

Introduction to
Speech Sound Disorders



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PREFACE

The motivation and inspiration for *Introduction to Speech Sound Disorders* comes from our work as pediatric speech-language pathologists, as instructors and mentors of students in communication sciences and disorders, and as researchers in the assessment and treatment of speech sound disorders. This comprehensive textbook was written for undergraduate students in speech, language, and hearing sciences as well as their instructors. Children with speech sound disorders form the largest part of the speech-language pathologist caseload in child-focused settings. A course on speech sound disorders is often among the first courses with a clinic focus offered in the curriculum of programs in our discipline. However, this does not mean that speech sound disorders is an easy subject, or that treating children with speech sound disorders is easy to do—in fact, phonological development is a complex process, speech sound disorders are varied and challenging, and competent treatment of children requires a broad range of domain-specific and domain-general skills.

With this book, we aimed to introduce undergraduate students to foundational concepts and procedures that will prepare students for graduate level study of speech sound disorders and early supervised clinical practice with children. The text and associated companion

website are intended to support new and experienced instructors as they strive to facilitate novice-level clinical competencies in their speech-language pathology students. The book is organized in a coherent manner to ensure that all new terms are defined. Furthermore, important concepts are reintroduced repeatedly in new contexts to enrich learning. Practice activities are provided in each chapter to encourage interactive learning. The flow of the chapters was carefully developed to ensure that students can build on previous knowledge and proceed from introduction to practice.

One challenge for instructors of courses on speech sound disorders is the varied range of knowledge that students bring to this course—some will remember all concepts covered in their prerequisite phonetics course and speech and hearing science course, and some students will have forgotten most of the information they learned one or two years earlier. For this reason, Chapter 1 defines the major concepts and constructs in phonetics and phonology currently framing the study of speech sound disorders in children that we wish every undergraduate student remembered. This chapter can be covered in the course or not—it could be assigned as independent work for students who need to review this material, and the instructor could begin the course with

Chapter 2. The second chapter provides a thorough description of typical and atypical development of speech perception and speech production in infants, toddlers, preschoolers, and school-age children. Subsequent chapters cover assessment, interpretation and diagnosis, treatment planning, and the selection and implementation of an appropriate intervention. The last chapters of the book describe input-oriented, output-oriented, and phonological approaches. Detailed examples, illustrations, tables, and figures increase comprehension throughout each chapter. Key point boxes encourage review of important concepts at the end of each section.

It is our hope that this book will raise the standard for undergraduate instruction in the field of speech sound disorders and that we will inspire students to pursue careers dedicated to improving the communication abilities of children. Our lives have been immeasurably enriched by our many years of service to children with speech and language disorders, to whom we dedicate this book. We also thank our families for all the support they provided to us throughout the process of writing our second book together: Françoise's husband Ray and her daughters Sophie, Laura, and Catherine and Susan's husband Ken Bott and her daughter, Vivian Bott.

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Concepts in Phonetics and Phonology

Learning Objectives

- Explain the difference between phonetics and phonology.
- Determine the phonetic repertoire from the transcription of a child's speech sample.
- Evaluate the advantages and disadvantages of transcription to describe articulatory knowledge.
- Define categorical perception and differentiate identification and discrimination tests of phoneme perception.
- Define phoneme, allophone, and phonotactic rule.
- Describe the three primary components of prosody and identify words with trochaic and iambic prosodic patterns.
- Diagram the internal components of syllables (onset, nucleus, coda).
- Identify common patterns of phonological error in child speech.

There is great power in being able to communicate effectively, which requires at a minimum being understood by our communication partner. However, the value of producing speech accurately is often taken for granted. Most of us use speech to communicate, without difficulties, and do not reflect on the way in which speech sounds are produced and combined to produce language. Speech-language pathologists

(SLPs) must be able to describe the child's ability to produce speech sounds clearly, perceive speech sounds accurately, and combine speech sounds into words that other listeners will understand. Although the child's knowledge of these aspects of phonetics and phonology is implicit, the SLP's knowledge must be explicit. That is, the SLP must not only be able to say a word; he or she must be able to explain

why that is the appropriate word to use in that context, describe the sounds that make up the word, and show how those sounds are produced. The first part of this chapter presents basic concepts in phonetics, and the second portion focuses on basic concepts in phonology.

