

the vocal tract

[2]

2.01 Speaking and Breathing

All speech sounds in all languages are produced by modifying ordinary respiration. In quiet breathing, air enters and leaves the lungs without any obstruction, passing freely through the throat and mouth (or nose). If, however, the tongue or some other organ is placed in the path of the airstream, this free passage of air is disturbed; the air from the lungs may be set into vibration or the flow momentarily interrupted. For example, the lips close and briefly cut off the airstream for [p] and [b]. Any such disturbance generates a sound wave — a ripple effect that travels through the air between speaker and hearer(s) and is then interpreted as a particular speech sound. Articulatory phonetics studies the various ways in which airstreams can be “interfered with”.

2.02 The Source of Air for Speech Sounds

The LUNGS (Fig. 1) are basically sponge-like in design, except that they hold air (in a myriad of tiny airsacs), not water. When we breathe in, we enlarge the chest cavity (in part by lowering the diaphragm). This in turn expands the lungs, and air rushes in to fill the vacuum. Breathing out involves the opposite procedure. The chest is contracted and air is squeezed out of the lungs, passing through the two BRONCHI (or bronchial tubes), then through the windpipe (more technically the TRACHEA), and finally emerging in the throat.

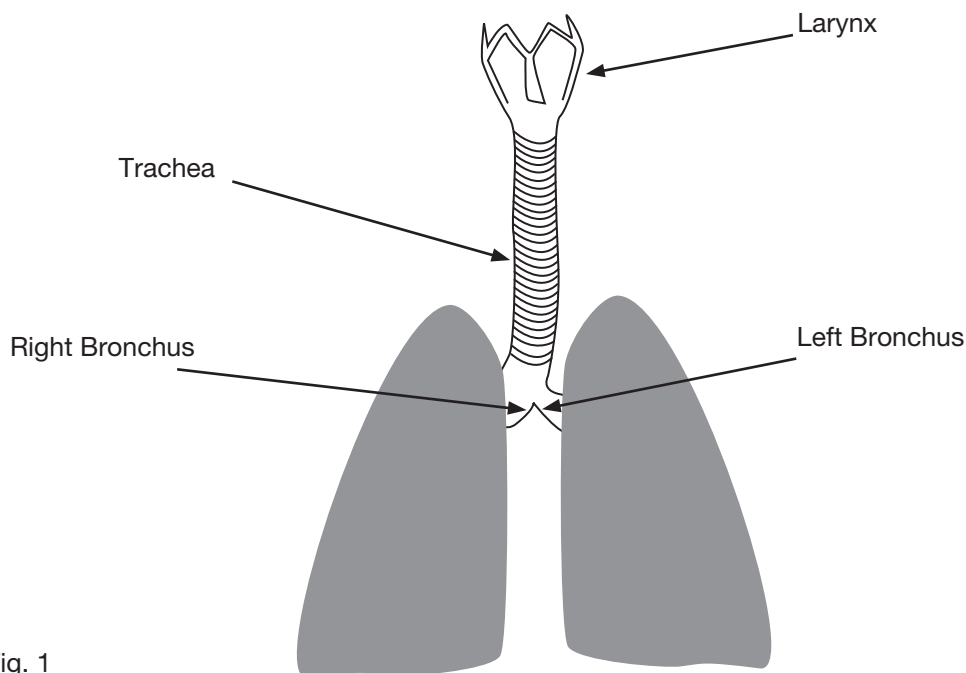


Fig. 1

One or two refinements on this simple picture might be noted in passing.

First, we normally speak only while breathing out. It's also quite possible to speak while breathing in (for example when counting and not wishing to pause to draw breath), but this is an inefficient way of making sounds and therefore not a regular feature of any language. In some speech-communities, though, people use "ingressive air" as a conventional means of disguising their voices.

Second, there are various ways of making speech sounds with air that *doesn't* originate in the lungs. The disapproving noise conventionally represented as *tut tut!* is an example. Some languages make regular use of "click" sounds like this one, as well as other "non-pulmonic" sounds that from a European point of view seem even more exotic.

Third, if we used the same breathing rhythm for talking as for just breathing quietly, we'd have to pause for breath every couple of words. (Try it and see.) In speech, quite complex adjustments of the chest muscles and diaphragm are constantly being made in order to slow down the airstream and hold it back as it leaves the lungs.

