonetics, this chapter will serve as

a summary review. The student without such background should be able to acquire at least the basics of articulatory phonetics. The topics to be discussed are these:

- The Speech Mechanism
- Vowels
  - Monophthongs (single vowels)
  - Diphthongs
- Consonants
  - Stops
  - Nasals
  - Fricatives
  - Affricates
  - Liquids
  - Glides
- Suprasegmentals
- Coarticulation
- Aerodynamics
- Acoustics
- Sensory Information
- Implications for Acquisition

FUNDAMENTALS OF ARTICULATORY PHONETICS

The Speech Mechanism

The anatomy of the speech production system is not within the scope of this chapter, but some general anatomical descriptions are needed to discuss the fundamentals of articulatory phonetics. The basic aspects of speech production can be understood by an examination of six principal organs or subsystems, illustrated in Figure 2.2. The *respiratory system*, consisting of the lungs, airway, rib cage, diaphragm, and associated structures, provides the basic air supply for generating sound. The *larynx,* composed of various cartilages and muscles, generates the voiced sounds of speech by vibration of the vocal folds, or it allows air to pass from lungs to the vocal tract (the oral and nasal cavities) for voiceless sounds. The *velopharynx*—the soft palate (or velum) and associated structures of the velopharyngeal port—joins or separates the oral and nasal cavities so that air passes through the oral cavity, the nasal cavity, or both. The *tongue*, primarily a complex of muscles, is the principal articulator of the oral cavity; it is capable of assuming a variety of shapes and positions in vowel and consonant articulation. For articulatory purposes, the tongue is divided into five major parts: the tip or apex, the blade, the back or dorsum, the root, and the body. These divisions are illustrated in Figure 2.3. The *lips*, along with the jaw, are the most visible of the articulators; they are involved in the production of vowels and consonants. The *jaw*, the massive bony structure and its associated muscles, supports the soft tissues of both tongue and lower lip. It participates in speech production by aiding tongue and lip movements and by providing skeletal support for these organs. Other anatomical features shown in Figure 2.2 provide general orientation or are relevant in a significant way to the processes of speech and hearing.

The respiratory system and larynx work together to provide the upper airway with two major types of air flow: a series of pulses of air created by the action of the vibrating vocal folds (for voiced sounds like the sounds in the word *buzz*) and a continuous flow of air that can be used to generate noise energy in the vocal tract (for voiceless sounds like the *s* in *see*). The basic function of the respiratory system in speech is to push air into the airway composed of the larynx and the oral and nasal cavities. The basic function of the larynx is to regulate the airflow from the lungs to create both voiced and voiceless segments. The upper airway, often called the *vocal tract*, runs from the larynx to the mouth or nose and is the site of what is commonly called

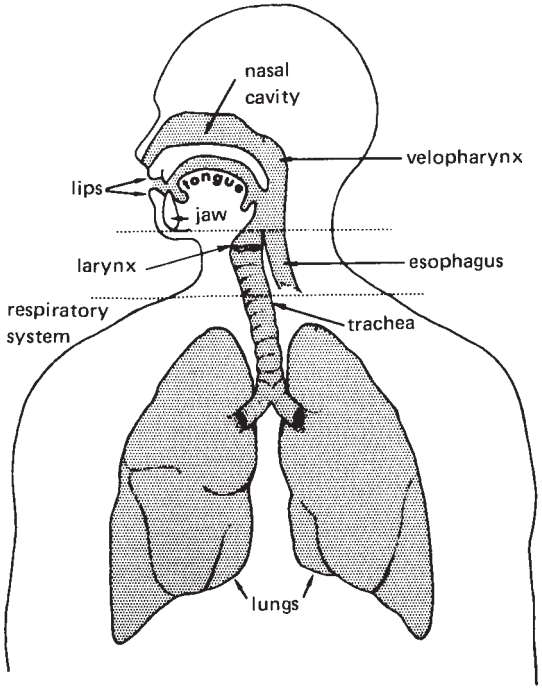

FIGURE 2.2 Organs of speech production.

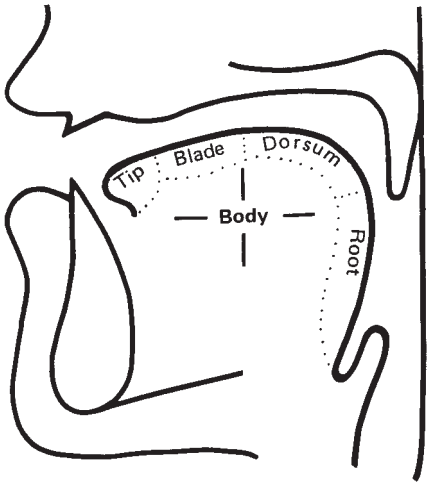

FIGURE 2.3 Divisions of tongue into five functional parts for speech articulation.

