Chapter 2

Articulatory Phonetics

Speech Sound Form

Learning Objectives

When you have finished this chapter, you should be able to:

2.1 Define and classify phonetics and the branches of phonetics.

2.2 Briefly review the anatomical-physiological foundations of speech production.

2.3 List the differences in production and function of vowels versus consonants.

2.4 Identify the descriptive parameters used for vowels of General American English and categorize the vowels accordingly.

2.5 Identify the descriptive parameters used for the consonants of General American English and classify the consonants accordingly.

2.6 Define coarticulation and assimilation, and list the different types of assimilatory processes.

2.7 Identify the various types of syllable structures, including phonotactic restraints that might be noted in children.

Chapter Application: Case Study

Harry is a 7-year-old first-grader. He has a noticeable r-sound problem. Harry's parents thought that he would grow out of the speech problem. However, Harry is beginning to be very self-conscious of the difficulty, especially since the r-sound is in his name. At the beginning of words with "r," he uses a "w" sound; at the end of words, "r" sounds like a type of "uh" (as in "come") or "oo" (as in "look"). Harry is showing some difficulties in spelling. Since r-sounds are so frequent in General American English, Harry's teacher wonders if his articulation might be affecting his spelling. Does he hear the difference between "ring" and "wing," for example, if the context isn't provided when spelling out words to dictation? Harry is now enrolled in speech-language therapy. Considering his "r" problems, what would you do?

Are there specific placement techniques you could use to establish an r-sound? Since there are three ways in which r-sounds can be produced, is one

(continued)

better to try to achieve versus the others? Knowledge of the production features of speech sounds is important for clinicians as they evaluate and treat children with specific sound errors.

Phonetics: Definitions and Classification

The description and classification of speech sounds or phones is the main aim of phonetics. Sounds may be identified with reference to their production (or "articulation"), their acoustic transmission, or their auditory reception. The most widely used description is articulatory, which is the emphasis of this chapter.

Generally stated, phonetics is the science of speech. However, it might be useful to delineate speech in its entirety while also indicating the various divisions of phonetics. Thus defined, **phonetics** is the study of speech emphasizing the description and classification of speech sounds (phones) according to their production, transmission, and perceptual features. Speech production is exemplified by articulatory phonetics; speech transmission by acoustic phonetics; and speech perception by auditory phonetics. In this chapter, the terms *speech sounds* and *phones* will be used interchangeably. However, it should be remembered that according to the American Speech-Language-Hearing Association (ASHA, n.d.-b) definition, speech sounds and their disorders are represented by both form (phone) and function (phoneme) difficulties.

Articulatory phonetics deals with the production features of phones, their categorization, and arrangement according to specific details of their production. Central aspects include the way they are actually articulated, their objective similarities, and their differences. *Articulation* is typically used as a more general term to describe the overall speech production of individuals. Articulatory phonetics as a field of study attempts to document phones according to specific parameters, such as their manner or voicing features. Articulatory phonetics is closely aligned with speech sounds/phones and speech sound disorders.

Acoustic phonetics deals with the transmission properties of speech. Here, the frequency, intensity, and duration of phones are described and categorized, for example. If you have ever analyzed specific sounds according to their frequencies, this would be classified as one aspect of acoustic phonetics.

Video Example 2.1
This short video presents the definition and scope of phonetics. What is the difference between phonetics and phonology? How do the three basic areas of study in phonetics align with what you have just read in this text? Can you add anything to the definitions noted on this page?
https://www.youtube.com/watch?v=nG_tcUlp634

Within **auditory phonetics**, investigators focus on how we perceive sounds. Our ears are not objective receivers of acoustic data. Rather, many factors, including our individual experiences, influence our perception. Such factors are examined in the field of auditory phonetics.

In this text, we are primarily interested in articulatory phonetics and in articulation. An integral portion of articulatory phonetics is the description and classification of speech sounds, in other words, the actualities of how phones are formed. This knowledge is important for both the assessment and treatment of speech sound form errors. Knowledge of the production features of speech sounds guides clinicians when they are evaluating the various misarticulations noted in a clinical evaluation. Thus, one important step in our diagnostic process involves gathering phonetic information on the exact way an individual misarticulates sounds.

Thus, articulatory phonetics *categorizes* and *classifies* the production features of speech sounds. A thorough knowledge of how vowels and consonants are generated remains essential for successful assessment and remediation of speech sound disorders. Although contemporary phonological theories have provided new ways of viewing the diagnosis and intervention of these disorders, knowledge of the speech sounds' production features provides a firm basis for using such procedures. Without this knowledge, phonological process analysis, for example, is impossible.

This chapter discusses articulatory-phonetic aspects of the speech sounds of General American English. The specific goals are to:

1. Provide a brief review of the anatomical-physiological foundation of speech production.
2. List the production features of vowels and consonants of General American English.
3. Introduce the concepts of coarticulation and assimilation as a means of describing how sounds change within a given articulatory context.
4. Examine the structure of syllables, including the phonotactics of General American English.