2.03 The Larynx

The statement above that the airstream "emerges from the trachea (windpipe) into the throat" is actually an over-simplification. Before the air reaches the "throat", it has to pass through one of the most important speech organs, the LARYNX. It's at this point that the first possibilities occur of modifying the airstream and generating sound.

The larynx can conveniently be thought of as an irregularly-shaped, hollow box made of cartilage, which sits on top of the trachea. (This is reflected in the non-technical name for it: the "voice-box".) The front of the larynx can easily be seen and touched: it forms the projection an inch or two below the chin, known as the "Adam's apple" (more prominent in males than in females — hence presumably the name).

Across the interior of the larynx are stretched two horizontal sheets of muscle tissue. When these are relaxed and wide apart, then the air is free to pass between them. This is how they are held for normal respiration (Fig. 2). But if they are brought together with their inner edges in close contact, then air is prevented from entering or leaving the lungs: the only way in or out is through the larynx cavity, which is now sealed off (Fig. 3). This is the configuration for swallowing: it prevents not only air but, more importantly, foreign bodies from getting into the lungs.

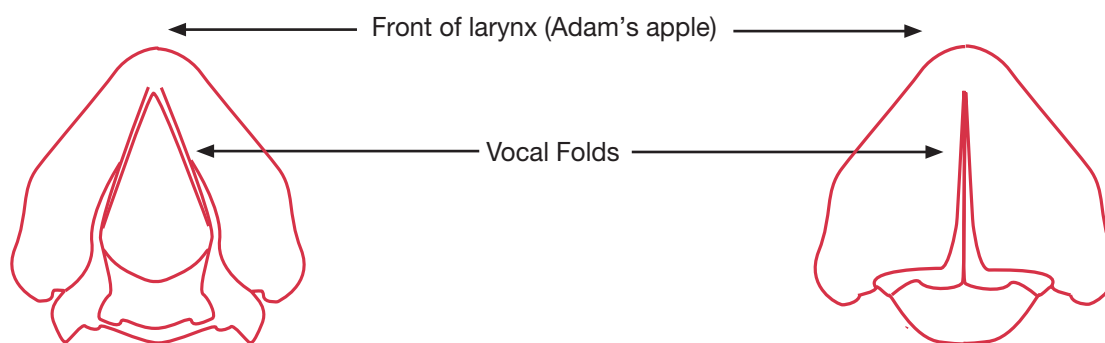


Fig. 2

Fig. 3

A third possibility is shown in Fig. 4. The sheets of muscle are again in contact, but very loosely this time, instead of being pressed firmly together as they were in Fig. 3. As a result, air is able to pass through, but not freely: it has to force its way, so to speak. This sets the inner edges of the muscles into vibration, and this vibration causes a disturbance in the airstream — i.e. a sound wave. The sound is greatly amplified by the resonance of the mouth and throat cavities, and the result is: the human voice. As a consequence, the inner edges of the muscles stretched across the larynx are known as the *vocal folds* (alternatively *vocal cords* or, occasionally, *vocal lips*). Say *aaah*, for instance: the sound you're producing is amplified vocal fold vibration. In essence, the vibration is similar to the effect which you get by folding over a piece of thin paper and blowing between the edges.

The space between the vocal folds is known as the GLOTTIS. So Fig. 2 shows an open glottis, Fig. 3 a closed glottis, and Fig. 4 a vibrating glottis.

The vocal folds also control the pitch of the voice. As with the strings of a musical instrument, the greater the tension, the higher the pitch. The larynx is provided with a number of muscles which, together with the vocal fold muscles themselves, carry out the complex adjustments of vocal fold tension that take place continually during speech.

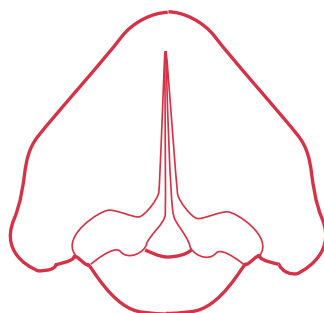


Fig. 4

The larynx and vocal folds of women and children are smaller than those of adult males: hence the difference between soprano and bass voices. When a boy's voice "breaks" at puberty, this is due to a rapid increase in the size of the larynx.