1.1 PHONETIC CONCEPTS

Phonetics is concerned with the physical characteristics of speech sounds as produced by the speaker to transmit meaning and as received by the listener to understand what was said (Ohala, 1999). A **phone** is the smallest unit of speech; any sound that is used for speech in any of the languages of the world is a phone. Phonetics is therefore the study of speech sounds, or the study of phones. By convention, speech sounds that are produced by a speaker (phones) are represented between square brackets []. These square brackets are differentiated from slashes / /, which are used to identify **phonemes**, a more abstract representation of speech sounds that will be discussed in section 1.4.

Different tools and scientific specializations are required to study speech sounds as they are produced, as they are transmitted through the air, and as they are received by the listener (Pierrehumbert, 2003). **Articulatory phonetics** is concerned with the way that speech sounds are produced with the articulators. **Articulators** are the parts of the human body that are involved in speech production, as will be described further in this chapter. **Acoustic phonetics** is the study of speech sounds as transmitted through the air in the form of sound waves. Acoustic phonetics may also be concerned with the relationship between the acoustic properties of sound waves and the way that the listener perceives different speech sounds. This process is called **phonetic encoding**. Figure 1–1 presents a simple schema of the speaking and listening process as related to these branches of phonetics. In the figure, the speaker wants to transmit a message about the cat. In order to do so, the speaker must access a semantic representation (“cat”) that contains information about the meaning of this word and a phonological representation (/kæt/), shown in the figure as a series of pho-

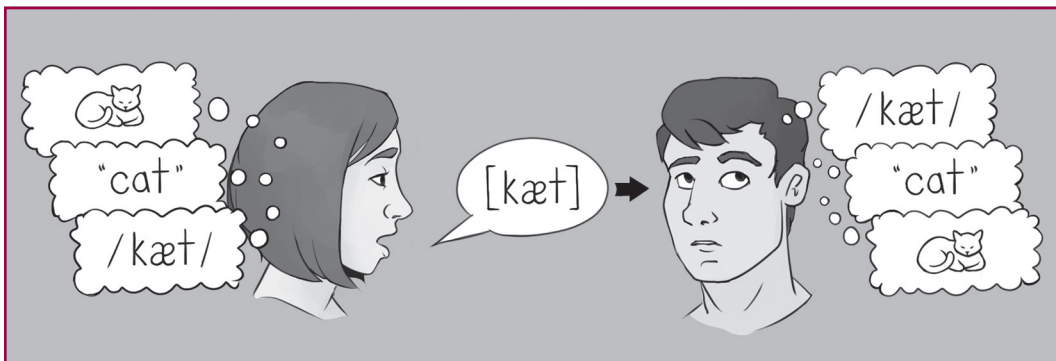


Figure 1–1. Phonetics is concerned with the production, transmission, and encoding of speech sounds (see text for explanation). Used with permission from Ellen Graham-Platt.

nemes for convenience, but actually containing more abstract information about the phonology of this word, as will be discussed in more detail later in this chapter. Once having accessed these abstract representations, the speaker retrieves and sequences **articulatory-phonetic representations** [k], [æ], [t] and sends the corresponding motor commands to the articulators to produce the word. The acoustic signal is transmitted through air and reaches the listener's outer ears; the eardrum vibrates; the vibrations are carried through the middle ear to the inner ear, and the cochlea provides auditory input to the central auditory system in the brain. The listener must now reverse the speaker's process to abstract the sequence of sounds ([kæt]), this time in the form of an **acoustic-phonetic representation**, and link the result to the corresponding phonological (/kæt/) and semantic ("cat") representations to understand the speaker's intended meaning.

1.1.1 Articulatory Phonetics

Articulatory phonetics focuses on how speech sounds are produced and how these sounds can be classified based on aspects of their production. **Articulation** usually refers more broadly to the general production of speech by a talker, such as whether the individual articulates speech sounds clearly and precisely or mumbles.

Three physiological subsystems contribute to speech production: the respiratory system, the phonatory system, and the articulatory/resonating system. Figure 1–2 shows a simplified schema of these three subsystems. First, the respiratory system provides airflow, the required energy source to produce speech sounds.