The production of vowels and consonants as well as their subsequent language-specific arrangements into syllables and words depends on articulatory-motor processes. If these processes are impaired, speech sound production will be disordered. Articulatory motor processes depend in turn on many anatomical-physiological prerequisites, which include respiratory, phonatory, or resonatory processes. For example, the speech problems of children with cerebral palsy often originate in abnormal respiration, resonance, and/or phonation prerequisites for articulation. Therefore, the proper function of these basic systems must first be secured before any articulatory improvement can be expected. Articulatory-motor ability is embedded in many different anatomical-physiological requisites, which are of fundamental importance to speech-language pathologists.

Anatomical-Physiological Review of the Foundations of Speech Production

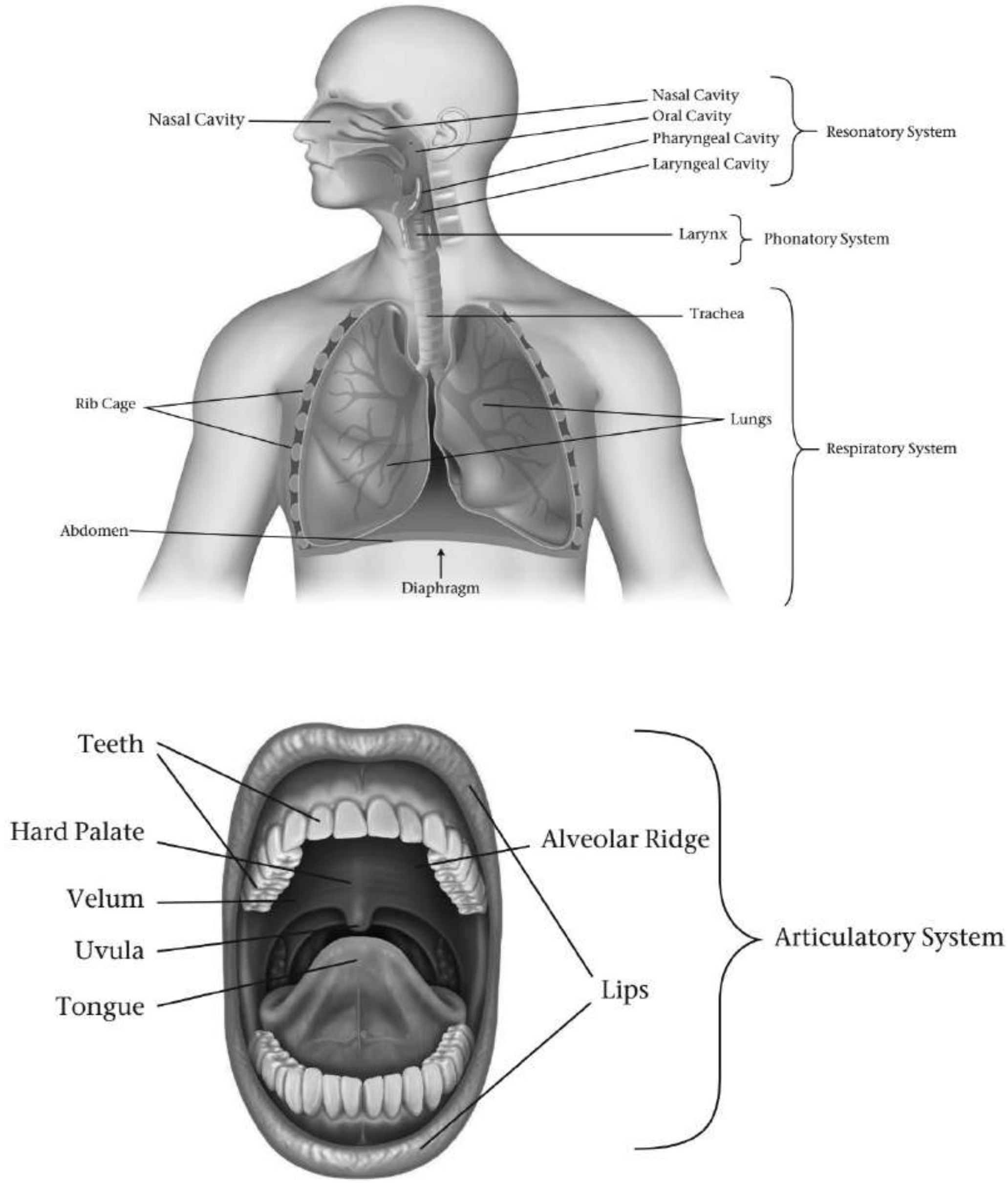
This section provides an overview of the anatomical and physiological prerequisites for speech production. The structures involved in producing speech are cumulatively labeled the **speech mechanism.** The speech mechanism is further divided into the respiratory, phonatory, resonatory, and articulatory systems. Refer to Figure 2.1 for a representation of these four systems. In addition, further references for anatomy and physiology texts are provided in Appendix 2.1.