Subtle and complex adjustments of the glottis give rise not just to "normal" voice at a range of pitches, but also to such varied vocal effects as stage whisper, falsetto and so-called "breathy voice". But it's worth remembering that voice is a only secondary adaptation of the "vocal" folds, despite the name. (Other mammals and even reptiles have a larynx too.) Biologically the primary function of the larynx in general and the vocal folds in particular is to serve as a valve for the lungs. As has been mentioned already, it's advisable to close the glottis firmly when swallowing — we all do so instinctively in fact. A second important reason for having a larynx is that the closed vocal folds, by holding back the airstream, can create a firm column of air in the chest, against which we can push during various kind of physical exertion. Weightlifting, defecation and childbirth all involve a tightly closed glottis!

2.04 Voicing

Although it's merely a biological by-product, the importance of voice for languages can't be overestimated. All vowel sounds are normally uttered with the vocal folds in vibration (i.e. they are *voiced*) and so are around half the consonants. Take [s] and [z],

for instance. As we'll see in more detail later, for both these sounds there is a constriction of the airflow just behind the upper front teeth. The difference between them is that [s] is *voiceless* (vocal folds held apart in the Fig. 2 position and the airstream able to pass between them unhindered) whereas [z] is *voiced*, with the vocal folds in the Fig. 4 position and consequently in vibration. You should be able to spot the absence or presence of voicing easily enough if you say [s] ... [z] ... [s] ... [z] loudly several times in alternation. The difference becomes even more obvious if you place your fingers firmly over your ears while doing so.

The same relationship exists between the *th* in *thin* and the *th* in *this*. This time, unfortunately, the spelling doesn't show any difference. But by repeating these two words in alternation you should be able to tell that in the case of *thin* we have a voiceless *th* and in the case of *this* a voiced one. The phonetic alphabet uses a separate symbol for each: [θ] (read "theta") for the *th* of *thin* and [ð] (read "eth") for the *th* of *this*. [ð] is also sometimes called "thorn" (from the name of a letter of the Old English alphabet).

Yet another voiceless/voiced pair is [p] and [b]. Try to say [apa] and [aba] in alternation. In both cases there's a momentary blockage of the airstream between the lips when the consonant is made. What makes the difference between them is voicing (present for [b], absent for [p]).

In fact almost all consonants come in voiced and voiceless pairs — an very efficient use of a single feature (*voicing*) in order to double, at a stroke, the number of available sounds.

Exercises

1. Choose an appropriate term from the list, and insert it into one (or more) of the gaps in the paragraph that follows:

bronchi
glottis
larynx

lungs
trachea
vocal folds

The _____ supply the air for almost all speech sounds. Air passes from them into the _____, one from each of the two _____, and these two airstreams merge in the _____, a short tube situated in the lower part of the neck. On top of this is a valve known as the _____. Here the supply of air to the throat and mouth is controlled by opening or closing the _____ the gap between the two _____. In ordinary quiet breathing the _____ is open; for swallowing it is closed in order to protect the _____. A noteworthy evolutionary adaptation in humans allows voice

to be produced by positioning the _____ in such a way that passage of air between them causes them to vibrate.

2. Say whether the following consonants are voiced or voiceless. The first group have already been mentioned — see if you can answer without looking at the text. For the second group the decision is up to you.

(a) [z], [θ], [b], [p], [ð], [s].

(b) [f], [v], [t], [d], [k], [g], [ʃ] (this is the symbol for the *sh* of *ship*)

3. The following pairs of words are distinguished in pronunciation partly or solely according to whether they contain a voiced (*vd*) or a voiceless (*vl*) consonant. Say which is the crucial consonant in each case, and specify its voicing status.

pin, bin
fail, veil
toll, dole
gin, chin

zoo, sue
wreath, wreathe (“in smiles”)
either, ether (a kind of gas)
Aleutian, allusion.