Second, the larynx (also called "voice box") is the main component of the phonatory system. The vocal folds are situated in the larynx and vibrate very rapidly, setting the airflow into vibration, creating sound. Third, the articulatory/resonating system is composed of the pharyngeal, oral, and nasal cavities. These three cavities form the vocal tract. The cavities of the vocal tract resonate the vibrating sound waves as they pass through from the larynx to the outside air. Specifically, when the speaker varies the size and shape of the vocal tract, the sound waves are modified, to create all the vowels and consonants (Kent, 1997). The human vocal tract is shown in Figure 1–3. The shape and size of the vocal tract is primarily modified by movements of the tongue, although the lips, teeth, hard palate, and velum also impact speech production.

Practice 1–1



Articulators are the parts of the body that you move to produce speech. Produce the words "key," "me," "see," "bee," and "boot."

Notice that changes in the larynx and in the manner of airflow through the vocal tract also result in different speech sounds. Try to sense how changes in the position of the tongue and the lips impact speech production. The shape of your lips when saying [b] in "bee" and "boot" were probably different because of **co-articulation**.

While producing speech, the stages of respiration, phonation, and articulation do not each have a clear and distinct beginning. Speech is continuous, and the

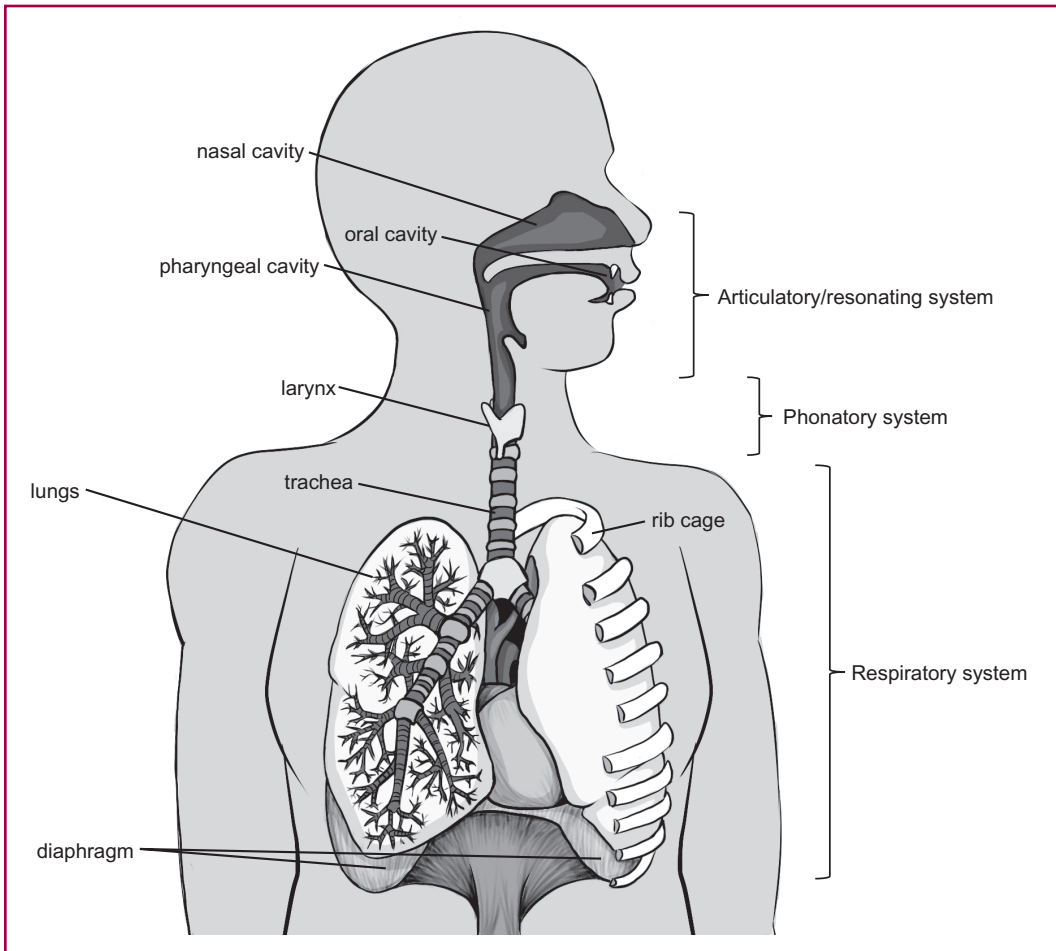


Figure 1–2. Simplified schema of the speech production system. Used with permission from Ellen Graham-Platt.

