INTERNATIONAL STUDENT EDITION

FIFTH EDITION

A COURSE IN PHONETICS

Peter Ladefoged

INTERNATIONAL STUDENT EDITION

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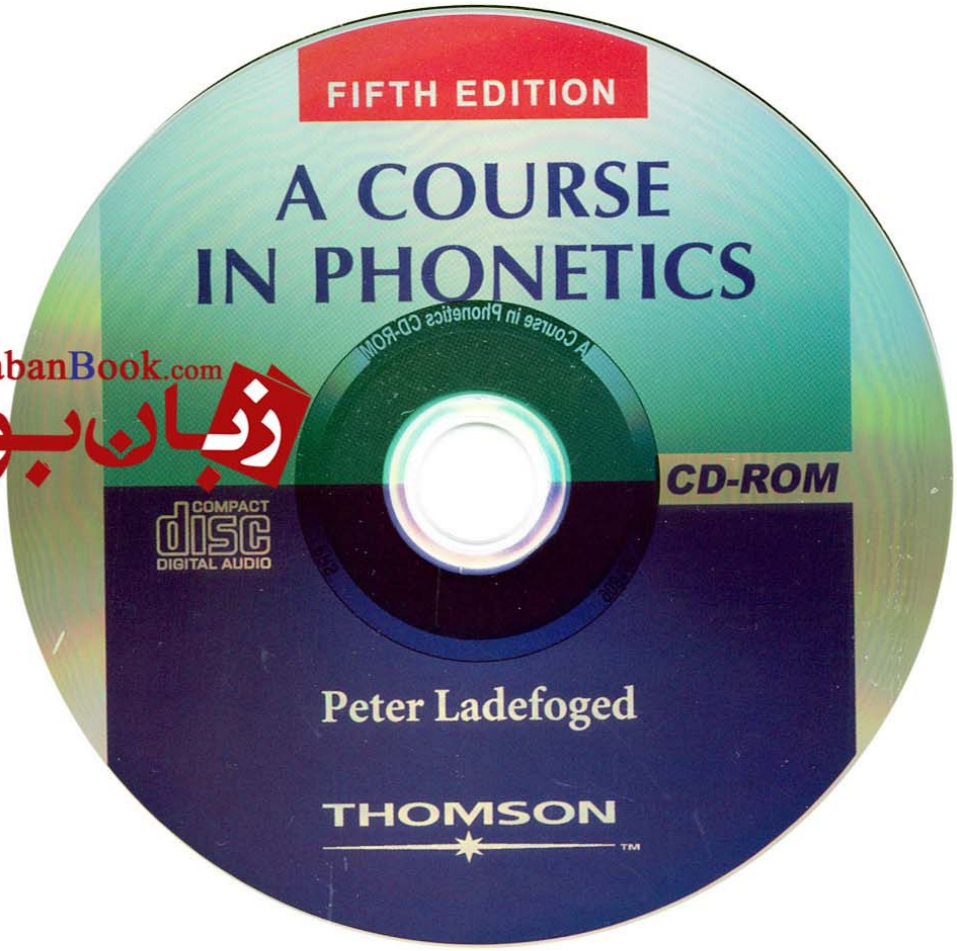


Contents

PART II: ENGLISH PHONETICS

PART III: GENERAL PHONETICS

Preface

This is the first complete revision of this book since its original publication in 1975. The intended audience remains the same, a diverse group including students of linguistics and those who are concerned with studying the sounds of English, as well as speech pathologists and communication scientists who want to know about the sounds of speech. It also remains a course textbook, something that I hope you will work through, doing the exercises. If you want a shorter, more general introduction, you should read another of my books, *Vowels and Consonants* (see Further Reading at the back of this book). As in previous editions of this book, there is an introduction to how speech is produced; a description of speech in acoustic terms; and instruction in practical phonetic skills. These approaches all use phonetic transcription. Whether you are a speech pathologist, a linguist, or any other kind of student of speech, you need to be able to represent the sounds of speech by using the symbols of the International Phonetic Alphabet (IPA). This is the accepted way of recording observations of what people say. Ordinary spelling does not allow you to represent all the subtle variations that occur when different people talk. Learning to use the IPA symbols is an essential part of phonetics.

There are a few major changes from previous editions. The most important is the inclusion of a CD, which all students should use when going through the book. Clicking on *A Course in Phonetics* on the front (title) page of the CD will lead you to the contents page for the material most relevant to this book. Each chapter is listed on this contents page, usually with links to three sections that provide data for the chapter. The first section, linked to the chapter title itself, contains recordings of nearly all the words in the tables and many of the examples cited in the text. The second section has downloadable files of most of the exercises. These files can be printed out so that students can fill in the answers and hand them in to their instructors. The third section (present for all chapters except the first) demonstrates the phonetic performance exercises that students should practice. In addition to the material keyed to the chapters, there are several extras that inquiring students may find interesting, including map indexes, incidental notes on some of the recordings, and recordings of other languages that could have been put in the text but were left out so that the book did not become too extensive to be a useful textbook.