4. Changing the voicing of a single consonant in each of the following results in a different word. Which consonant and which word? (Sometimes there’s more than one possibility. Concentrate on the pronunciation, not on the spelling.)

seal
razor
ice
scarce
ankle
dug

bicker
lunge
Jews
choke
thigh
Confucian

2.05 The Upper Vocal Tract

The next thing you need to get a clear idea about is the configuration of the cavities through which the air passes once it has left the larynx. These are referred to collectively as the UPPER VOCAL TRACT — “upper” because the vocal tract as a whole includes the larynx as well. You can call it the *supra-glottal tract* if you prefer (*supra* is a Latin word meaning “above”). Fig. 5 gives the overall picture. You can see from this that the upper vocal tract consists of the mouth and throat cavities (together referred to as the *oral tract*) and the nasal cavity (or *nasal tract*). The oral tract has a part to play in all speech sounds. Sounds like [n] or [m] or the nasal vowels of French or Portuguese involve the nasal tract as well, as will be seen later.

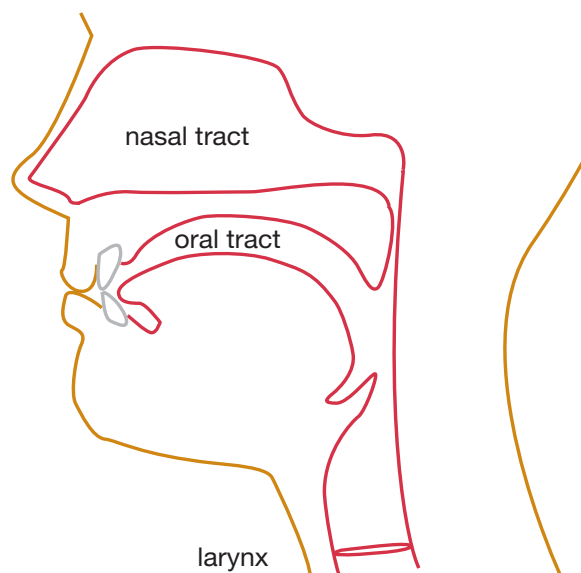


Fig. 5

Let's go through the various parts of the oral tract, drawing attention to those that are directly involved in the production (or articulation) of speech sounds, and are therefore known as *articulators*. A number of consonant sounds will be mentioned in passing in order to illustrate the part played by different articulators, but there's no need to concentrate too much on individual sounds at this stage: they will be presented in more detail in later chapters. For the moment you should aim at understanding the location and names of the various "organs of speech" labelled in Fig. 6.

2.06 The Oral Tract from Lips to Uvula

a. THE LIPS. These are too familiar to need further comment, and the involvement of the upper and lower lip in sounds like [p] and [b] is also very obvious. (Details about exactly what happens will be provided later.)