articulators are in constant motion when the air is flowing. **Co-articulation** occurs when articulators are moving at the same time to produce two different but overlapping phones. In the words “bee” and “sheep” the lips will be spread even before speaking, whereas the lips will be rounded at the beginning of the words “boot” and “shoe,” anticipating the upcoming vowels in these words. **Assimilation** refers to the articulatory changes that occur when one phone becomes more like an adjacent

(neighboring) phone or another phone in the word which is not directly adjacent. Assimilation is the reason that the word “pumpkin” is not pronounced the way it is spelled: the [k] at the beginning of the second syllable makes it easier to end the first syllable with the tongue raised at the back of the mouth. In normal speech production, the movement of the articulators will be modified depending on preceding or following phones to reduce effort and increase efficiency of speech

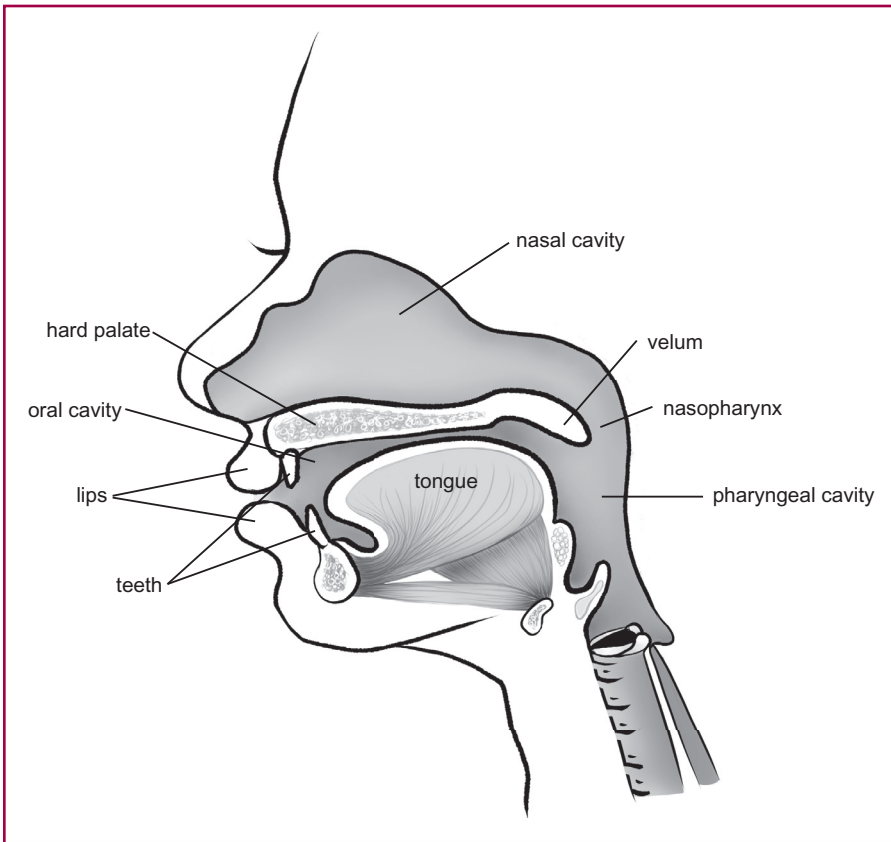


Figure 1–3. The adult human vocal tract with articulators labeled. Used with permission from Ellen Graham-Platt.

production. Therefore, co-articulation and assimilation occur very frequently in adult and child speech.

