"I can inquire." [ˈaɪkŋ̩ ŋ̩ ˈkwaɪə]

"Did you eat yet?" [ˈdʒiʔjɛʔ]

"I don't believe him." [aɪˈdoʊmbəˈlivɪm]

"We ought to have come." [wiˈɔtʃˈkʌm]

B. Working with a partner, try to transcribe the intonation of a few sentences. You may find it difficult to repeat a sentence over and over again with the same intonation. If you do, try to work from a recording. In any case, write down the sentence and the intonation you intend to produce. Practice saying it in this way before you say it to your partner.

C. Take turns saying nonsense words such as those shown below, transcribing them and comparing transcriptions.

ʃkeɪʒdʒˈmiɲʒe

ʔɑŋkliθuntθ

sfeˈeʔəm̥ɑ

grɔɪpstˈbraɪgz

D. Also make up lists of words for improving your memory span. These words are more difficult if the stress is varied and if the sounds are mainly of the same class (stops, front vowels, voiceless fricatives, etc.).

tipeˈkiketiˈpe

θɔɪˈsaɪθaʊˈfɔɪʃaʊθɐʊ

ˈmonɑŋuˈŋonɔmɑ

woˈʔɔɪlaʊrɑˈrɔlojɔ

bəbdɪgˈbɛdgɪbdɛdˈbɛbdəd

6

Airstream Mechanisms and Phonation Types

In this part of the book we will start considering the total range of human phonetic capabilities, not just those used in normal English speech. We will look at the sounds of the world's languages, as in this way we can find stable, repeatable examples of almost all the different speech sounds that people can make. To do this we will have to enlarge the sets of terms we have been using to describe English. In the first place, all English sounds are initiated by the action of lung air going outward; other languages may use additional ways of producing an airstream. Second, all English sounds can be categorized as voiced or voiceless; in some languages, additional states of the glottis are used. This chapter will survey the general phonetic categories needed to describe the airstream mechanisms and phonation types that occur in other languages. Subsequent chapters will survey other ways in which languages differ. These foreign sounds should be studied even by those who are concerned only with the phonetics of English, both because they throw light on general human phonetic capabilities and also because they are important for a precise description of the shades of sounds present in normal English utterances. In addition, many of them occur regularly in pathological forms of English.

AIRSTREAM MECHANISMS

Air coming out of the lungs is the source of power in nearly all speech sounds. When lung air is pushed out, we say that there is a **pulmonic airstream mechanism.** The lungs are sponge-like tissues within a cavity formed by the rib cage and the diaphragm (a dome-shaped muscle indicated by the curved line at the bottom of Figure 1.2). When the diaphragm contracts, it enlarges the lung cavity so that air flows into the lungs. The lung cavity can also be enlarged by raising the rib cage, a normal way of taking a deep breath in. Air can be pushed out of

the lungs by pulling the rib cage down, or by pushing the diaphragm upward by contracting the abdominal muscles.

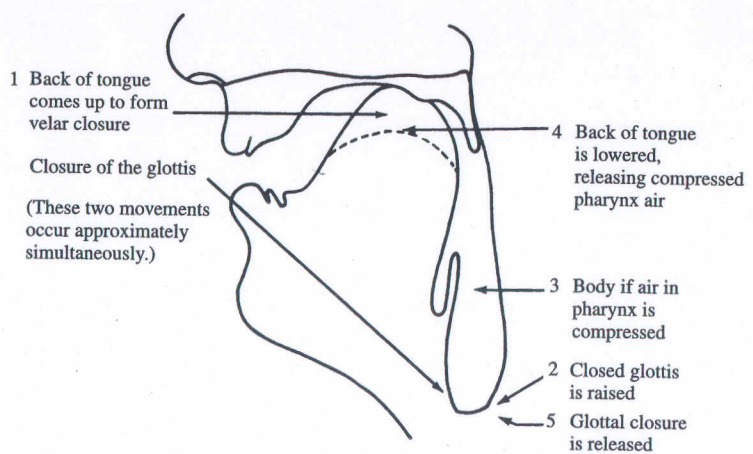
In the description of most sounds, we take it for granted that the pulmonic airstream mechanism is the source of power. But in the case of stop consonants, other airstream mechanisms may be involved. Stops that use only an egressive, or outward-moving, pulmonic airstream are called **plosives.** Stops made with other airstream mechanisms will be specified by other terms.

In some languages, speech sounds are produced by moving different bodies of air. If you make a glottal stop, so that the air in the lungs is contained below the glottis, then the air in the vocal tract itself will form a body of air that can be moved. An upward movement of the closed glottis will move this air out of the mouth. A downward movement of the closed glottis will cause air to be sucked into the mouth. When either of these actions occurs, there is said to be a **glottalic airstream mechanism.**

An egressive glottalic airstream mechanism occurs in many languages. Hausa, the principal language of northern Nigeria, uses this mechanism in the formation of a velar stop that contrasts with the voiceless and voiced velar stops [k, g]. The movements of the vocal organs are shown in Figure 6.1. These are estimated, not drawn on the basis of x-rays.

As far as I can tell, in Hausa the velar closure and the glottal closure are formed at about the same time. Then, when the vocal folds are tightly together, the larynx is pulled upward, about 1 cm. In this way it acts like a piston, compressing the air in the pharynx. The compressed air is released by lowering the back of the tongue while the glottal stop is maintained, producing a sound with a quality different from that in an English [k]. Very shortly after the release of

FIGURE 6.1 The sequence of events that occurs in a glottalic egressive velar stop [k'].



the velar closure, the glottal stop is released and the voicing for the following vowel begins.

Stops made with a glottalic egressive airstream mechanism are called **ejectives.** The diacritic indicating an ejective is an apostrophe ['] placed after a symbol. The Hausa sound I have just described is a velar ejective, symbolized [k'], as in the Hausa word for 'increase' [k'aːràː], which, as you can hear on the CD, contrasts with [kaːràː] 'put near'. (The symbol [ː] indicates that the vowels are long. The accents over the vowels indicate the pitch, a low tone. We will discuss tones in Chapter 10.) The CD also illustrates the contrasts between the Hausa words [kʷaːràː] 'pour' and [kʷ'aːràː] 'shea nut'. It is possible to use an ejective mechanism to produce fricatives as well as stops, as Hausa does in the words [saːràː] 'cut' and [s'aːràː] 'arrange', which are also on the CD. Of course, a fricative made in this way can continue only for a short length of time, as there is a comparatively small amount of air that can be moved by raising the closed glottis.