The Respiratory System

The respiratory system consists of the lungs, rib cage, thorax, abdomen, trachea, and those muscles associated with breathing. The primary function of the respiratory system is the vital exchange of gases for life support. The secondary function of this system is to generate a stream of air for the production of speech. Without this airflow, voice is not possible and speech sounds are not audible.

The principal muscle of inhalation is the diaphragm. The diaphragm consists of a strong fibrous central tendon as well as a peripheral muscular section. The muscular portion of the diaphragm is connected anteriorly and laterally to the lower edges of the ribs. Its posterior connection is to the upper lumbar vertebrae located toward the lower back area. These attachments of the diaphragm create a

Figure 2.1 Overview of the Respiratory, Phonatory, Resonatory, and Articulatory Systems

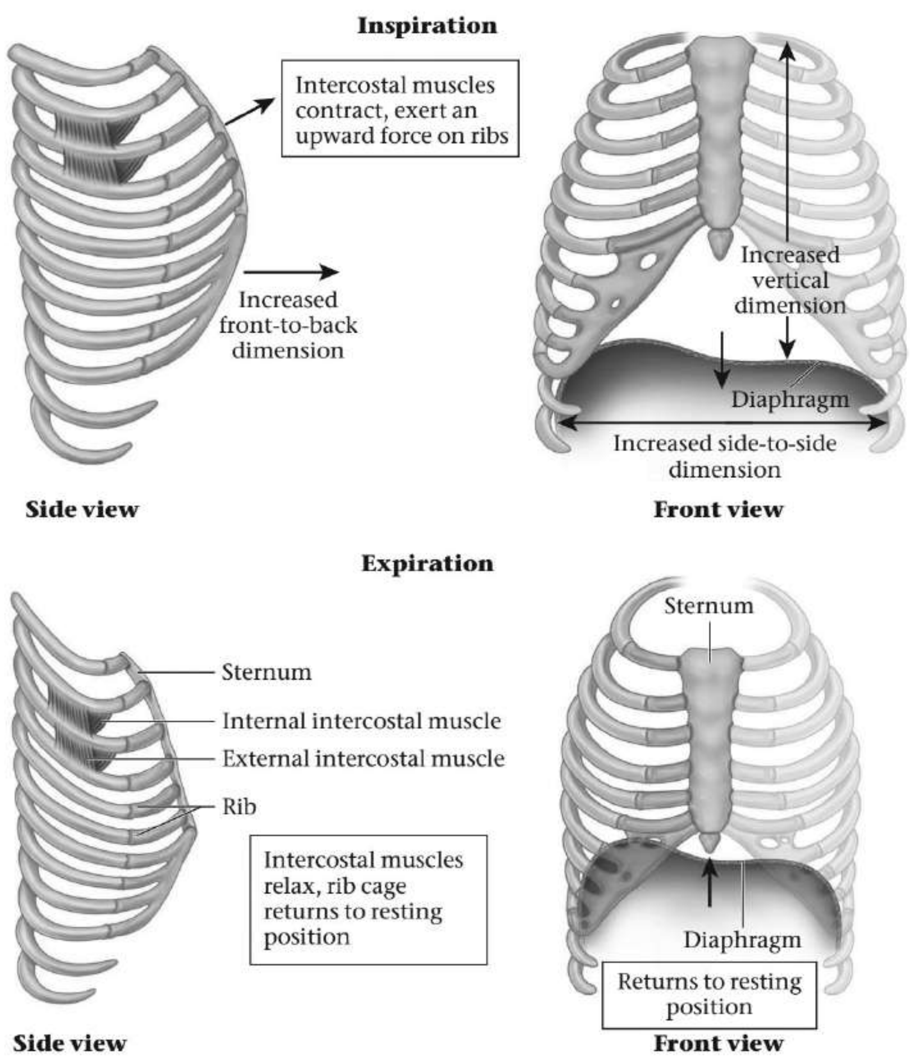


continuous sheet that divides the torso of the body into the thoracic cavity (above the diaphragm) and the abdominal cavity (below the diaphragm). Several muscles aid inhalation; the more important ones are the external and internal intercostals.

As inhalation begins, the muscular portion of the diaphragm contracts. Contraction shortens the muscular fibers, which then pull the central tendon down and somewhat forward. As the diaphragm moves downward, the up-and-down dimensions of the thoracic cavity increase and the contents of the abdominal cavity are compressed. Therefore, the saying "take a breath deep in the belly" does not mean that the air is going into your belly but rather that the deeper the inspiration, the more the abdominal contents are compressed and the belly is somewhat extended. At the same time, contractions of specific thoracic muscles attached to the ribs cause the ribs to swing up and outward. This increases the front-to-back and side-to-side dimensions of the thoracic cavity (refer Figure 2.2).