Given the importance of articulatory phonetics to the competent practice of speech-language pathology, a brief overview of the articulatory characteristics of English vowels and consonants is provided here. Consultation with a detailed phonetics text is advised for all SLPs, however (e.g., Shriberg & Kent, 2013; Small, 2016). Phone classes are first determined by **manner of articulation**, that is, the manner or type of constriction that is made in the vocal tract. Phone classes are

further distinguished by **place of articulation**, that is, the location of the constriction in the vocal tract. Finally, phones may be **voiced** or **voiceless**, in other words, produced with or without vibration of the vocal folds.

Beginning with the manner classes, summarized in Table 1–1, **vowels** are produced with an open vocal tract. Vocal fold vibration is usually maintained throughout the production of the sound, but otherwise the airflow through the vocal folds to the lips is mostly unblocked. In English the airflow is directed through the oral cavity during most vowels, although there

Table 1-1. Articulatory Characteristics of Major Classes of Phones in English by Manner of Articulation

Manner Class	Articulatory Characteristic	English Phones
Vowels	Transmit air through vibrating vocal folds and open vocal tract; constrictions made by movements of the tongue do not impede airflow between vocal folds and lips.	Monophthongs: [i,ɪ,ʊ,u,e,o,ε,ə,ʌ,ɔ,æ,a,ɑ] Diphthongs: [aɪ,aʊ,oɪ,ou,eɪ] Rhotics: [ə,ɜː]
Consonants	Produced with partial or complete closure of the vocal tract and with the vocal folds open or vibrating.	Voiceless: [p,t,k,ʔ,f,θ,s,ʃ,tʃ,h] Voiced: [b,d,g,m,n,ŋ,v,ð,z,ʒ,dʒ,w,j,ɹ,l]
Plosives (stops)	Briefly close vocal tract to build up air pressure behind the constriction; then release the pressure in the oral cavity.	[p,b,t,d,k,g,ʔ]
Nasals	Close oral cavity but permit airflow through nasal cavity.	[m,n,ŋ]
Fricatives	Close nasopharynx forcing air through narrow constriction in the oral cavity, creating turbulent air flow.	[f,v,θ,ð,s,z,ʃ,ʒ,h]
Affricates	Rapidly release a stop into a narrow constriction that permits a prolonged fricative sound.	[tʃ,dʒ]
Approximants	Approximate the articulators more closely than in the case of vowels but without creating a constriction narrow enough to produce turbulent noise.	Glides: [w,j] Liquids: [l,r]

may sometimes be nasal airflow due to assimilation. Oral airflow is accomplished by raising the velum to close the passage between the pharyngeal and nasal cavities. This passage, shown in Figure 1-3, is called the **nasopharynx** or the velopharyngeal port. The position of the lips impacts the length of the vocal tract—retracting the lips shortens the tract, while rounding and protruding them lengthens the tract. The position of the tongue will modify the size of the pharyngeal cavity (shown in Figure 1-3), such that the pharyngeal cav-

ity will enlarge when the tongue is moved forward, and diminish when the tongue is moved toward the rear of the mouth. Each shape of the vocal tract will have different resonance characteristics, resulting in the production of a different vowel. For example, the vowel in “bee” is produced with a constriction near the front of the mouth which shapes the vocal tract into two parts—a large back cavity joined to a small front cavity. In contrast, the vowel in the word “boot” is produced with a constriction near the back of the mouth so

that the front and back cavities are both large. The front cavity can be made larger still by lowering the jaw, as in words like “bad” and “bought.” When the configuration of the vocal tract changes during the production of the vowel, there is a change in the resonance quality within the same vowel, and a **diphthong** is produced, as in the word “bye” (Ladefoged & Johnson, 2010).

As opposed to the relatively open vocal tract configuration for vowels, **consonants** are characterized by constriction in the oral and/or pharyngeal cavities. For certain consonants, the vocal tract will be completely closed for a moment. For others, the airflow will encounter obstacles, resulting in a partial closure of the vocal tract. In English many but not all consonants are produced in two forms, the **voiced** form and the **voiceless** form, with pairs at the same place of articulation known as **cognates**.

Practice 1–2



Place your fingers over your “Adam’s apple” on the front of your neck and slowly say the sound [p] with a puff of air; then slowly say the sound [b]. You should notice vibration on your fingers during the second sound that was absent during the first sound. Take care to say [p] and not [pa] and compare with [b] and not [ba] because the vocal folds will vibrate during the vowel [a], making it hard to differentiate the voicing characteristics of the two consonants. Try this again with prolonged production of [s] and [z], noticing the lack and presence of vibration during the production of these **voiceless** and **voiced cognates**.