CD 6.1

Ejectives of different kinds occur in a wide variety of languages, including American Indian languages, African languages, and languages spoken in the Caucasus. Table 6.1 gives examples of ejectives and contrasting sounds made with a pulmonic airstream mechanism in Lakhota, an American Indian language. The sounds of Lakhota differ from those of English in many ways in addition to having contrastive ejectives. Later in this book we will discuss the unfamiliar symbols in this table.

CD 6.2

Some people make ejectives at the ends of words in English, particularly in sentence final position. I have heard people say words such as *bike* with a glottal stop accompanying the final [k]. If the velar stop is released while the glottal stop is still being held, a weak ejective may be heard. See if you can superimpose a glottal stop on a final [k] and produce an ejective. Now try to make a slightly more forceful ejective stop. By now you should be fully able to make a glottal stop in a sequence such as [aʔa], so the next step is to learn to raise and lower the glottis. You can recognize what it feels like to raise the glottis by singing a very low note and then moving to the position for singing the highest note that you possibly can. Doing this silently makes it easier to concentrate on feeling the muscular sensations involved. Putting your fingers on your

TABLE 6.1 Contrasts involving ejective stops in Lakhota. An ejective mechanism is shown by a following apostrophe.

Ejective	p'o 'foggy'	t̪'uʃə 'at all costs'	k'u 'to give'
Voiceless Unaspirated	paɣõ t̪a 'mallard'	t̪uwa 'who'	kah 'that'
Voiceless + Velar Fricative	pˣa 'bitter'	t̪ˣawa 'own'	kˣant̪a 'plum'

throat above the larynx is also a help in feeling the movements. Repeat (silently) this sequence—low note, very high note—until you have thoroughly experienced the sensation of raising your glottis. Now try to make this movement with a closed glottis. There will, of course, be no sounds produced by these movements alone.

The next step is to learn to superimpose this movement on a velar stop. Say the sequence [ɑk]. Then say this sequence again, very slowly, holding your tongue in the position for the [k] closure at the end for a second or so. Now say it again, and while maintaining the [k] closure, do three things: (1) make a glottal stop; (2) if you can, raise your larynx; and (3) release the [k] closure while maintaining the glottal stop. Don't worry about step (2) too much. The important thing to concentrate on is having a glottal stop and a velar closure going on at the same time, and then releasing the velar closure *before* releasing the glottal stop. The release of the velar closure will produce only a very small noise, but it will be an ejective [k'].

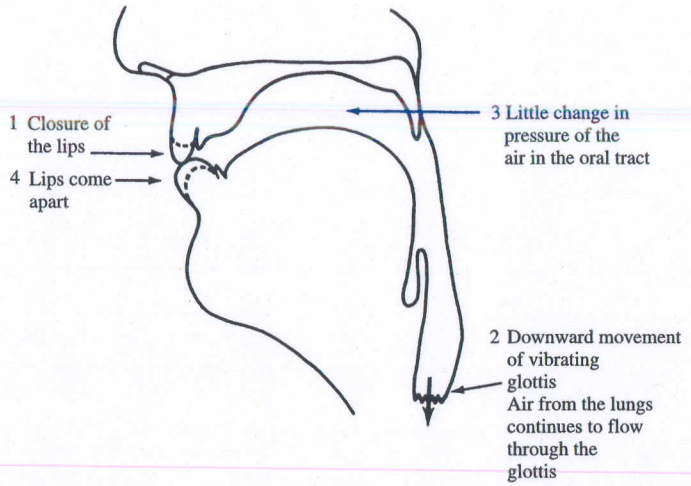
Next, try to produce a vowel after the ejective. This time start from the sequence [ɑkɑ]. Say this sequence slowly, with a long [k] closure. Then, during this closure, make a glottal stop and raise the larynx. Then release the [k] closure while still maintaining the glottal stop. Finally, release the glottal stop and follow it with a vowel. You should have produced something like [ɑk'ʔɑ]. When this sequence becomes more fluent, so that there is very little pause between the release of the velar closure and the release of the glottal stop, it will be simply an ejective followed by a vowel—[ɑk'ɑ]. There is, of course, still a glottal stop after the release of the velar stop and before the vowel, but unless it is exceptionally long, we may consider it to be implied by the symbol for the ejective.

Another way of learning to produce an ejective is to start from the usual American (and common British) pronunciation of *button* as ['bʌʔn̩]. Try starting to say *button* but finishing with another vowel [ʌ] instead of the nasal [n]. If you make sure you do include the glottal stop form of / t /, the result will probably be ['bʌʔtʌ]. If you say this slowly, you should be able to convert it first into ['bʌʔt'ʔʌ], then into ['bʌt'ʌ], and finally, altering the stress, into [bʌ't'ʌ].

Eventually you should be able to produce sequences such as [p'ɑ, t'ɑ, k'ɑ] and perhaps [tʃ'ɑ, s'ɑ] as well. Practice producing ejectives before, after, and between a wide variety of vowels. You should also try to say the Lakhota words in Table 6.1. But if you find ejectives difficult to produce, don't worry. Many people take years to learn to say them. Just keep on practicing.

It is also possible to use a downward movement of the larynx to suck air inward. Stops made with an ingressive glottalic airstream mechanism are called **implosives.** In the production of implosives, the downward-moving larynx is not usually completely closed. The air in the lungs is still being pushed out, and some of it passes between the vocal folds, keeping them in motion so that the sound is voiced. Figure 6.2 shows the movements in a voiced bilabial implosive of a kind that occurs in Sindhi (an Indo-Aryan language spoken in India and Pakistan).

FIGURE 6.2 Estimated sequence of events in a Sindhi bilabial implosive [ɓ].



Implosives sometimes occur as allophones in English, particularly in emphatic articulations of bilabial stops, as in ***absolutely billions and billions.***

In all the implosives I have measured, the articulatory closure—in this case, the lips coming together—occurs first. The downward movement of the glottis, which occurs next, is like that of a piston that would cause a reduction in the pressure of the air in the oral tract. But it is a leaky piston in that the air in the lungs continues to flow through the glottis. As a result, the pressure of the air in the oral tract is not affected very much. (In a plosive [b] there is, of course, an increase in the pressure of the air in the vocal tract.) When the articulatory closure is released, there is neither an explosive nor, in a literal sense, an implosive action. Instead, the peculiar quality of the sound arises from the complex changes in the shape of the vocal tract and in the vibratory pattern of the vocal folds.

In many languages, such as Sindhi and several African and American Indian languages, implosives contrast with plosives. However, in some languages (for example, Vietnamese), implosives are simply variants (allophones) of voiced plosives and are not in contrast with those sounds. The top line of Table 6.2 illustrates implosives in Sindhi. The symbols for implosives have a small hook on the top of the regular symbol. For the moment, we will consider only the first and last columns in Table 6.2, which illustrate [ɓ] and [ɠ], the bilabial and velar implosives respectively, in the first row, contrasting with the regular plosives [b] and [g] in the second row. Sindhi has additional places of articulation illustrated in the second, third, and fourth columns, which we will consider in Chapter 7. The lower rows in the table illustrate phonation types that we will consider later in this chapter.