For respiration to occur, the lungs must increase their volume during inspiration and decrease their volume during expiration. Because the lungs do not contain skeletal muscle tissue, this process must be mediated by what has been termed **pleural linkage**. Two pleurae accomplish this pleural linkage, one covering the outer surface of the lungs and one covering the inner surface of the thorax and the top portion of the diaphragm. The two membranes are airtight and fused together, producing a small amount of fluid that provides smooth, lubricated movement of the lungs during respiration. There is a powerful negative pressure between the two membranes, which links the membranes so closely that the lungs cohere (stick) to the thoracic walls. Thus, any movement of the thoracic cavity results in movement of the lungs. As the dimensions of the thoracic cavity increase, these airtight membranes cause the lungs to follow the thoracic walls as they enlarge; thus, the lungs are forced to expand.

Figure 2.2 Changes in the Dimensions of the Thoracic Cavity During Inhalation



During rest, the pressure within the lungs, the so-called **alveolar pressure**, is equal to the outside air pressure. However, as inspiration begins, the increase in the thoracic dimensions and the consequent expansion of the lungs as they follow the expanding thoracic cavity results in a negative alveolar pressure. The consequence is that the outside air rushes in until the alveolar pressure again equals the outside air pressure. As outside air rushes into the lungs, the muscles of inhalation gradually cease their activity. At this point, exhalation begins. The diaphragm starts to relax to its uncontracted state, moving upward; the thoracic cavity's dimensions decrease. Both actions, the upward movement of the diaphragm and the relaxation of the extended wall of the thorax, increase the alveolar pressure to the degree that air is forced out of the lungs; thus, exhalation occurs. Generally, one can state that thoracic muscles support inhalation, whereas abdominal muscles can support exhalation. Under normal circumstances, exhalation is rather passive, however; if we want to make a prolonged utterance (or try to prolong "ah" for 20 seconds), then we might use the abdominal muscles to assist.

The task of the respiratory system during speech production is even more complex. Speech production necessitates a regulated amount of subglottal pressure over a rather wide range of volumes. **Subglottal air pressure** refers to the pressure below the vocal folds, the glottis being the space between the vocal folds. If you take a deep breath, but only say a word or two, this pressure will have to be regulated if normal but not excessive loudness is to be maintained. On the other hand, if you utter a longer sentence, a relatively constant amount of subglottal pressure must be maintained from the beginning of the utterance, when there is clearly more air in the lungs, to its end, when there is far less air. To maintain a constant loudness level during the whole utterance, the outflow of air must somehow be equalized. This equalization of various lung volumes and pressure levels is accomplished through an interplay of inspiratory and expiratory muscles. Based on this interplay of balancing actions between inspiratory and expiratory muscles, the respiratory system is able to constantly supply the laryngeal system with precisely regulated subglottal pressures.

The Phonatory System

The next important system for speech production is the phonatory system. We have noted that, through controlled expiration, the respiratory system provides a relatively even flow of pressurized air from the lungs. This air moves through the passage from the lungs to the larynx. The vocal folds, the most important part of the larynx, provide the source of sound for speech. However, the primary function of the larynx and vocal folds is not speech but rather preventing foreign substances from entering the respiratory system. We have all had the experience of "swallowing the wrong way" or "something going down the wrong tube." One can probably recall that this resulted in coughing, sometimes rather forcefully. This powerful reflex entails the vocal folds coming together so that air is trapped under them, which results in a buildup of air pressure. A sudden release of this closure produces an explosive expulsion of air sufficient enough to hopefully expel the foreign substance from the respiratory tract.

When not fulfilling the previously mentioned primary function, the larynx can serve as a sound generator for speech. The larynx is suspended from the hyoid bone, a horseshoe-shaped bone located at the base of the tongue, above the thyroid cartilage. Several of the laryngeal muscles are attached to this bone. The larynx itself consists of nine cartilages (one thyroid, one cricoid, one epiglottis, two arytenoid, two corniculate, and two cuneiform) as well as connecting membranes and ligaments.

Extrinsic muscles of the larynx (those having at least one attachment to structures outside the larynx) are primarily responsible for support and fixation of the larynx, whereas **intrinsic muscles of the larynx** (those having both attachments within the larynx) are necessary for control during voice production. The extrinsic muscles surround the larynx and anchor it in its position. The intrinsic muscles are far more interesting during voice production. Two muscles help to **adduct**, or close, the vocal folds, one opens the vocal folds, one tenses the vocal folds, and one comprises the main mass of the vocal folds. These muscles and their functions are summarized in Table 2.1 and Figure 2.3.