A second change is the inclusion of a small amount of material on acoustics early in the text. Our ability to describe the acoustic structure of speech has grown enormously, so that it now exceeds our knowledge of speech articulation. We

know more precise details about the acoustics of speech than we do about the movements of the articulators. We can even synthesize high-quality speech on the basis of our acoustic knowledge. Our attempts at synthesizing continuous speech by using computer models of the lips, tongue, and vocal folds are far cruder. For this reason it seemed advisable to integrate acoustic descriptions of speech into the basic framework of this book, starting in a small way in the first chapter. In some institutions acoustic phonetics is taught as a separate course, after an introduction to phonetics based on articulations. This seems to me to be the wrong approach, one that is based on tradition and the history of scientific investigations of speech rather than on our present-day knowledge, in which speech technology plays a major role. However, instructors who prefer the traditional system of teaching only articulatory phonetics to start will still find it possible to do so by simply skipping the acoustic sections. I by no means intend to imply that I no longer value traditional work on the production of speech sounds. A true phonetician is one who can make, hear, and describe a wide range of speech sounds.

Another change is one of emphasis. Phoneticians have always realized that speech consists of a series of movements, although our textbook descriptions have tended to describe static positions. There is now a theory, articulatory phonology, that provides a good way of describing speech as a sequence of movements by thinking in terms of gestures of the tongue, lips, and other vocal organs. Much of this theory is too complex to include in a basic textbook, but we can begin to adopt its basic premises by putting more emphasis on the gestures involved in speech production.

There are also a number of small changes, including a change in the transcription of English (dropping the length mark in the transcription of vowels) and the addition of further exercises, particularly at the ends of the first five chapters.

An addition requested by many instructors is the provision of recordings that can be used for transcription exercises. Students should learn to transcribe their own speech, but in a class situation it is also advisable for everyone to transcribe the same recording. Usually a lot of interesting discussion ensues. The exercises corresponding to the first few chapters have samples of a speaker of British English and a speaker of American English that have been carefully planned for transcription. Later chapters have fewer exercises of this kind, but in an appendix, there are further recordings by these two speakers and short recordings of a number of different accents of English.

As with the previous editions, numerous people have contributed to this book. My colleagues Pat Keating, Bruce Hayes, and Sun-Ah Jun have been very helpful. The emphasis on speech gestures is due to the work on articulatory phonology by Cathe Browman and Louis Goldstein. I am grateful to Louis Goldstein for a copy of his class notes. Several people have sent me useful suggestions and notable corrections, including Dani Byrd, Nina Gronnum, Heriberto Avelino and Karen Chung.

Useful reviews were provided by

Jessica Barlow, *San Diego State University*
Hugh Buckingham, *Louisiana State University*
Alexander Francis, *Purdue University*
Jackson Gandour, *Purdue University*
Bruce Hayes, *University of California, Los Angeles*
William Katz, *University of Texas at Dallas*
Vera Lee-Schoenfeld, *University of California at Santa Cruz*
Christine Matyear, *University of Texas at Austin*
Donna Mendelson, *Binghamton University*
Diane Ohala, *University of Arizona*
Natasha Warner, *University of Arizona*
Ratree Wayland, *University of Florida*

I am also indebted to Karen Judd, Joe Gallagher, and Lianne Ames of Thomson/Wadsworth, and Ronn Jost and Nancy Tenney of Lachina Publishing Services for excellent book production and copy editing. Assistance from many other people is acknowledged in the Sources section at the back of this book.

As always, without my wife this would have been an incomparably poorer book.