TABLE 6.2 Contrasts involving implosives and plosives with different phonation types in Sindhi.

ɓani 'field'		ɖɪnu 'festival'	ʄatu 'illiterate'	ɠanu 'handle'
banu 'forest'	daru 'door'	ɖoːru 'you run'	ɟatu 'illiterate' [variant]	gunu 'quality'
panu 'leaf'	taru 'bottom'	ʈanu 'ton'	caʈu 'to destroy'	kanu 'ear'
pʰanu 'snake hood'	tʰaru (district name)	ʈʰaʂu 'thug, cheat'	cʰaʈu 'crown'	kʰanu 'you lift'
bʱaːnu 'manure'	dʱaɾu 'trunk'	ɖʱaʂu 'bull'	ɟʱaʈu 'a grab'	gʱanɪ 'excess'

I do not know any simple way of teaching people to make implosives. Some people can learn to make them just by imitating their instructor; others can't. (I, incidentally, was one of the latter group. I did not learn to make implosives until nearly the end of a year studying phonetics.) The best suggestion I can make is to start from a fully voiced plosive. Say [ɑbɑ], making sure that the voicing continues throughout the closure. Now say this sequence slowly, making the closure last as long as you can while maintaining strong vocal fold vibrations. Release the closure (open the lips) *before* the voicing stops. If you put your fingers on your throat above the larynx while doing this, you will probably be able to feel the larynx moving down during the closure.

There are straightforward mechanical reasons why the larynx moves down in these circumstances. To maintain voicing throughout a [b], air must continue to flow through the glottis. But it cannot continue to flow for very long, because, while the articulatory position of [b] is being held, the pressure of the air in the mouth is continually increasing as more air flows through the glottis. To keep the vocal folds vibrating, the air in the lungs must be at an appreciably higher pressure than the air in the vocal tract so that there is a pressure drop across the glottis. One of the ways of maintaining the pressure drop across the glottis is to lower the larynx and thus increase the space available in the vocal tract. Consequently, there is a natural tendency when saying a long [b] to lower the larynx. If you try to make a long, fully voiced [b] very forcibly but open the lips before the voicing stops, you may end up producing an implosive [ɓ]. You can check your progress in learning to produce implosives by using a straw in a drink. Hold a straw immersed in a liquid between your lips while you say [ɑbɑ]. You should see the liquid move upward in the straw during the [ɓ].

Historically, languages seem to develop implosives from plosives that have become more and more voiced. In many languages, as I mentioned earlier, voiced implosives are simply allophones of voiced plosives. Often, as in Vietnamese, these languages have voiced plosives that have to be fully voiced to keep them distinct from two other sets of plosives that we will discuss in the next section. In languages such as Sindhi, for which we have good evidence of the earlier stages of the language, we can clearly see that the present implosives grew out of older voiced plosives in this way; the present contrasting voiced plosives are due to later influences of neighboring languages.

One other airstream mechanism is used in a few languages. This is the mechanism that is used in producing **clicks,** such as the interjection expressing disapproval that novelists write *tut-tut* or *tsk-tsk*. Another type of click is commonly used to show approval or to signal horses to go faster. Still another click in common use is the gentle, pursed-lips type of kiss that one might drop on one's grandmother's cheek. Clicks occur in words (in addition to interjections or nonlinguistic gestures) in several African languages. Zulu, for example, has a number of clicks, including one that is very similar to our expression of disapproval.

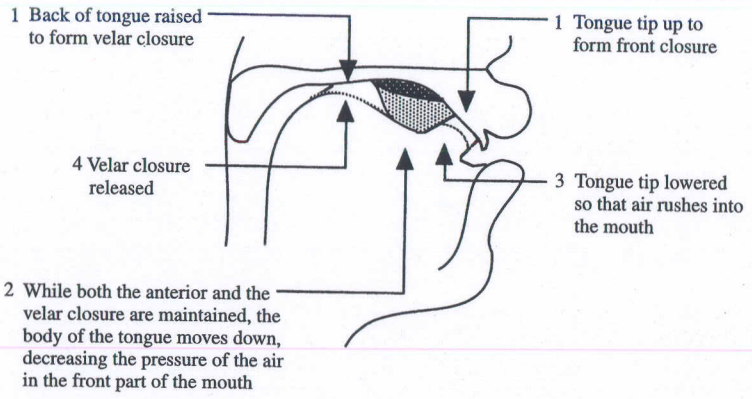
The easiest click to start studying is the gentle-kiss-with-pursed-lips type. In a language that uses bilabial clicks of this sort, the gesture is not quite the same as that used by most people making a friendly kiss. The linguistic gesture does not involve puckering the lips. They are simply compressed in a more grim manner. Make a "kiss" of this type. Say this sound while holding a finger lightly along the lips. You should be able to feel that air rushes into the mouth when your lips come apart. Note that while you are making this sound, you can continue to breathe through your nose. This is because the back of the tongue is touching the velum, so that the air in the mouth used in making this sound is separated from the airstream flowing in and out of the nose.

Now say the click expressing disapproval, the one that authors sometimes write *tut-tut* or *tsk-tsk* when they wish to indicate a click sound; they do not, of course, mean [tʌt tʌt] or [tɪsk tɪsk]. Say a single click of this kind and try to feel how your tongue moves. The positions of the vocal organs in the corresponding Zulu sound are shown in Figure 6.3. At the beginning of this sound, there are both dental and velar closures. As a result, the body of air shown in the dark shaded area in Figure 6.3 is totally enclosed. When the back and central parts of the tongue move down, this air becomes rarefied. A click is produced when this partial vacuum is released by lowering the tip of the tongue. The IPA symbol for a dental click is [|], a single vertical stroke extending both above and below the line of writing.

Movement of the body of air in the mouth is called a **velaric airstream mechanism.** Clicks are stops made with an ingressive velaric airstream mechanism (as shown in Figure 6.3). It is also possible to use this mechanism to cause the airstream to flow outward by raising the tongue and squeezing the contained body of air, but this latter possibility is not actually used in any known language.