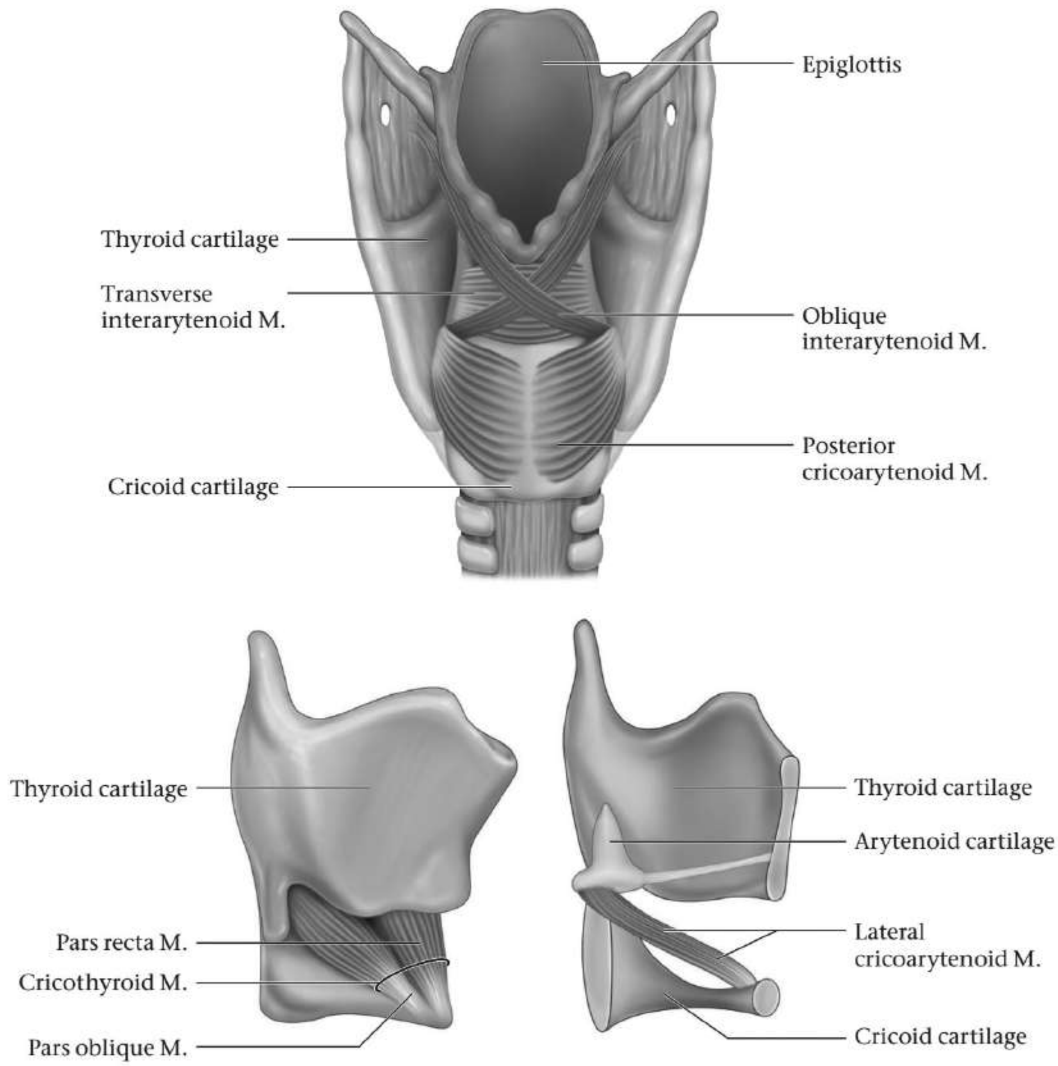
Looking at vocal fold vibration in a simplistic manner, we see that during quiet breathing the vocal folds are drawn away from the midline. The onset of phonation is marked by the vocal folds moving toward the midline, into an adducted position. In this adducted position, the vocal folds obstruct expiratory airflow, and subglottal pressure begins to build up. At a critical point of pressure buildup, the vocal folds are "blown apart"; the glottis is now open, with the natural consequence of an immediate decrease in subglottal pressure. The folds come together again due to their inherent elasticity, the sudden pressure drop between the folds, and aerodynamic properties.

The average number of glottal openings per second is known as a person's **fundamental frequency**. Although every speaker is capable of producing a wide range of fundamental frequencies, females typically have a higher range of fundamental frequencies than males (the fundamental frequency for females is approximately 200 to 260 cycles per second, whereas for males it is between 120 and 145 cycles per second; Zemlin, 1998). Changes in the *tension* of the vocal folds are primarily responsible for variations in fundamental frequency. On the other hand, changes in vocal loudness result from *variations in subglottal air pressure*, which varies the *amplitude of the vocal folds' vibratory cycle*. When more subglottal air pressure is present, the vocal folds move farther away from the midline during their vibratory cycles. We perceive this as an increase in loudness.