1

Articulation and Acoustics

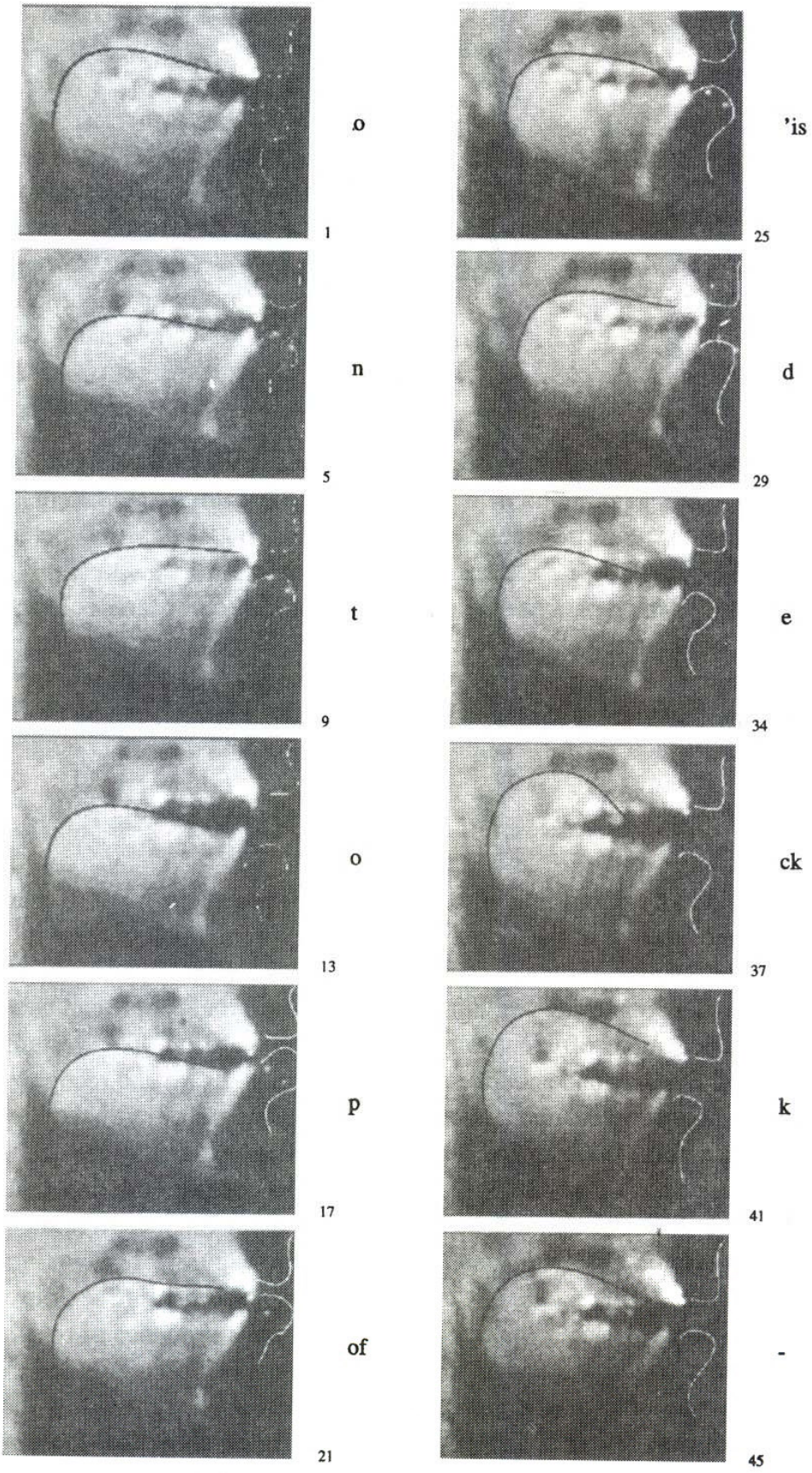
Phonetics is concerned with describing speech. There are many different reasons for wanting to do this, which means that there are many different kinds of phoneticians. Some are interested in the different sounds that occur in languages. Some are more concerned with pathological speech. Others are trying to help people speak a particular form of English. Still others are looking for ways to make computers talk more intelligibly, or to get computers to recognize speech. For all these purposes phoneticians need to find out what people are doing when they are talking and how the sounds of speech can be described.

SPEECH PRODUCTION

We will begin by describing how speech sounds are made. Most of them are the result of movements of the tongue and the lips. We can think of these movements as gestures forming particular sounds. We can convey information by gestures of our hands that people can see, but in making speech that people can hear humans have found a more efficient way to impart information. The gestures of the tongue and lips are made audible so that they can be heard and recognized.

Making speech gestures audible involves pushing air out of the lungs while producing a noise in the throat. This basic noise is changed by the actions of the tongue and lips. Later we will study how the tongue and lips make about twenty-five different gestures to form the sounds of English. We can see some of these gestures by looking at an x-ray movie. Figure 1.1 shows a series of frames from an x-ray movie of the phrase *on top of his deck.* (See Sources at the end of the book for an account of this movie.) In this sequence of twelve frames (one in every four frames of the movie) the tongue has been outlined to make it clearer. The lettering at the left of the frames shows, very roughly, the sounds being produced. The individual frames in the figure show that the tongue and lips move rapidly from one position to another. To appreciate how rapidly the

FIGURE 1.1 Frames from an x-ray movie of a speaker saying *On top of his deck.*



gestures are being made, however, you should look at the movie on the CD. Demonstration 1.1 plays the sounds and shows the movements involved in the phrase *on top of his deck.* Even in this phrase, spoken at a normal speed, the tongue is moving speedily. The actions of the tongue are among the fastest and most precise physical movements that people can make.