The sound described in Figure 6.3 is a dental click. If the partial vacuum is released by lowering the side of the tongue, a lateral click—the sound sometimes used for encouraging horses—is produced. The phonetic symbol is [‖], a pair of vertical strokes, again going both above and below the line of writing. Clicks can also be made with the tip (*not* the blade) of the tongue touching the posterior part

FIGURE 6.3 The sequence of events in a dental click. Initially, both the tip and the back of the tongue are raised, enclosing the small pocket of air indicated by the dark shading. When the center of the tongue moves down, the larger, lightly shaded cavity is formed. Then the tip moves down to the position shown by the dashed line, and, a little later, the back of the tongue comes down to the position shown by the dashed line.



of the alveolar ridge. The phonetic symbol for a click of this kind is [!], an exclamation point (this time resting on the line of writing). These three possibilities all occur in Zulu and in the neighboring language Xhosa. Some of the aboriginal South African languages, such as Nama and !Xóõ, have an even wider variety of click articulations. !Xóõ, spoken in Botswana, is one of the few languages that have bilabial clicks—a sort of thin, straight-lips kiss sound, for which the symbol is [ʘ].

In the production of click sounds, there is a velar closure, and the body of air involved is in front of this closure (that is, in the front of the mouth). Consequently, it is possible to produce a velar sound with a glottalic or pulmonic airstream mechanism while a click is being made. You can demonstrate this for yourself by humming continuously while producing clicks. The humming corresponds to a long [ŋ], a voiced velar nasal. We may symbolize the co-occurrence of a nasal and a click by writing a tie bar [‿] over the two symbols. Thus a dental click and a velar nasal would be written [ŋ͡ǀ]. In transcribing click languages, the tie bar is usually left off, and simultaneity is assumed.

Even if the soft palate is raised so that air cannot flow through the nose, the pulmonic airstream mechanism can still be used to keep the vocal folds vibrating for a short time during a click. When the back of the tongue is raised for a click and there is also a velic closure, the articulators are in the position for [g]. A voiced dental click of this kind is therefore a combination of [g] and [ǀ] and may be symbolized [gǀ] (omitting the tie bar).

At this point, we should note that, strictly speaking, the transcription of clicks always requires a symbol for both the click itself and for the activity associated with the velar closure. We transcribed the voiced click with a [g] plus the click symbol, and the nasalized click with [ŋ] plus the click symbol. We should also transcribe the voiceless click with [k] plus the click symbol. It is perhaps not necessary for a beginning student in phonetics to be able to produce all sorts of different clicks in regular words. But you should be able to produce at least a simple click followed by a vowel. Try saying [kǀ] followed by [ɑ]. Make a vowel as soon after the click as possible, so that it sounds like a single syllable [kǀɑ] (using the convention that regards the [k] and the click as simultaneous, as if there were a tie bar).

As a more challenging exercise, learn to produce clicks between vowels. Start by repeating [kǀɑ] a number of times, so that you are saying [kǀɑkǀɑkǀɑ]. Now say dental, post-alveolar, and lateral clicks in sequences such as [ɑkǀɑ], ɑk!ɑ, ɑk‖ɑ]. Make sure there are no pauses between the vowels and the clicks. Now try to keep the voicing going throughout the sequences, so that you produce [ɑgǀɑ], ɑg!ɑ, ɑg‖ɑ]. Last, produce nasalized clicks, perhaps with nasalized vowels on either side [ɑŋǀɑ], ɑŋ!ɑ, ɑŋ‖ɑ] (again with the nasal being simultaneous with the click). Repeat with other vowels.

The spelling system regularly used in books and newspapers in Zulu and Xhosa employs the letters *c, q, x* for the dental, post-alveolar, and lateral clicks for which we have been using the symbols [ǀ, !, ‖], respectively. The name of the language Xhosa should therefore be pronounced with a lateral click at the beginning. The *h* following the orthographic *X* indicates a short burst of aspiration following the click. Try saying the name of the language with an aspirated lateral click at the beginning. Table 6.3 shows a set of contrasting clicks in Xhosa.

TABLE 6.3 Contrasts involving clicks in Xhosa. The rows differ in phonation types, as will be discussed later in this chapter.

	Dental	Post-alveolar	Alveolar Lateral
Voiceless unaspirated velar plosive	ukúkǀola 'to grind fine'	ukúk!oɓa 'to break stones'	úk‖olo 'peace'
Voiceless aspirated velar plosive	úkukǀʰóla 'to pick up'	ukúk!ola 'perfume'	ukúk‖ʰoɓa 'to arm oneself'
Murmured velar plosive	úkuɡ̤ǀôɓa 'to be joyful'	ukúɡ̤!oba 'to scoop'	ukúɡ̤‖oba 'to stir up mud'
Voiced velar nasal	ukúŋǀoma 'to admire'	ukúŋ!ola 'to climb up'	ukúŋ‖iɓa 'to put on clothes'
Murmured velar nasal	ukúŋ̤ǀola 'to be dirty'	ukúŋ̤!ala 'to go straight'	ukúŋ̤‖oŋ̤‖a 'to lie on back, knees up'

CD 6.4

Nearly all the words in this table are infinitive forms of words, which is why they begin with the prefix [ukú].

The CD also illustrates clicks in Zulu, a language closely related to Xhosa, and in Nama and X!óõ, two Khoisan languages spoken in Namibia and Botswana. You can find examples of these languages by going to the index of languages, the index of sounds, or the map index, all of which are accessible from the foot of the title page. They are also listed on the contents page for this chapter.

Table 6.4 summarizes the principal airstream mechanisms. Note that pulmonic sounds can be voiced or voiceless. Glottalic egressive sounds—ejectives—are always voiceless. Glottalic ingressive sounds—implosives—are nearly always voiced by being combined with a pulmonic egressive airstream, but voiceless glottalic ingressive sounds (voiceless implosives) have been reported in a few languages, such as the Owerri dialect of Igbo, spoken in Nigeria. (Igbo examples are among the extra material on the CD, accessible through the index of languages.)

TABLE 6.4 The principal airstream processes.

Airstream	Direction	Brief Description	Specific Name for Stop Consonant	Examples	Vocal Folds
Pulmonic	egressive	lung air pushed out under the control of the respiratory muscles	plosive	p t k b d g	voiceless or voiced
Glottalic	egressive	pharynx air compressed by the upward movement of the closed glottis	ejective	p' t' k'	voiceless
Glottalic	ingressive	downward movement of the vibrating glottis; pulmonic egressive airstream may also be involved	implosive	ɓ ɗ ɠ	usually voiced by the pulmonic airstream
Velaric	ingressive	mouth air rarefied by the backward and downward movement of the tongue	click	ǀ ǃ ǁ ʘ	combine with the pulmonic airstream for voiced or voiceless velar nasals

Velaric ingressive sounds (clicks) may be combined with pulmonic egressive sounds so that the resulting combination can be voiced or voiceless. These combinations can also be oral or nasal.