Plosives are produced with a complete but brief interruption of the airflow through the vocal cavity, which is why these phones are also called stops. Closure of the nasopharynx is essential so that air cannot escape through the nose. At the same time, a second closure is created with the tongue or lips in the oral cavity, which creates a build-up of air pressure behind the constriction. When this pressure is suddenly released, an audible burst of air may result that is called **aspiration**.

Nasals are sometimes referred to as nasal stops because their production requires a constriction to close the oral cavity. However, during the production of nasals the velopharynx remains open, allowing sound to enter and escape the nasal cavity. This also lengthens the vocal tract, and changes the resonance of these sounds.

In contrast to stops, **fricatives** are produced with a partial rather than complete closure of the vocal tract. When the air passes through the narrow constriction in the vocal tract, turbulence is created, resulting in a friction noise. Fricatives also require closure of the velopharyngeal port to prevent nasal air escape. The lack of complete interruption of the airflow means that fricative sounds can be prolonged (such as the sound [s] that can be produced continuously for a few seconds, as in “sssssssss”). A related phone class comprises the **affricates**, which combine characteristics of a plosive and a fricative sound. Initially, the oral cavity is sealed and air pressure builds behind the tongue. The tongue then quickly releases contact with the palate to create a constricted opening that permits a prolonged fricative sound to follow the release of the stop.

Approximants are produced by approximating the articulators more closely than in the case of vowels but without

creating a constriction narrow enough to produce turbulent noise. There are two types of approximants, the glides and the liquids. **Glides** are produced with less constriction than during production of a liquid but more than in the production of vowels. Glides are sometimes called semi-vowels, since their production initially requires a slight constriction before transitioning into a more vowel-like open vocal tract. **Liquids** are more consonant-like than the glides but they are continuous in the manner of approximants. During their production there is some constriction in the vocal tract, but the oral cavity is fairly open, and the velopharynx closed. In English, one liquid is a **rhotic**, specifically the sound at the beginning of the word “row” and the end of the word “bar.” This phone can be pronounced with different tongue configurations, as shown in Figure 1–4. The other liquid, specifically the phone at the beginning of the word “low” and the end of the word “ball,” is called a **lateral** because air escapes around the sides of the tongue when the tongue tip is held at the top of the mouth near the alveolar ridge. The liquids /l/ and /ɹ/ may be produced with the tongue tip in a **retroflex** position in which the tongue tip is curled back, but this articulatory gesture is not required to achieve the correct sound.

Practice 1–3



Compare your tongue posture for liquid consonants in the words “row” versus “low” and in “light” versus “pull.” How do you shape your tongue when you say the liquid sounds in these words? Is the tongue tip curled back? Is the tongue body more forward or more back in your oral cavity?

Phones that are differentiated by manner of articulation are also differentiated by the location of the constriction in the vocal tract, that is, by place of articulation. The different places of constriction are shown in Figure 1–5 and described in Table 1–2. Not all possible places of articulation are used by all languages. Furthermore, within one language such as English, not all places of articulation are used within every manner class.

Moving from the front of the vocal tract and working back, the first place of articulation in English is **bilabial**, meaning sounds that are produced by putting the upper and lower lip together. Sometimes these phones, which include plosives, nasals, and a glide, are referred to simply as labial. In the fricative class there are **labiodental** phones, produced by placing the top teeth on the lower lip.