CD 1.1

Producing any sound requires energy. In nearly all speech sounds, the basic source of power is the respiratory system pushing air out of the lungs. Try to talk while breathing in instead of out. You will find that you can do it, but it is much harder than talking when breathing out. When you talk, air from the lungs goes up the windpipe (the trachea, to use the more technical term) and into the larynx, at which point it must pass between two small muscular folds called the vocal folds. If the vocal folds are apart (as yours probably are right now while you are breathing in and out), the air from the lungs will have a relatively free passage into the pharynx and the mouth. But if the vocal folds are adjusted so that there is only a narrow passage between them, the airstream from the lungs will set them vibrating. Sounds produced when the vocal folds are vibrating are said to be **voiced,** as opposed to those in which the vocal folds are apart, which are said to be **voiceless.**

In order to hear the difference between a voiced and a voiceless sound, try saying a long '*v*' sound, which we will symbolize as [vvvvv]. Now compare this with a long '*f*' sound [fffff], saying each of them alternately—[fffffvvvvvfffffvvvvv]. (As indicated by the symbol in the margin, this sequence is on the accompanying CD.) Both of these sounds are formed in the same way in the mouth. The difference between them is that [v] is voiced but [f] is voiceless. You can feel the vocal fold vibrations in [v] if you put your fingertips against your larynx. You can also hear the buzzing of the vibrations in [v] more easily if you stop up your ears while contrasting [fffffvvvvv].