STATES OF THE GLOTTIS

So far we have been considering sounds to be either voiceless, with the vocal folds apart, or voiced, with the folds nearly together so that they will vibrate when air passes between them. But in fact the **glottis** (which is defined as the space between the vocal folds) can assume a number of other shapes. Some of these glottal states are important in the description of other languages, and in the description of pathological voices.

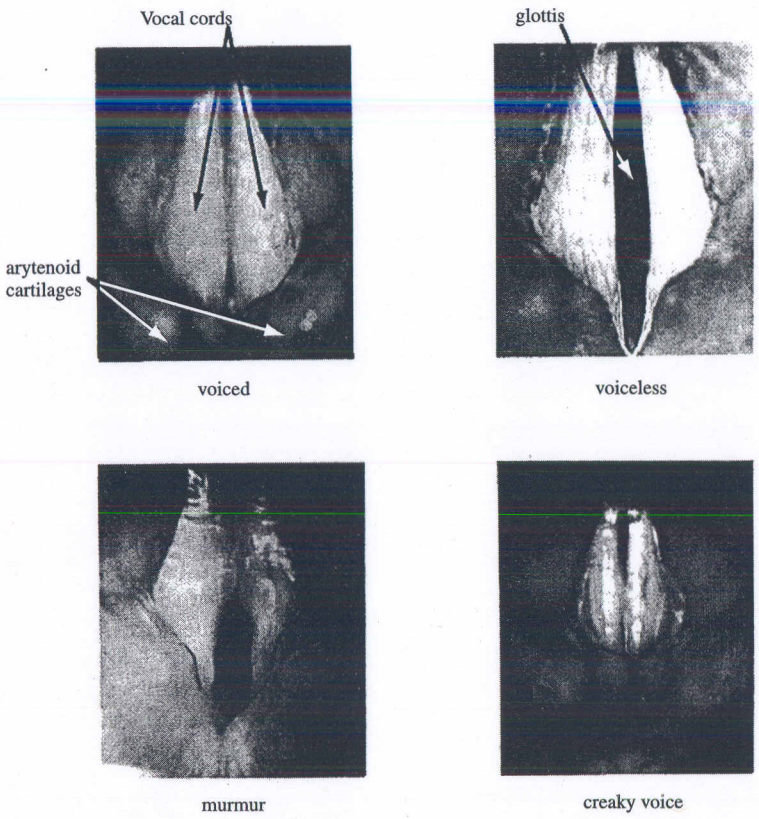
Photographs of four states of the glottis are shown in Figure 6.4. These photographs were taken by placing a small mirror at the back of the mouth, so that it was possible to look straight down the pharynx toward the larynx. The top of the picture is toward the front of the neck, the lower part toward the back. The vocal folds are the white bands running vertically in each picture. Their position can be adjusted by the movements of the **arytenoid cartilages,** which are underneath the small protuberances visible in the lower part of the pictures.

In a voiced sound, the vocal folds are close together and vibrating, as in the first photograph. In a voiceless sound, as in the second photograph, they are pulled apart. This position will produce a completely voiceless sound if there is little or no airflow through the glottis, as in the case of a voiceless fricative or an unaspirated stop. But if there is considerable airflow, as, in an *h*-like sound, the vocal folds will be set vibrating while remaining apart. In this way they produce what is called **breathy voice,** or **murmur.** I have labeled the second photograph "voiceless" because this is the usual position in voiceless fricatives. But in an intervocalic [h] as in *ahead,* the vocal folds are in a very similar position. In these circumstances they will produce breathy voice, vibrating loosely, so they appear to be simply flapping in the airstream. The third photograph shows another kind of breathy voice. In this sound, the vocal folds are apart between the arytenoid cartilages in the lower (posterior) part of the photograph. They can still vibrate, but at the same time a great deal of air passes out through the glottis.

Murmured sounds occur in English in the pronunciation of / h / in between vowels as in *ahead* and *behind.* In most of the speakers of English I have been able to observe, the / h / in these words is made with the vocal folds slightly apart along their entire length, but still continuing to vibrate as if they were waving in the breeze. The term voiced *h* is sometimes used for this sound, but it is somewhat confusing as there is certainly no voicing in the usual sense. The term murmured *h* is preferable. The symbol for this sound is [ɦ].

Learn to distinguish between the murmured sound [ɦ] as in *aha* and the voiceless sound [h] as at the beginning of an English word such as *heart.*

FIGURE 6.4 Four states of the glottis.



The murmured sound is like a sigh produced while breathing heavily. Take a deep breath and see how long you can make first [ɦ] and then [h]. In the voiceless sound [h], the air from the lungs escapes very rapidly, so that this sound cannot be prolonged to any great extent. But you can make the murmured sound [ɦ] last much longer, as the flow of air from the lungs is slowed down by the vibrating vocal folds. Note that [ɦ] can be said on a range of different pitches.

Now say [ɦ] before a vowel. When you say [ɦɑ], you will probably find that the breathiness extends into the vowel. But try to make only the first part of the syllable breathy and produce regular voicing at the end. Finally, try to produce the sequence [ɦɑ] after a stop consonant. Murmured stops of this kind occur in Hindi and in many other languages spoken in India. These sounds will be discussed more fully in the next section. But we can note here that in murmured stops the murmur occurs only during the release of the stop. There must

Table 6.5 Murmured vowels in Gujarati.

Breathy				Plain	
b̤ar	'outside'	b̤ʱar	'burden'	bar	'twelve'
mɛ̤l	'palace'			mɛl	'dirt'

be a comparatively high rate of flow of air out of the lungs to produce murmur, and this cannot happen during the stop closure.

It is fairly easy to produce the required flow rate for murmur during a vowel. Some languages contrast plain and murmured vowels. Table 6.5 shows a set of words in Gujarati, another language spoken in India. Murmured sounds are indicated by placing two dots below the symbol. In Gujarati the contrast between murmured or breathy voiced sounds and regular, modal voice can occur in both consonants and vowels. In the first row you can hear a three-way contrast between a murmured vowel, a murmured release of a stop, and a word that has only modal voice.