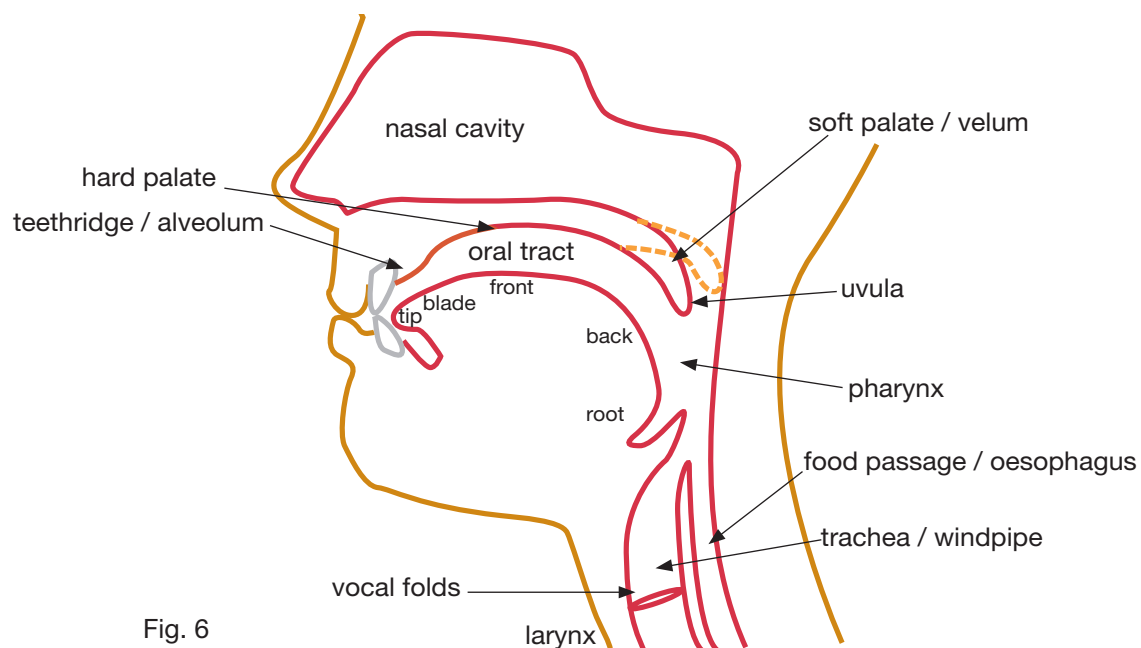


Fig. 6

b. THE UPPER FRONT TEETH. These are involved for example in the production of [θ] and [ð] (as in *thin* and *this*), for which the tongue comes into contact with the back of the teeth. As the tongue is the moveable organ which initiates the contact, it is said to be an active articulator, and the teeth, which don't move, are a passive articulator. The lower teeth and the remaining upper teeth don't appear to have any role in language.

c. THE ALVEOLAR RIDGE. Place the tip of your tongue against the rear of your upper front teeth. Then draw it slowly backwards along the roof of the mouth. You'll notice that there is a bulge or ridge just behind the teeth, after which the roof of the mouth rises in quite a steep, domelike way. This is the *teethridge* — in phonetics more commonly called the *alveolar ridge* or *alveolum*. It's an important passive articulator for sounds like [t], [d], [s] or [z]. Again the tongue is the active articulator.

d. THE HARD PALATE. This is the steeply rising section of the roof of the mouth behind the alveolar ridge. It serves as a passive articulator in sounds like the *h* of *huge*.

e. THE SOFT PALATE or VELUM. If you continue to run your tongue backward along the roof of the mouth (as far back as it can go) you will come to a point where the hard bone of the palate gives way to soft tissue. This section of the roof of the mouth is accordingly known as the soft palate, or, more commonly, the velum. The back of the tongue comes into contact with the velum for consonants like [k] and [g].

The velum is an important organ of speech because it's moveable and its movement controls the entrance to the nasal cavity. (That's why it's soft not hard: it consists of muscle tissue.) Raising the velum so that it's pressed against the rear wall of the throat has the effect of closing off the nasal tract, so that air is diverted into the mouth (dashed line in Fig. 6). If you want to breathe through your nose, you have to lower the velum (solid line in Fig. 6).

Nasal consonants like [m] or [n] and nasalized vowels are articulated with the velum lowered. For non-nasal sounds (that's the vast majority), the velum must be in the raised position, so that the airstream passes into the mouth. Note that the velum can't block the entrance to the oral cavity, even when it's lowered. So even for nasal sounds, some air enters the mouth. More about this point in 3.08 and 4.09.

f. THE UVULA. This is the extreme tip of the velum, and isn't directly involved in the closure of the nasal cavity: you can see from Fig. 6 and several of the other figures how it dangles down instead of being pressed against the rear wall. Some *r* sounds in French and German involve the uvula. More about these in 4.11.

2.07 The Tongue.

The tongue has long been thought of the speech organ *par excellence*, even though its biological role lies in tasting and swallowing, not in vocalizing. In many languages the word for “tongue” and the word for “language” are one and the same (French *langue*, Spanish *lengua*, Russian *iazyk* for instance, or *tongue* in Biblical and Shakespearean English). In actual fact the larynx is also important, as we have seen — but as people are much less conscious of it, it seems to have attracted less attention.

Anyway, the tongue is certainly involved in the articulation of a large number of sounds, just a few of which have been mentioned above. Its versatility is due to the fact that it consists entirely of nerve and muscle tissue, so it is highly flexible and mobile. You can see from Fig. 6 that the tongue is not thin and flat (even though it may feel that way), but has a considerable amount of depth or body.