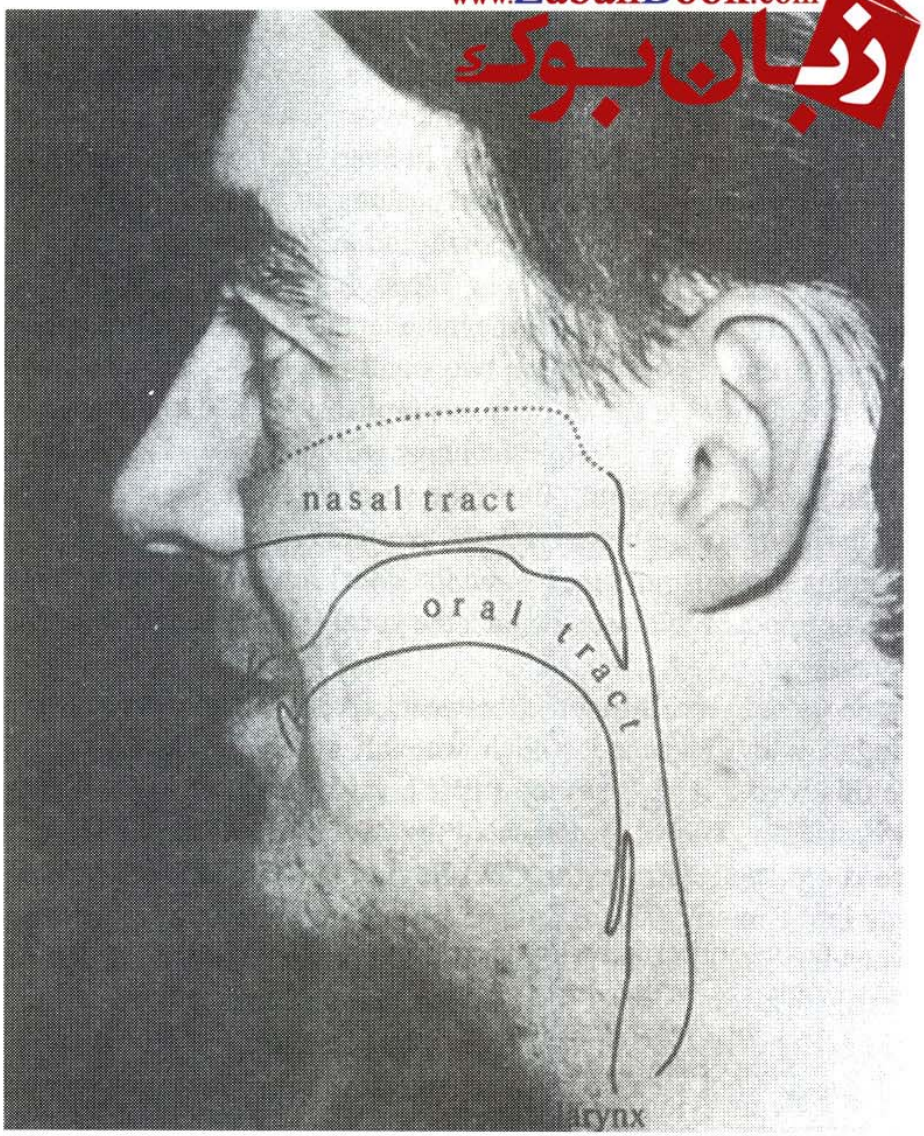
CD 1.2

The difference between voiced and voiceless sounds is often important in distinguishing sounds. In each of the pairs of words *fat, vat; thigh, thy; Sue, zoo* the first consonant in the first word of each pair is voiceless; in the second word, it is voiced. To check this for yourself, say just the consonant at the beginning of each of these words and try to feel and hear the voicing as suggested above. Try to find other pairs of words that are distinguished by one having a voiced and the other having a voiceless consonant.

CD 1.3

The air passages above the larynx are known as the **vocal tract.** Figure 1.2 shows their location within the head (actually within my own head in a photograph taken many years ago). The shape of the vocal tract is a very important factor in the production of speech, and we will often refer to a diagram of the kind that has been superimposed on the photograph in Figure 1.2. Learn to draw the vocal tract by tracing the diagram in this figure. Note that the air passages that make up the vocal tract may be divided into the oral tract, within the mouth and pharynx, and the nasal tract, within the nose. When the flap at the back of the mouth is lowered (as it probably is for you now, if you are breathing

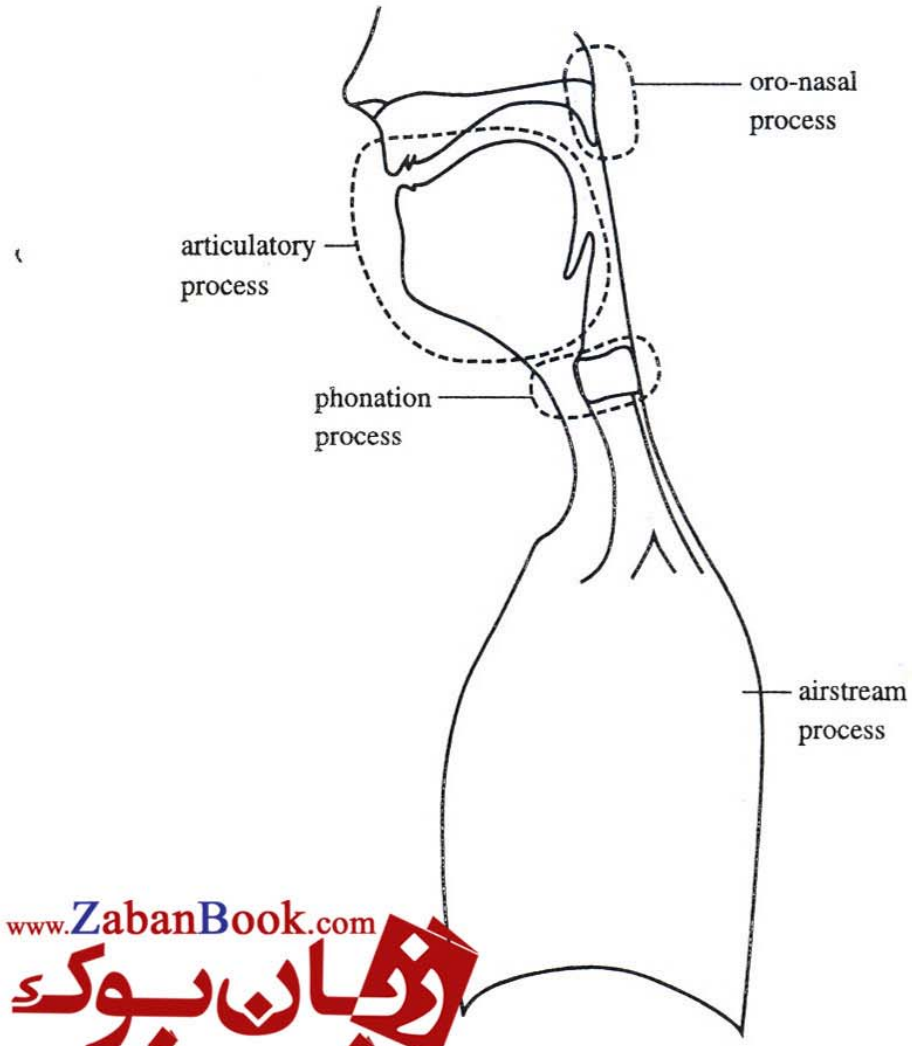
FIGURE 1.2 The vocal tract.



with your mouth shut), air goes in and out through the nose. Speech sounds such as [m] and [n] are produced with the vocal folds vibrating and air going out through the nose. The upper limit of the nasal tract has been marked with a dotted line since the exact boundaries of the air passages within the nose depend on soft tissues of variable size.