In **creaky voice,** which is the other state of the glottis illustrated in Figure 6.4, the arytenoid cartilages are tightly together, so that the vocal folds can vibrate only at the anterior end (the small opening at the top of the photograph). Note that the vocal folds appear to be much shorter in this photograph. This is partly because the posterior portion at the bottom of the photograph is not visible when the arytenoid cartilages are pulled together. But it is also the case that in creaky voice the folds are not stretched from front to back as they are on higher pitches. It is not possible to make accurate measurements of the lengths of the vibrating folds in these photographs, as the glottis is at varying distances from the camera, but this probably accounts for only a small proportion of the variation in length apparent in the photographs. Creaky voice is a very low-pitched sound that occurs at the ends of falling intonations for some speakers of English. You can probably learn to produce it by singing the lowest note that you can—and then trying to go even lower. Creaky-voiced sounds may also be called **laryngealized.**

In some languages, laryngealization is used to distinguish one sound from another. Hausa and many other Chadic languages of northern Nigeria distinguish between two palatal approximants. One has regular voicing, rather like the English sound at the beginning of *yacht,* and the other has creaky voice. The IPA diacritic to indicate creaky voice is [˷] placed under the symbol. Hausa orthography uses an apostrophe (') before the symbol for the corresponding voiced sound, thus contrasting *y* and *'y*. The Hausa letters *y* and *'y* correspond to IPA [j] and [j̰]. Try differentiating between the laryngealized and nonlaryngealized sounds in the Hausa words [jaː] *ya* 'he' and [j̰aː] *'ya* 'daughter', which are included on the CD with the other Hausa words discussed earlier in this chapter. CD 6.1

A slightly more common use of laryngealization is to distinguish one stop from another. Hausa and many other West African languages have voiced stops

[b, d] contrasting with laryngealized stops [b̰, d̰], which are sometimes implosives. In these sounds, the creaky voice is most evident not during the stop closure itself but during the first part of the following vowel. Similar sounds occur in some American Indian languages.

VOICE ONSET TIME

We saw earlier that the terms voiced and voiceless refer to the state of the glottis during a given articulation. We also saw that the terms aspirated and unaspirated refer to the presence or absence of a period of voicelessness during and after the release of an articulation. The interval between the release of a closure and the start of the voicing is called the **voice onset time** (usually abbreviated VOT). The easiest way to visualize VOT is by reference to the waveform of a sound. This is the technique used in Chapter 3 to discuss the differences between *tie* and *die*. The VOT is measured in milliseconds (ms) from the spike indicating the release of the stop closure to the start of the oscillating line indicating the vibrations of the vocal folds in the vowel. If the voicing begins during the stop closure (i.e., before the release), the VOT has a negative value.

The top part of Figure 6.5 shows the waveforms of the first parts of three of the Sindhi words in Table 6.2: [daru] 'door', [taru] 'bottom', [t^haru] (name of a district). The dashed line indicates the moment of release of the stop. A time scale centered on that moment is at the bottom of the figure. In the waveform for [da] at the top of the figure there is voicing throughout the closure, the release, and the vowel. This is a fully voiced stop that has a negative VOT of –130 ms.

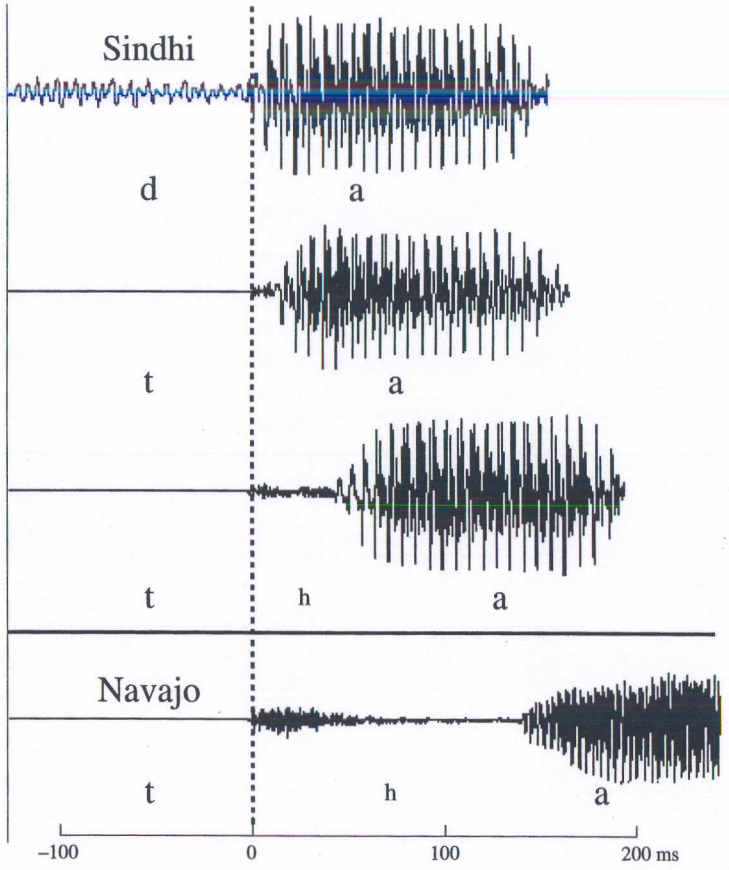
:D 6.3

In the next waveform, [ta], there are no voicing vibrations during the closure (before the dashed line). This is, therefore, a voiceless stop. The voicing starts very shortly after the closure, the VOT being less than 20 ms, making this an unaspirated stop. To produce this stop, the vocal folds are apart during the whole of the closure period but close together at the moment of release of the closure, so that voicing starts as soon as there is sufficient air flow through the glottis. In the middle of the closure, the vocal folds might be in a position similar to that shown in the top right photograph in Figure 6.4.

The third waveform, [t^ha], shows an aspirated stop, with a VOT of about 50 ms. In producing this sound, the vocal folds are apart during the stop closure and the glottis is still open at the moment of the release of the stop closure.

There is a continuum of possible voice onset times. Some languages, such as Sindhi, have very fully voiced stops with a large negative VOT. Others, such as English, have little or no voicing during the closure, unless the stop is preceded by a sound in which the vocal folds are already vibrating, in which case the vibration may continue through the closure. Similarly, languages vary in the VOT they use for aspirated stops. In the Sindhi example in the third row in Figure 6.5 it is only 50 ms. In Navajo, as shown in the last row in Figure 6.5, aspirated stops have a VOT of about 150 ms. When producing a strongly aspirated stop such as this, the maximum opening of the vocal folds will be much larger than that

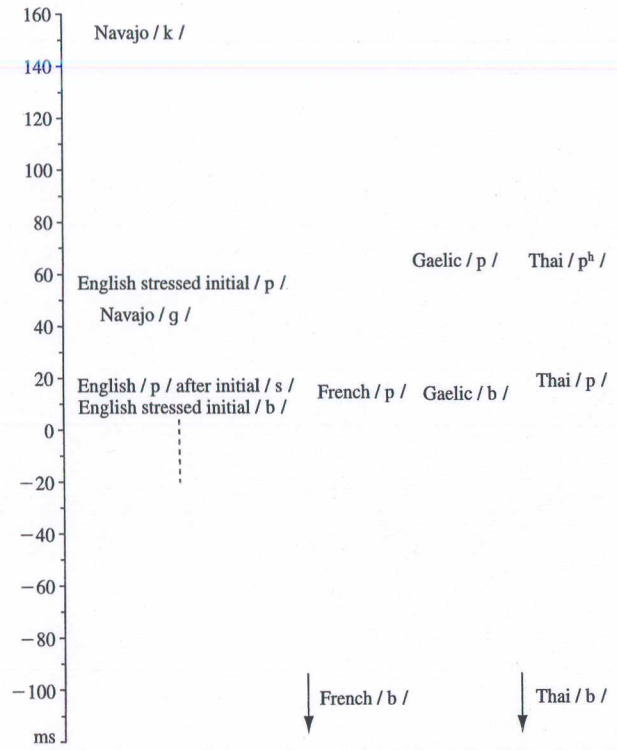
FIGURE 6.5 Waveforms showing stops with different degrees of voicing and aspiration.