speech articulation. For the most part, this process is accomplished by movements of the *articulators*: tongue, lips, jaw, and velopharynx. The vocal tract may be viewed as a flexible tube that can be lengthened or shortened (by moving the larynx up and down in the neck or by protruding and retracting the lips) and constricted at many points along its length by actions of tongue, velopharynx, and lips. Speech articulation is thus a matter of lengthening, shortening, and constricting the tube known as the *vocal tract.*

This entire process is controlled by the nervous system, which must translate the message to be communicated into a pattern of signals that run to the various muscles of the speech mechanism. As these muscles contract, a variety of things can happen: Air may be pushed out of the lungs, the vocal folds may start to vibrate, the velopharynx may close, the jaw may lower, or the

lips may protrude. The brain has the task of coordinating all the different muscles so that they contract in the proper sequence to produce the required phonetic result. The margin for error is small; sometimes an error of just a few milliseconds in the timing of a muscle contraction can result in a misarticulation.

It is appealing to suppose that speech production is controlled at some relatively high level of the brain by discrete units, such as phonemes. However, a major problem in the description of speech articulation is to relate the discrete linguistic units that operate at a high level of the brain to the muscle contractions that result in articulatory movements. For example, to say the word *stop*, a speaker's brain must send nerve instructions, in the proper sequence, to the muscles of the respiratory system, larynx, tongue, lips, and velopharynx. The full understanding of speech production therefore involves a knowledge of *phonology* (the study of how sounds are put together to form words and other linguistic units), *articulatory phonetics* (the study of how the articulators make individual sounds), *acoustic phonetics* (the study of the relationship between articulation and the acoustic signal of speech), and *speech perception* (the study of how phonetic decisions are made from the acoustic signal).

Vowel Articulation: Traditional Phonetic Description

A vowel sound is usually formed as sound energy from the vibrating vocal folds escapes through a relatively open vocal tract of a particular shape. Because a syllable must contain a vowel or vowel-like sound, vowels sometimes are called *syllable nuclei*. Each vowel has a characteristic vocal tract shape that is determined by the position of the tongue, jaw, and lips. Although other parts of the vocal tract, like the velum, pharyngeal walls, and cheeks, may vary somewhat with different vowels, the positions of the tongue, jaw, and lips are of primary consequence. Therefore, individual vowels can be described by specifying the articulatory positions of tongue, jaw, and lips. Furthermore, because the jaw and tongue usually work together to increase or reduce the mouth opening (Figure 2.4), for general phonetic purposes, vowel production can be described by specifying the positions of just two articulators, tongue and lips. Usually the vocal folds vibrate to produce voicing for vowels, but exceptions, such as whispered speech, do occur.

The two basic lip articulations can be demonstrated with the vowels in the words *he* and *who*. Press your finger against your lips as you say first *he* and then *who*. You should feel the lips push against your finger as you say *who*. The vowel in this word is a rounded vowel, meaning that the lips assume a rounded, protruded posture. Vowels in English are described as being either rounded, like the vowel in *who*, or unrounded, like the vowel in *he*. Figure 2.5 illustrates the lip configuration for these two vowels.

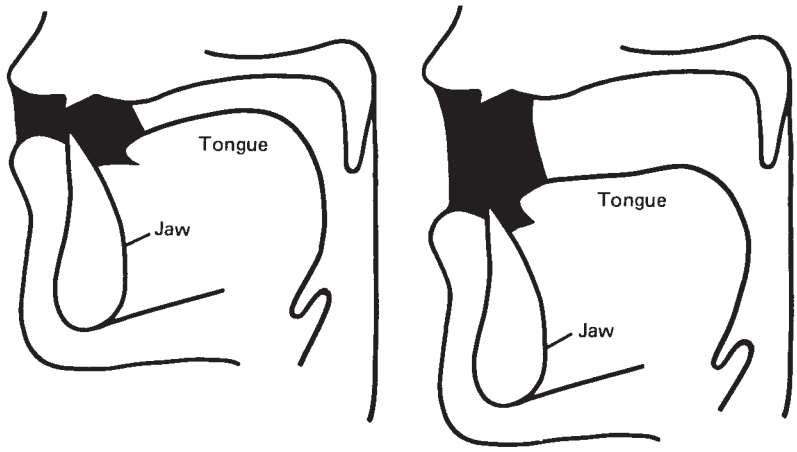

FIGURE 2.4 Variations in mouth opening (darkened area) related to lowering of jaw and tongue.

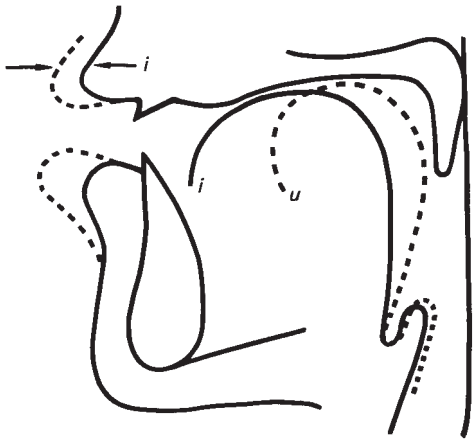

FIGURE 2.5 Vocal tract configurations for /i/ and /u/. Note lip rounding for /u/.