The parts of the vocal tract such as the tongue and the lips that can be used to form sounds are called articulators, but before we discuss them, let's summarize the speech production mechanism as a whole. Figure 1.3 shows the four main components—the airstream process, the phonation process, the oro-nasal process, and the articulatory process. The airstream process includes all the ways of pushing air out (or, as we will see later, of sucking it in) that provide the power for speech. For the moment we have considered just the respiratory system, the lungs

FIGURE 1.3 The four main components of the speech mechanism.



pushing out air, as the prime mover in this process. The phonation process is the name given to the actions of the vocal folds. Only two possibilities have been mentioned, voiced sounds in which the vocal folds are vibrating and voiceless sounds in which they are apart. The possibility of the airstream going out through the mouth, as in [v] or [z], or the nose, as in [m] and [n], is determined by the oro-nasal process. The movements of the tongue and lips interacting with the roof of the mouth and the pharynx are part of the articulatory process.

SOUND WAVES

So far, we have been describing speech sounds by stating how they are made, but it is also possible to describe them in terms of what we can hear. The way in which we hear a sound depends on its acoustic structure. We want to be able to describe

the acoustics of speech for many reasons. Linguists and speech pathologists need to understand how certain sounds become confused with one another. We can give better descriptions of some sounds (such as vowels) by describing their acoustic structure rather than by describing the articulatory movements involved. A knowledge of acoustic phonetics is also helpful for understanding how computers synthesize speech and how speech recognition works (topics that are addressed more fully in my book *Vowels and Consonants*). Furthermore, often the only permanent data that we can get of a speech event is a recording, as it is normally impossible to obtain photographs or x-rays showing what the speaker is doing. Accordingly, if we want permanent data that we can study, it will often have to come from analyzing a recording.

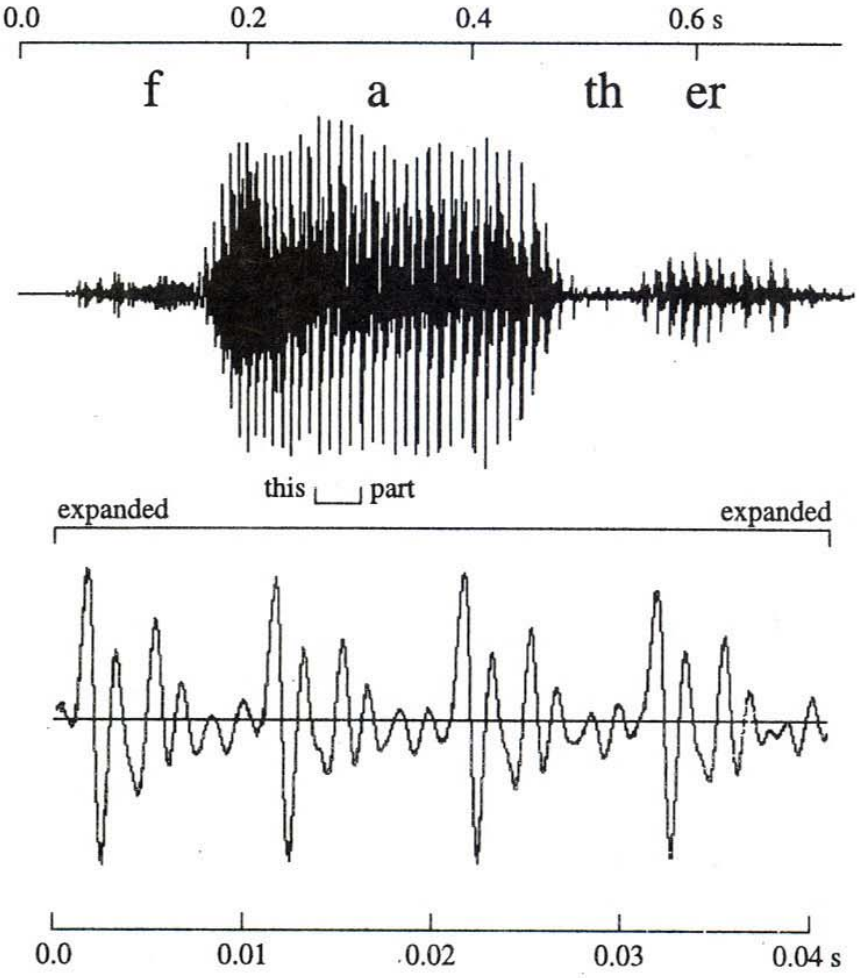
Speech sounds, like other sounds, can differ from one another in three ways. They can be the same or different in (1) pitch, (2) loudness, and (3) quality. Thus two vowel sounds may have exactly the same pitch and loudness but differ in that one might be the vowel in *bad* and the other the vowel in *bud.* On the other hand, they might have the same vowel quality, but differ in that one was said on a higher pitch or that one of them was spoken more loudly.