shown in the top right photograph in Figure 6.4. The maximum opening will occur at about the moment of release of the stop closure. In general, the degree of aspiration (the amount of lag in the voice onset time) will depend on the degree of glottal aperture during the closure. The greater the opening of the vocal folds during a stop, the longer the amount of the following aspiration.

Different languages choose different points along the VOT continuum in forming oppositions among stop consonants. This point is illustrated in Figure 6.6, in which some of the possibilities that occur in different languages are shown with reference to a scale going from most aspirated (largest positive VOT) at the top to most voiced (largest negative VOT) at the bottom. The Navajo aspirated stops, shown in the first column, have a very large VOT that is quite exceptional. Navajo does not have a bilabial stop series, but for all the other languages the positions shown on the scale correspond to bilabial stops. As you can see, also in the first column, a normal value for the VOT of English

FIGURE 6.6 Differences in voice onset time in different languages on a scale going from most voiced (largest negative VOT) to most aspirated (largest positive VOT).



stressed initial / p / would be between 50 and 60 ms. English initial / b /, at the bottom of the first column, may have a VOT of about 10 ms, but, as indicated by the dashed line, it may be less, and even slightly negative. After an initial / s /, English / p / will have a VOT much like English initial / b /.

Other languages make the contrast between phonemes such as / p, t, k / and / b, d, g / in initial position with very different VOTs. Navajo contrasts initial / k / with a / g / that is far from voiced; it has a VOT of over 40 ms. As this sound is completely voiceless, it might be better to say that the contrast in Navajo is between / kʰ / and / k /, rather than between / k / and / g /. However, both ways of transcribing Navajo are perfectly valid. As we saw in Chapter 2, you can make a broad transcription that shows the phonemic contrasts in a language using the simplest possible symbols, or you can make a narrow transcription that shows the phonetic detail. As long as the broad transcription is accompanied by a statement that specifies how it should be interpreted, it is equally accurate. The choice of symbol depends in part on the reason for making the transcription.

In broad transcriptions of English, it is sufficient just to use / b, p /. But if one wants to show more phonetic detail, one can specify that the phoneme / b / is a completely voiceless [b̥] in, for instance, *that boy* [ðæʔtb̥ɔɪ] in my English. Similarly, one might want to show phonetic details such as the aspirated / p / that occurs in *pie* [pʰaɪ] or the unaspirated / p / in *spy* [spaɪ].

The second column in Figure 6.6 shows how the sounds of French line up with those of English and Navajo. The voiced stops in French (and Spanish, Italian, and many other languages) are nearly always fully voiced. The length of the voicing varies, depending on the length of the closure, which is why I added an arrow alongside French / b /. Voiceless stops in these languages are unaspirated, making French / p / similar to English initial / b /.

French / p / is even more like Gaelic / b /, which is virtually never voiced, even between vowels. The Gaelic opposition between / b / and / p / is, in a narrow phonetic transcription, / p / versus / pʰ /. In the Gaelic spoken in the Outer Hebrides of Scotland, the VOT of / pʰ / is around 65 ms, not nearly as long as that in Navajo, but longer than that in English.

Some languages contrast three different voice onset times. Thai has voiced, voiceless unaspirated, and aspirated stops, as shown in the final column in Figure 6.6. Words illustrating these contrasts in Thai are given in Table 6.6. As in the case of French, the voiced stops are fully voiced, with the duration of the voicing depending on the length of the stop closure.

Many languages spoken in India, such as Hindi and Sindhi, have not only the three possibilities that occur in Thai, but murmured stops as well. After the release of the closure, there is a period of breathy voice or murmur before the regular voicing starts. Some illustrative Hindi words are given in Table 6.7. The breathy voice release of these stops is indicated by [ʱ], a raised hooked letter *h*. The Sindhi words in the last row of Table 6.2 also illustrate breathy voiced stops. As shown in the tables, in addition to the breathy voiced stops, both Sindhi and Hindi also contrast stops with three different voice onset times.

Figure 6.7 shows the waveforms of the Hindi dental stops in the second row of Table 6.7. There is voicing during the stop closure of [d̪] (in the top line), but not during the stops in the second and third lines. The second line has a voiceless unaspirated [t̪] with a VOT of about 20 ms. The third line has an aspirated [t̪ʰ], with a VOT of almost 100 ms. In the fourth line, the [d̪ʱ] has voicing during the

TABLE 6.6 Stops in Thai.

Voiced	bâː	d̪àː
	'crazy'	'curse'
Voiceless Unaspirated	pâː	t̪aː
	'aunt'	'eye'
Voiceless Aspirated	pʰâː	t̪ʰâː
	'cloth'	'landing place'

CD 6.9

TABLE 6.7 Stops in Hindi.

	Voiceless Unaspirated	Voiceless Aspirated	Voiced	Breathy Voiced
Bilabial	pal 'take care of'	pʰal 'knife blade'	bal 'hair'	bʱal 'forehead'
Dental	t̪al 'beat'	t̪ʰal 'plate'	d̪al 'lentil'	d̪ʱal 'knife'
Retroflex	ʈal 'postpone'	ʈʰal 'wood shop'	ɖal 'branch'	ɖʱal 'shield'
Post-alveolar Affricate	t̠ʃʌl 'walk'	t̠ʃʰʌl 'deceit'	d̠ʒʌl 'water'	d̠ʒʱʌl 'glimmer'
Velar	kan 'ear'	kʰan 'mine'	gan 'song'	gʱan 'bundle'