Table 2.1 The Function and Attachments of the Intrinsic Muscles of the Larynx

Muscle	Specific Function	Attachments
	ADDUCTORS	
Lateral cricoarytenoid	Closes the vocal folds	Upper border of cricoid to the anterior surface of the arytenoid cartilage
Interarytenoid	Closes the vocal folds: two portions, transverse and oblique	Transverse: lateral margin and posterior portion of one arytenoid, runs horizontally to the lateral margin and posterior portion of the opposite arytenoid cartilage Oblique: from the base of one arytenoid to the apex of the opposite one.
	ABDUCTOR	
Posterior cricoarytenoid	Only one abductor of the vocal folds. It opens the vocal folds	Runs obliquely from the posterior portion of the cricoid lamina to the upper surface and the posterior surface of the arytenoid cartilage
	ELONGATING/TENSING	
Cricothyroid	Regulates longitudinal tension: two portions, pars recta and pars oblique	Both portions originate on the lateral edges of the cricoid cartilage; pars recta inserts into the bottom edge of the thyroid cartilage, pars oblique inserts into the top portion of the body of thyroid cartilage
Thyroarytenoid	**MAIN MASS OF VOCAL FOLDS**	From the inner surface of the thyroid cartilage to two different portions of the arytenoid cartilages

Figure 2.3 Intrinsic Muscles of the Larynx: Transverse and Oblique Interarytenoid Muscles, Posterior Cricoarytenoid Muscle, Cricothyroid Muscle (Pars Recta and Pars Oblique), and the Lateral Cricoarytenoid Muscle



The consistent cyclic vibration of the vocal folds also plays a role in the quality or timbre of the voice. The term **timbre** refers to the tonal quality that differentiates two sounds of the same pitch, loudness, and duration (Crystal, 2010). If you produce "ah" and your friend then says "ah," trying to match your pitch, loudness, and duration, the two utterances will still sound different. This is due to the characteristic vocal quality, or timbre, of each person's voice.

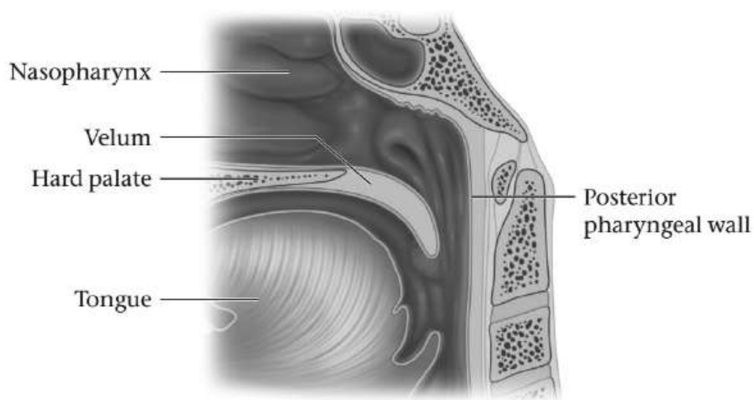
The Resonatory System

The resonatory system is composed of three cavities within the vocal tract: the pharyngeal, oral, and nasal cavities. (The **vocal tract** consists of all speech-related systems above the vocal folds.) The **pharyngeal cavity**, a muscular and membranous tube-like structure, extends from the epiglottis to the soft palate. The **oral cavity**, or mouth area, extends from the lips to the soft palate. The **nasal cavities**, or nose area, consist of two narrow chambers that begin at the soft palate and end at the exterior portion of the nostrils. The floor of the nasal cavities is the hard palate.

Sound energy generated by the larynx is modified as it travels through the pharyngeal, oral, and/or nasal cavities. This portion of the speech mechanism is called the resonatory system because the modification of sound energy is primarily the result of resonance principles. **Resonance** is the selective reinforcement and absorption of sound energy at specific frequencies. In other words, certain frequencies are amplified or intensified (reinforced), whereas others are suppressed or damped out (absorbed). Resonance is one major component in determining our characteristic vocal qualities as well as in providing the basis for specific speech sounds. The pharyngeal, nasal, and oral areas could be described as differently shaped cavities that are variable in size and form. For example, protruding the lips would change the shape of the oral cavity, whereas muscular action lowering the larynx would change the dimensions of the pharyngeal cavity. In addition, variations in the walls of the resonating cavity (i.e., certain structures are softer and more pliable, whereas others are harder and denser) contribute to the resonating properties.