Sound consists of small variations in air pressure that occur very rapidly one after another. These variations are caused by actions of the speaker's vocal organs that are (for the most part) superimposed on the outgoing flow of lung air. Thus, in the case of voiced sounds, the vibrating vocal folds chop up the stream of lung air so that pulses of relatively high pressure alternate with moments of lower pressure. Variations in air pressure in the form of sound waves move through the air somewhat like the ripples on a pond. When they reach the ear of a listener, they cause the eardrum to vibrate. A graph of a sound wave is very similar to a graph of the movements of the eardrum.

The upper part of Figure 1.4 shows the variations in air pressure that occur during my pronunciation of the word *father.* The ordinate (the vertical axis) represents air pressure (relative to the normal surrounding air pressure), and the abscissa (the horizontal axis) represents time (relative to an arbitrary starting point). As you can see, this particular word took about 0.6 seconds to say. The lower part of the figure shows part of the first vowel in *father.* The major peaks in air pressure recur about every 0.01 seconds (that is, every one-hundredth of a second). This is because my vocal folds were vibrating approximately one hundred times a second, producing a pulse of air every hundredth of a second. This part of the diagram shows the air pressure corresponding to four vibrations of the vocal folds. The smaller variations in air pressure that occur within each period of one-hundredth of a second are due to the way air vibrates when the vocal tract has the particular shape required for this vowel.

In the upper part of Figure 1.4, which shows the waveform for the whole word *father,* the details of the variations in air pressure are not visible because the time scale is too compressed. All that can be seen are the near-vertical lines corresponding to the individual pulses of the vocal folds. The sound [f] at the beginning of

FIGURE 1.4 The variations in air pressure that occur during my pronunciation of the vowel in *father*.

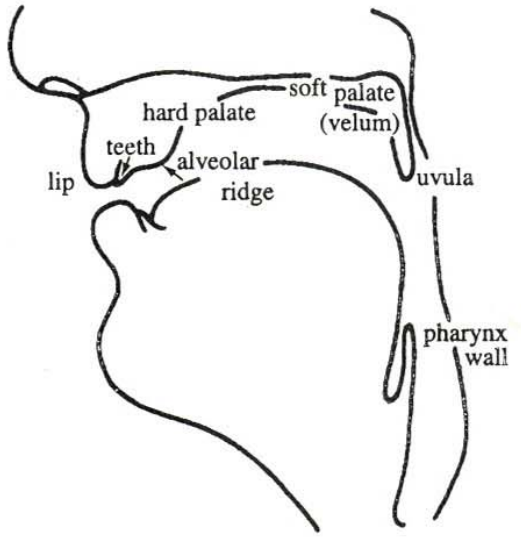


the word *father* has a low amplitude (it is not very loud) in comparison with the following vowel, and the variations in air pressure are smaller and more nearly random. There are no regular pulses, because the vocal folds are not vibrating. We will be considering waveforms and their acoustic analysis in more detail later in this book. For the moment we will simply notice the obvious difference between sounds in which the vocal folds are vibrating (which have comparatively large regular pulses of air pressure) and sounds without vocal fold vibration (which have a smaller amplitude and irregular variations in air pressure).

PLACES OF ARTICULATORY GESTURES

The parts of the vocal tract that can be used to form sounds are called articulators. The articulators that form the lower surface of the vocal tract are highly mobile. They make the gestures required for speech by moving toward the

FIGURE 1.5 The principal parts of the upper surface of the vocal tract.

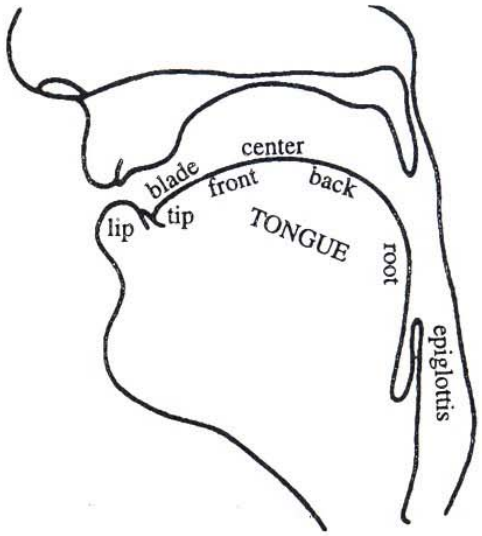


articulators that form the upper surface. Try saying the word *capital* and note the major movements of your tongue and lips. You will find that the back of the tongue moves up to make contact with the roof of the mouth for the first sound and then comes down for the following vowel. The lips come together in the formation of *p* and then come apart again in the vowel. The tongue tip comes up for the *t* and again, for most people, for the final *l*.