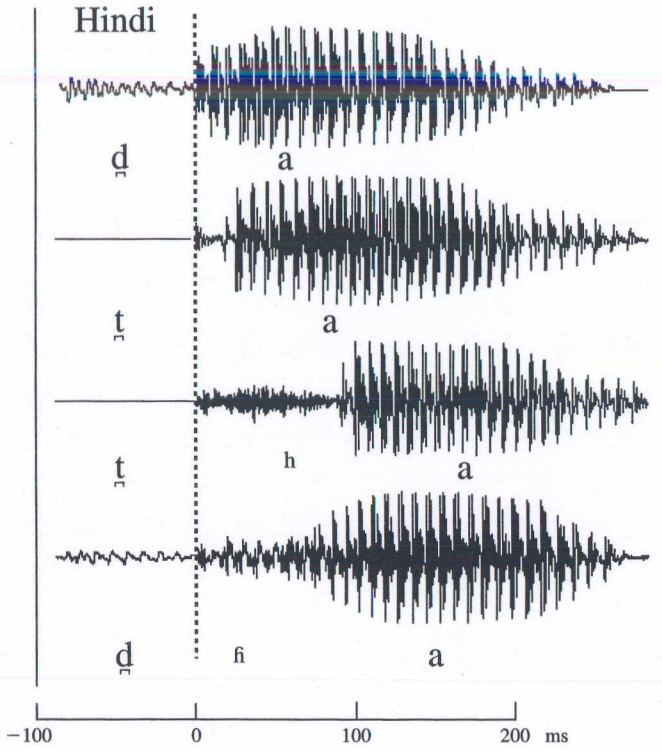
closure followed by a waveform that has some of the appearance of voicing—a wavy line—but also has noise superimposed on it. This is breathy voicing. It is difficult to say how long this breathy voiced aspiration lasts, as it shades into the regular voicing for the vowel. During this breathy voicing the vocal folds are drawn into loose vibrations and do not come fully together.

The difference between voiceless unaspirated, aspirated, and murmured stops (the last three rows in Figure 6.7) is largely a matter of the size and timing of the opening of the vocal folds. In voiceless unaspirated stops, the maximum opening of the glottis (which is not very great) occurs during the stop closure. In (voiceless) aspirated stops the glottal opening is larger and occurs later, near the moment of release of the stop closure. In murmured stops, the glottal opening is similar in size to that in voiceless unaspirated stops. but it occurs later, during the release of the closure. Because there is a rapid flow of air through the vocal folds at this time, the vocal folds vibrate while remaining slightly apart, thus producing breathy voice.

Learn to produce a series of sounds with different voice onset times. Start by producing fully voiced stops [b, d, g]. See how long you can make the voicing continue during each of these sounds. You will find that you can make it last longer during [b] than during [d] or [g] because in [b] there is a fairly large space above the glottis. Air from the lungs can flow through the glottis for a relatively longer period of time before the pressure above the glottis begins to approach that of the air in the lungs. The vocal folds can be kept vibrating throughout this period. But in [g] there is only a small space above the glottis into which air can flow, so the voicing can be maintained only briefly. Languages often fail to have fully voiced velar stops. Note that Thai does not have a voiced stop contrasting with a voiceless unaspirated stop at this place of articulation.

When you can produce fully voiced stops satisfactorily, try saying voiceless unaspirated [p, t, k]. You may find it easiest to start with words like *spy, sty, sky.* Say these words very slowly. Now say words like them, but without the initial [s].

FIGURE 6.7 Waveforms showing the VOT of the stops in Hindi.



You will have less difficulty making aspirated stops, because they occur in most forms of English—in words such as *pie* [pʰaɪ] and *tie* [tʰaɪ]. But do try pronouncing all of the Thai and Hindi words in Tables 6.6 and 6.7.

SUMMARY OF ACTIONS OF THE GLOTTIS

The vocal folds are involved in many different kinds of actions. They are used in the production of implosives and ejectives, and in forming different phonation types. These two types of activities are often not clearly separable. The implosives of some forms of Hausa are as likely to be marked by creaky voice as by a downward movement of the glottis, and Zulu has weak ejectives that could well be considered simply as glottal stops superimposed on plosives. Consequently it is convenient to summarize all these activities in a single table. Table 6.8 shows the principal actions of the glottis.

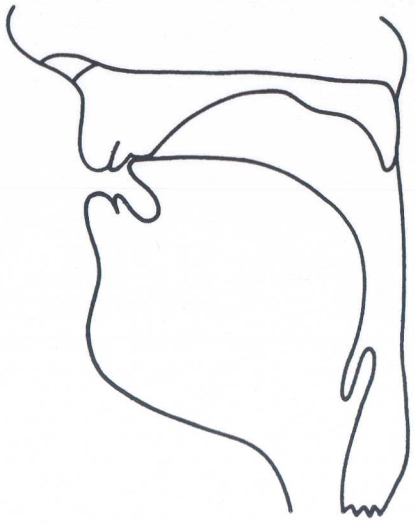
TABLE 6.8 The principal actions of the glottis.

Glottal stop	Vocal folds together	ʔ
Ejective	Vocal folds together and moving upward	pʼ, tʼ, kʼ, sʼ
Implosives	Closed vocal folds moving downward	ɓ, ɗ, ɠ
	Usually nearly closed vocal folds moving downward with regular vibrations or creaky voice	ɓ, ɗ, ɠ
Creaky voice	Vocal folds held tightly together posteriorly, but vibrating (usually at a low rate) anteriorly	b̰, d̰, a̰, ḛ
(Modal) voice	Regular vibrations of the vocal folds	b, d (in, e.g., French), a, e
Breathy voice (murmur)	Vocal folds vibrating without coming fully together.	a̤, e̤
	Often during a stop release	ɓʱ, dʱ
Voiceless	Vocal folds apart	p, t, k, s
		m̥, n̥, ŋ̊
Aspirated	Vocal folds apart during the release of an articulation	pʰ, tʰ, tʰ, sʰ

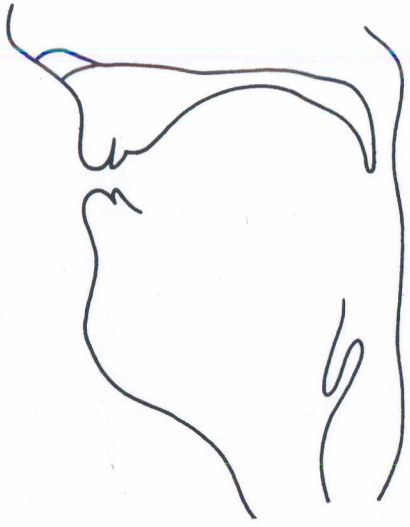
EXERCISES

(Printable versions of all the exercises are available on the CD.)

A. Label the diagram below so as to show the sequence of events involved in producing a voiced alveolar implosive.



B. Complete the diagram below so as to show the gesture of the vocal organs required for producing [n͡ŋ]. Add labels so that the sequence of events is clear.



C. Measure (to the nearest 10 ms) the VOT in the waveforms of the stops in *a pie, a buy, a spy*.