One structure within this system that does have a direct impact on the resonance quality of specific sounds in General American English is the velopharyngeal mechanism. It directly affects speech sound quality by channeling airflow through either the oral or the nasal cavities. The **velopharyngeal mechanism** consists of the structures and muscles of the velum (soft palate) and those of the pharyngeal walls (refer Figure 2.4). The **velopharyngeal port**, the passage that connects the oropharynx and the nasopharynx, can be closed by (1) elevation and posterior movements of the velum and (2) some forward and medial movements of the posterior and lateral pharyngeal walls. These combined movements resemble the action of a sphincter. Closure of the passageway between the oral and nasal cavities is important for three reasons. First, during the primary function of swallowing, the velopharyngeal port closes as the bolus of food or drink passes from the oral cavity to the pharyngeal cavity. This closure prevents the food or drink from entering the nasal cavity. Second, as a secondary function, closure of the velopharyngeal port is important for the production of specific groups of speech sounds, namely nasal versus non-nasal sounds. Nasal sounds are those produced with an open velopharyngeal port allowing airflow through the nasal cavity. In

Figure 2.4 The Velopharyngeal Mechanism



General American English, there are only three nasal sounds: "m," "n," and "ng." Non-nasal sounds are those produced with the velopharyngeal port closed; airflow passes through the oral cavity only. Third, accurately timed and adequate closure of the velopharyngeal port is necessary for normal vocal timbre. Without this, voice quality may sound hypernasal.

The Articulatory System

The articulatory system is directly involved in forming individual speech sounds. The structures within this system consist of the lips, tongue, mandible, teeth, hard palate (including the alveolar ridge), velum, and uvula, which are called articulators. Due to their importance for speech realization, a brief review of each of these structures will be helpful for later discussions about specific speech sound productions.

The lips consist primarily of the orbicularis oris muscle. However, many facial muscles insert into the lips. The lips are, therefore, very flexible for both facial expression as well as for speech sound production. The lips are the main articulators in sounds such as "b," "p," and "m," for example.

The next articulator, the tongue, is the most important and most active one for speech sound production. Due to the manner of its attachments and the number of intrinsic and extrinsic muscles involved, the tongue is capable of a wide range of movements. The body of the tongue, which is known as the **dorsum** (Zemlin, 1998), can move horizontally backward and forward and vertically up and down, can assume a concave or convex shape relative to the palate, can demonstrate central grooving, and can be spread or tapered in its appearance. Horizontal (forward and backward) and vertical (closer and farther away from the palate) movements are primarily responsible for vowel articulations. In addition, the shape of the tongue plays a major role in both vowel and consonant productions. There are many sounds for which various portions of the tongue are considered main articulators.

The mandible or lower jaw houses the lower teeth. Inadequate, inappropriate, or sluggish mandibular movement may contribute to articulatory difficulties (Zemlin, 1998).

The primary function of the teeth is to process food before it is swallowed and continues on its digestive route. For speech sound production, the secondary function of the teeth is their role as articulators for speech sounds such as "f" and "v" and the th-sounds in "the" or "with."

The next group of articulators consists of structures of the roof of the mouth: the hard palate, alveolar ridge, soft palate (velum), and uvula. If you glide your tongue posteriorly from behind the front teeth, you will encounter a prominent ridge-like structure known as the **alveolar ridge**. This protuberance is formed by the alveolar process, which is a thickened portion of the maxilla (upper jaw) housing the teeth. Moving past the alveolar ridge, the hard, bony structure is the hard palate. Farther back, there is a softer muscular portion, which is referred to as the soft palate or velum. An appendage-like extension of the soft palate is the uvula. All of these structures—alveolar ridge, hard palate, velum, and uvula—play a role in the qualitative end product of speech sounds. For example, "t" and "d" are produced by the tongue tip coming in contact with the alveolar ridge. The last sound in "wing," the so-called "ng" sound, has articulatory features that involve the back of the tongue coming in contact with the velum. In General American English, there are no uvular sounds. However, in French and German there is a uvular trilled-r-type sound where the uvula is actually brought into motion.

This section has provided a very brief review of the structure and function of the respiratory, phonatory, resonatory, and articulatory systems. The next section examines speech sounds, specifically the characteristics of vowel and consonant productions.

Vowels Versus Consonants

Speech sounds are commonly divided into two groups: vowels and consonants. **Vowels** are produced with a relatively open vocal tract; *no significant constriction* of the oral (and pharyngeal) cavities is required. The airstream from the vocal folds to the lips is relatively unimpeded. Therefore, vowels are considered to be *open sounds*. In contrast, **consonants** have *significant constriction* in the oral and/or pharyngeal cavities during their production. For consonants, the airstream from the vocal folds to the lips and nostrils encounters some type of articulatory obstacle along the way. Therefore, consonants are considered to be *constricted sounds*. For most consonants, this constriction occurs along the sagittal midline of the vocal tract. The **sagittal midline** *of the vocal tract* refers to the median plane that divides the vocal tract into right and left halves. This constriction for consonants can be exemplified by the first sound in *top* or *soap*. For "t," the contact of the front of the tongue with the alveolar ridge (the ridge behind the front teeth) occurs along the sagittal midline, whereas the characteristic s-quality is made by airflow at the sagittal midline as the tongue approximates the alveolar ridge. By contrast, during all vowel productions, the sagittal midline remains free.