The tongue moves in essentially two dimensions within the oral cavity, as shown in Figure 2.6. One dimension, front-back, is represented by the motion the tongue makes as you alternately say *he*, *who* or *map*, *mop*. The other dimension, high-low, is represented by the motion the tongue makes as you say *heave-have* or *who-ha*. With these two dimensions of tongue movement, we can define four extreme positions of the tongue within the oral cavity, as shown in Figure 2.7. The phonetic symbols for these four vowels also are shown in the illustration. With the tongue high and forward in the mouth, the high-front vowel /i/ as in *he* is produced. When the tongue is low and forward in the mouth, the low-front vowel /æ/ as in *have* is produced.

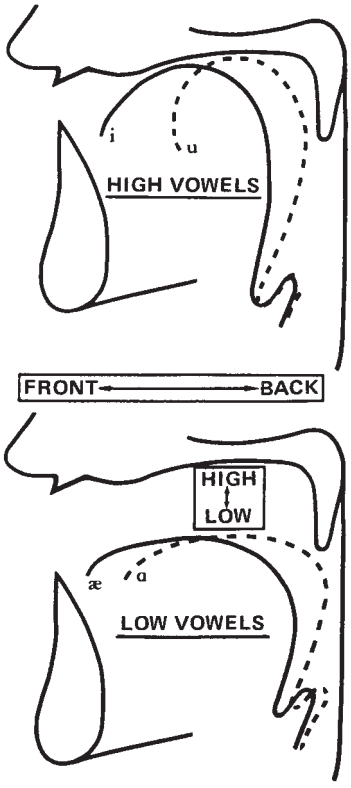

FIGURE 2.6 The two major dimensions of tongue position, front-back and high-low.

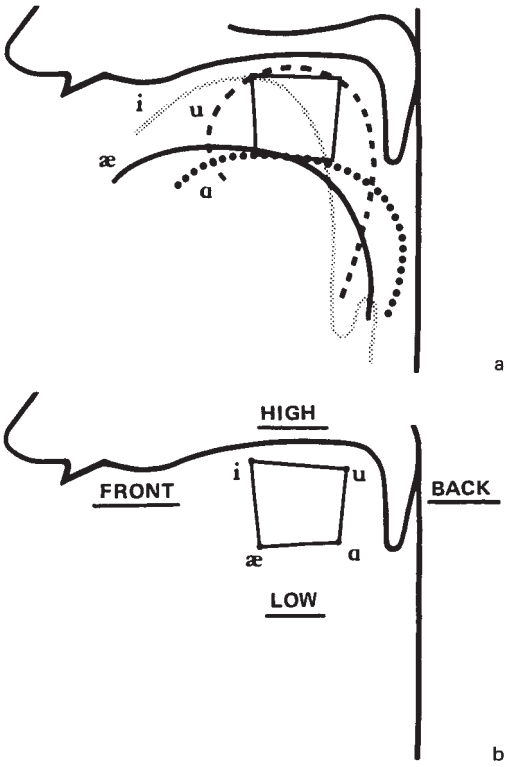

FIGURE 2.7 The four corner vowels /i/, /u/, /ɑ/, and /æ/ are shown *(a)* as tongue positions in the oral cavity and *(b)* as points of a quadrilateral.

A tongue position that is high and back in the mouth yields the high-back vowel /u/. Finally, when the tongue is low and back in the mouth, the vowel is the low-back /ɑ/. The four vowels, /i/, /æ/, /u/, and /ɑ/, define four points that establish the *vowel quadrilateral*, a four-sided figure against which tongue position for vowels can be described. In Figure 2.8, the vowels of English have been plotted by phonetic symbol and key word within the quadrilateral. As an example, notice the vowel /I/ as in *bit* has a tongue position that is forward in the mouth and not quite as high as that for /i/. The tongue position for any one vowel can be specified with terms such as low-high, front for /I/ as in *bit*, low-mid, front for /ɛ/ as in *bet*, mid-central for /ɝ/ as in *Bert*, and low-mid, back for /ɔ/ as in *bought*.

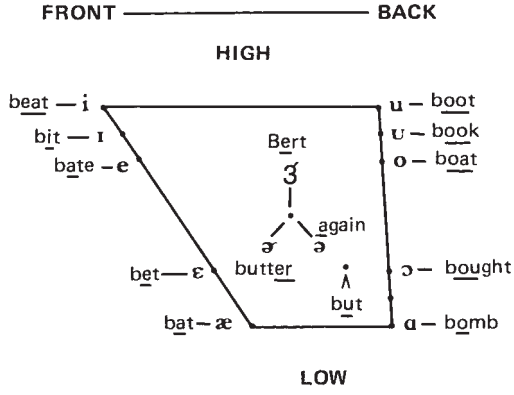

FIGURE 2.8 English vowels, identified by phonetic symbol and key word and plotted within vowel quadrilateral.