Moving to phones that are produced with constrictions of the tongue tip or blade, **dental** phones are produced by placing the tongue tip between the front teeth, and are thus also called interdental. In English the only interdental phones are fricatives. **Alveolar** sounds are produced by putting the tongue tip up against the alveolar ridge, the bumpy area just behind the upper front teeth. However, these sounds can be produced by placing the tongue tip against the top or bottom teeth as well. In English the alveolar class includes stops, nasals, fricatives, and approximants. **Post-alveolar** sounds in English are fricatives and are therefore produced by bringing the tongue blade close to the area of the palate that is just behind the alveolar ridge. There are no palatal fricatives in English to contrast with the post-alveolar fricatives and therefore the articulatory placement of the tongue during the production of these sounds can be quite variable—the tongue might be

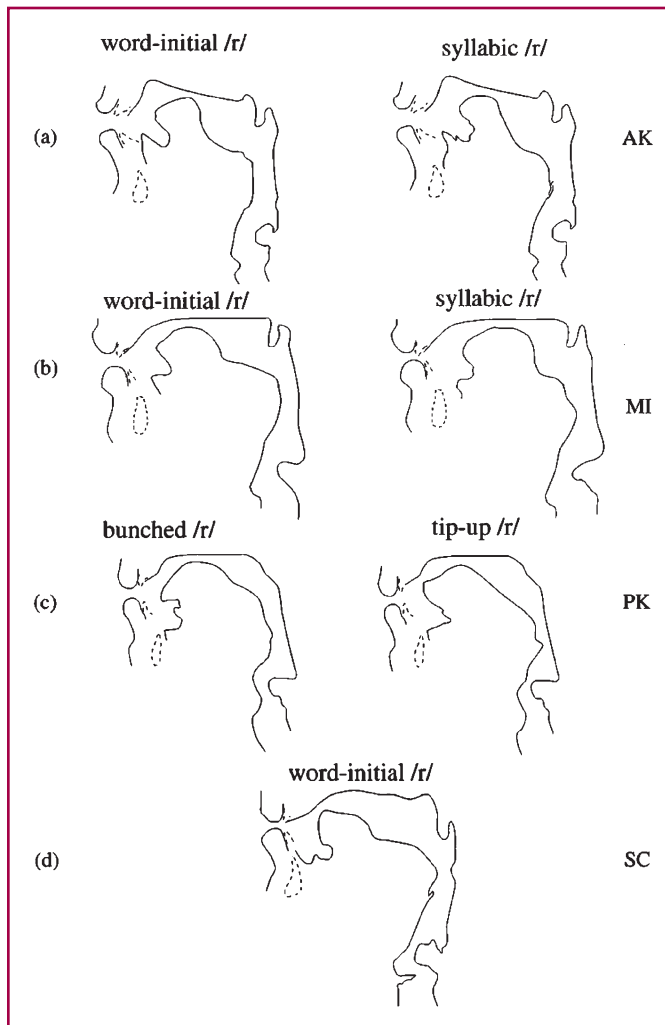


Figure 1–4. Sagittal profiles of the vocal tract during production of [ɹ] by four different adult talkers. Source: Alwan, Narayanan, and Haker (1997). *Toward articulatory-acoustic models for liquid approximants based on MRI and EPG data. Part II. The rhotics.* *Journal of the Acoustical Society of America by the Acoustical Society of America*, 101, Figure 1, p. 1079. Reproduced with permission from the American Institute of Physics for the Acoustical Society of America.

placed in the post-alveolar region or fully in the palatal region (where the hard palate rises behind the alveolar ridge, in the middle of the mouth). English contains two post-alveolar affricates as well.

The tongue body or dorsum is brought into contact with the velum to produce the **velar** phones, which include two stops and a nasal. The liquid [w] also has a velar constriction and is