In addition, under normal speech conditions, vowels in General American English are always produced with vocal fold vibration; they are voiced speech sounds. Only during whispered speech are vowels unvoiced. Consonants, on the other hand, may be generated with or without simultaneous vocal fold vibration; they can be voiced or voiceless. The transcription of various vowels and consonants with examples of words in which these sounds can be heard are provided in Table 2.2. Note that various phonetic texts might transcribe sounds in somewhat different ways. Examples are provided to guide you with the transcription that is used in this text. Refer Appendix 2.2 for a list of how several texts vary in the transcription of vowels.

Vowels can also be distinguished from consonants according to the patterns of acoustic energy they display. Vowels are highly resonant, demonstrating at least two formant areas. Thus, vowels are more intense than consonants; in other words, they are typically louder than consonants. In this respect, we can say that vowels have greater sonority than consonants. **Sonority** of a sound is its loudness relative to that of other sounds with the same length, stress, and pitch (Ladefoged & Johnson, 2010). Because of the greater sonority of vowels over consonants, vowels are also referred to as **sonorants**. Certain groups of consonants are also labeled sonorants. When contrasted to other consonants, **sonorant consonants** are produced with a relatively open expiratory passageway. The sonorant consonants include the nasals ([m, n, ŋ]) and the approximants ([l, ɹ, w, j]). The sonorants are distinguished from the **obstruents**, which are characterized by a complete or narrow constriction between the articulators hindering the expiratory airstream. The obstruents include the plosives ([p, b, t, d, k, g]), the fricatives ([f, v, s, z, θ, ð, ʃ, ʒ, h]), and the affricates ([ʧ, ʤ]).

There are also functional distinctions between vowels and consonants. In other words, vowels and consonants have different linguistic functions. This has often been referred to as the *phonological difference* between vowels and consonants (Crystal, 2010). The term *consonant* indicates this relationship: *con* meaning "together with" and *sonant* reflecting the tonal qualities that characterize vowels. Thus, consonants are those speech sounds that function linguistically *together with* vowels. As such, vowels serve as the center of syllables, or as syllable nuclei. Vowels can constitute syllables by themselves—for example, in the first syllable of *a-go* or *e-lope*. Vowels can also appear with one or more consonants, exemplified by *blue, bloom,* or *blooms*. Although there are many types of syllables, the vowel is always the center of the syllable, its nucleus. A small group of consonants can serve as the nucleus of syllables. A consonant that functions as a syllable nucleus is referred to as a **syllabic**. These form and functional differences are summarized in Table 2.3.

Table 2.2 International Phonetic Alphabet (IPA) Symbols

Consonant Symbol	Word Example	Consonant Symbol	Word Example	Consonant Symbol	Word Example	Vowel Symbol	Word Example	Vowel Symbol	Word Example
[p]	pay	[b]	boy	[m]	moon	[i]	eat	[ɝ]	girl
[t]	toy	[d]	doll	[n]	not	[ɪ]	in	[ɚ]	winner
[k]	coat	[g]	goat	[ŋ]	sing	[ɛ]	end	[ʌ]	cut
[f]	face	[v]	vase	[j]	yes	[æ]	at	[ə]	above
[θ]	think	[ð]	those	[l]	leap	[a]	father[3]	[eɪ]	ape
[s]	sip	[z]	zip	[ɹ][2]	red	[u]	moon	[oʊ]	boat
[ʃ]	shop	[ʒ]	beige	[h]	hop	[ʊ]	wood	[aɪ]	tie
[ʧ]	chop	[ʤ]	job			[ɔ]	father[3]	[aʊ]	mouse
[w]	win	[ʍ]	when[1]			[ɑ]	hop	[ɔɪ]	boy

[1]Historically, the [ʍ] was used in "wh" words such as "where" and "when"; it was a voiceless sound. It has now merged with [w] throughout much of the United States (Wolfram & Schilling-Estes, 2006).

[2]The symbol [ɹ] will be used throughout this text for "r"-sounds. This reflects the usage of the International Phonetic Alphabet for the General American English "r." Refer "Approximants" (page 35) for further explanation.

[3]May be regional or individual pronunciation.

Table 2.3 Features Differentiating Vowels and Consonants

Vowels	Consonants
No significant constriction of the vocal tract	Significant constriction of the vocal tract
Open sounds	Constricted sounds
Sagittal midline of the vocal tract remains open	Constriction occurs along sagittal midline of the vocal tract
Voiced	Voiced or unvoiced
Acoustically more intense	Acoustically less intense
Demonstrate more sonority	Demonstrate less sonority
Function as syllable nuclei	Only specific consonants can function as syllable nuclei