It's convenient to consider the tongue as consisting of a number of different sections (see Fig. 6). As there are no clear cut-off points on the tongue itself, these divisions are somewhat arbitrary, and can vary from one authority to another. But most phoneticians distinguish between the TIP, the BLADE, the FRONT (not a good name, as it's more like the middle than the front!), the BACK and the ROOT. These articulate against different parts of the roof of the mouth, giving sounds like the *s* of *so* (with the blade), the *sh* of *shall* (with the front), and so on.

2.08 The Pharynx

Even more so than *roof of the mouth* and *tongue*, the term *throat* is somewhat vague and general. (Should it be taken as including the larynx, for example?) Consequently throat isn't a word that's used much by phoneticians, who prefer more specific terms. *Larynx* is one which you already know, and another — not to be confused with it — is PHARYNX. This designates the tubular cavity bounded by the larynx, the root of the tongue and the soft palate, shown in Fig. 6.

You can see from the figure that the pharynx is a kind of crossroads: air passes through it from the lungs to the nasal cavity; food passes through it from the mouth to the oesophagus or food-pipe.

On the face of it, this mingling of food passage and airway sounds a rather unsatisfactory arrangement. And in fact in animals the larynx is situated higher up, so that it's linked directly with the nasal cavity: no danger of choking for our dumb friends. But a high larynx is much less efficient for the articulation of speech sounds. It looks as though the “low-slung” human larynx has been favoured by evolution, as it allows better vocal communication. That the occasional unfortunate individual should choke to death is presumably a price well worth paying! Incidentally human babies have a high larynx, which “migrates” downwards during the first months of life: a nice example of “ontogeny recapitulating phylogeny”.

In some languages, the rear wall of pharynx serves as a passive articulator. The root of the tongue is pulled back towards it, causing a constriction used for certain characteristically “guttural” sounds in Arabic or Hebrew (see 4.06).

Remember the difference: the larynx is a cartilaginous box immediately above the trachea; the pharynx is the cavity or “crossroads” above the larynx.

2.09 Pronunciation: an Acquired Skill

Two points by way of conclusion.

Firstly, the structures described above are universal in humans: whatever the race or speech-community, the speech organs are the same. There are of course differences in the size and even precise shape of particular parts of the vocal tract, but differences between individuals in a given speech-community are greater than the average differences between one community and another.

It follows from this that the pronunciation difficulties experienced by people learning a foreign language are due to psychological factors, not to anatomical ones. After the age of 10 or so, most people find it difficult to break away from their native sound system. So someone who finds French *r*, German *ü* or Spanish *j* troublesome doesn't have anything wrong with their uvula, tongue or velum (or at least this is highly unlikely): it's just that their brain is finding it hard to adapt to new articulatory habits. A person's knowledge of his or her mother tongue is in no way congenital. Had you been kidnapped at the age of six months and brought up in France, Germany or Spain — or China or the Amazon Basin for that matter — you'd be speaking the local language in a totally “native-like” manner ... and no doubt having problems with English.

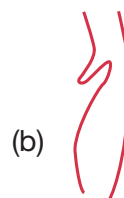
Exercises

5. Show where the following are situated on this diagram of the upper vocal tract:

1. blade of tongue,
2. front of tongue,
3. velum,
4. pharynx,
5. larynx,
6. uvula,
7. alveolum,
8. root of tongue.



6. Identify these close-ups of sections of the upper vocal tract.



7. Which of the following parts of the vocal tract are moveable?

lips, tongue, alveolum, pharynx, velum, uvula, nasal cavity.

8. Say whether the following are TRUE or FALSE. If false, say what the correct statement should be.

(a) *The pharynx is a cartilaginous structure attached to the trachea.*

(b) *The alveolum serves to open and close the entrance to the nasal cavity.*

(c) *The lower front teeth are not involved in speech.*

(d) *The uvula is the extreme tip of the soft palate.*

(e) *Larynx is an alternative name for the teethridge.*

9. Give the technical names for the following:

wind-pipe, voice-box, space between the vocal cords, food-pipe, soft palate, teethridge, cavity at the back of the throat.

10. Distinguish (when appropriate) between the following:

the vocal tract

the upper vocal tract

the supra-glottal tract

the oral tract

the nasal tract.

11. Draw from memory a labelled diagram of the upper vocal tract.