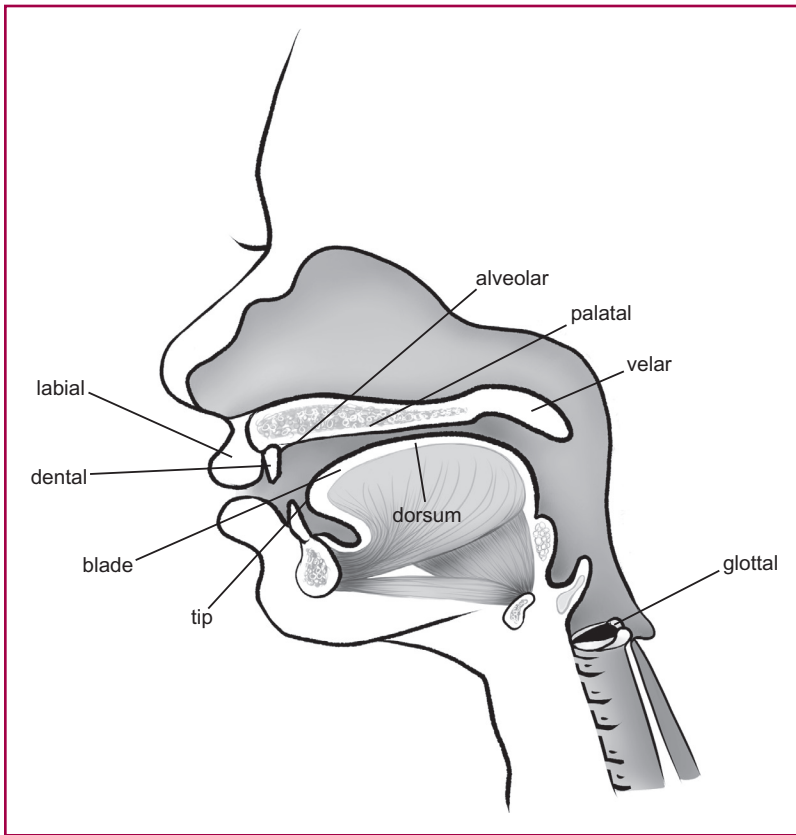


Figure 1–5. Places of constriction of the vocal tract for consonant articulation. Used with permission from Ellen Graham-Platt.

therefore properly classed as a bilabial-velar approximant, although it is put with the bilabials on Table 1–2 for convenience and due to the prominent labial constriction. Moving farther back in the vocal tract, one sound is produced with an obligatory constriction in the pharyngeal cavity, specifically the rhotic “r”: as shown in Figure 1–4, there are three constrictions involved in this phone—one in the pharyngeal cavity, one in the oral cavity in the alveolar or palatal region, and one at the lips. This phone is not classed as a pharyngeal phone, however, in Eng-

lish but rather as an alveolar approximant. Two sounds are produced via constrictions in the larynx: a **glottal** stop in which full closure of the vocal folds results in a build-up of pressure behind them that is released with a “pop” upon opening; and a glottal fricative [h] that is considered by many linguists to be a glide because the constriction is wide and closes into a vowel that is continuous with the [h] by sharing the same vocal tract configuration (Bernhardt & Stemberger, 2000). Both of these glottal sounds are voiceless.

Table 1–2. Articulatory Characteristics of Major Classes of Phones in English by Place of Articulation

Place Class	Articulatory Characteristic	English Phones
Bilabial (Labial)	Produced by putting the upper and lower lip together.	[p,b,m,w]
Labiodental	Produced by placing the top teeth on the lower lip.	[f,v]
(Inter)dental	Produced by placing the tongue tip between the front teeth.	[θ,ð]
Alveolar	Usually produced by placing the tongue tip on or near the alveolar ridge, although sometimes against the upper or lower front teeth.	[t,d,n,s,z,ɹ,l]
Post-alveolar	Usually produced by placing the tongue blade just behind the alveolar ridge or sometimes farther back in the palatal region.	[ʃ,ʒ,tʃ,dʒ,j]
Velar	Produced by bringing the tongue dorsum into contact with the velum or the back part of the palate.	[k,g,ŋ]
Glottal	Produced by closing or constricting the vocal folds.	[ʔ,h]

Note. Voiceless cognates are always shown first followed by the voiced cognate when both members of the pair are produced at a given place of articulation.

Box 1–1. Articulatory Phonetics: Key Points



- Phonetics is the study of speech sounds.
- A phone is the smallest unit of speech.
- Articulatory phonetics is the study of speech sounds as they are spoken.
- Vowels are characterized by an open vocal tract.
- Consonants are characterized by constriction in the oral and/or pharyngeal cavities.

1.2 DESCRIBING ARTICULATORY KNOWLEDGE

1.2.1 International Phonetic Alphabet

The International Phonetic Alphabet (IPA) contains symbols which can be used by a trained listener to transcribe the speech produced by a speaker of any of the world's languages. Figure 1–6 presents the IPA chart. The chart includes symbols for consonants, vowels, suprasegmental features, diacritics, and tones and word accents. Most of the examples contained in