The names of the principal parts of the upper surface of the vocal tract are given in Figure 1.5. The upper lip and the upper teeth (notably the frontal incisors) are familiar enough structures. Just behind the upper teeth is a small protuberance that you can feel with the tip of the tongue. This is called the **alveolar ridge.** You can also feel that the front part of the roof of the mouth is formed by a bony structure. This is the **hard palate.** You will probably have to use a fingertip to feel farther back. Most people cannot curl the tongue up far enough to touch the **soft palate,** or **velum,** at the back of the mouth. The soft palate is a muscular flap that can be raised to press against the back wall of the pharynx and shut off the nasal tract, preventing air from going out through the nose. In this case there is said to be a **velic closure.** This action separates the nasal tract from the oral tract so that the air can go out only through the mouth. At the lower end of the soft palate is a small appendage hanging down that is known as the uvula. The part of the vocal tract between the uvula and the larynx is the pharynx. The back wall of the pharynx may be considered to be one of the articulators on the upper surface of the vocal tract.

Figure 1.6 shows the lower lip and the specific names for different parts of the tongue that form the lower surface of the vocal tract. The tip and blade of the tongue are the most mobile parts. Behind the blade is what is technically

FIGURE 1.6 The principal parts of the lower surface of the vocal tract.



called the front of the tongue; it is actually the forward part of the body of the tongue and lies underneath the hard palate when the tongue is at rest. The remainder of the body of the tongue may be divided into the center, which is partly beneath the hard palate and partly beneath the soft palate; the back, which is beneath the soft palate; and the root, which is opposite the back wall of the pharynx. The epiglottis is attached to the lower part of the root of the tongue.

Bearing all these terms in mind, say the word *peculiar* and try to give a rough description of the gestures made by the vocal organs during the consonant sounds. You should find that the lips come together for the first sound. Then the back and center of the tongue are raised. But is the contact on the hard palate or on the velum? (For most people, it is centered between the two.) Then note the position in the formation of the *l*. Most people make this sound with the tip of the tongue on the alveolar ridge.

Now compare the words *true* and *tea*. In which word does the tongue movement involve a contact farther forward in the mouth? Most people make contact with the tip or blade of the tongue on the alveolar ridge when saying *tea,* but slightly farther back in *true*. Try to distinguish the differences in other consonant sounds, such as those in *sigh* and *shy* and those at the beginning of *fee* and *thief*.

When considering diagrams such as those we have been discussing, it is important to remember that they show only two dimensions. The vocal tract is a tube, and the positions of the sides of the tongue may be very different from the position of the center. In saying *sigh,* for example, there is a deep hollow in the center of the tongue that is not present when saying *shy*. We cannot represent this difference in a two-dimensional diagram that shows just the midline of

2

Phonology and Phonetic Transcription

Many people think that learning phonetics means simply learning to use phonetic transcription. But there is really much more to the subject than learning to use a set of symbols. A phonetician is a person who can describe speech, who understands the mechanisms of speech production and speech perception, and who knows how languages use these mechanisms. Phonetic transcription is no more than a useful tool that phoneticians use in the description of speech. It is, however, a very important tool.

When phoneticians transcribe an utterance, they are usually concerned with how the sounds convey differences in meaning. For the most part, they describe only the significant articulations rather than the details of the sounds. For example, when saying the English word *tie,* some people pronounce the consonant with the blade of the tongue against the alveolar ridge, others with the tip of the tongue. This kind of difference in articulation does not affect the meaning of the word and is not usually transcribed. We will begin by considering just this simplest form of transcription, sometimes called a broad transcription.

In order to understand what we transcribe and what we don't, it is necessary to understand the basic principles of phonology. **Phonology** is the description of the systems and patterns of sounds that occur in a language. It involves studying a language to determine its distinctive sounds, that is, those sounds that convey a difference in meaning. Children have to do this when they are learning to speak. To begin with they may not realize that, for example, there is a difference between the consonants at the beginnings of words such as *white* and *right.* Later they realize that these words begin with two distinct sounds. Eventually they learn to distinguish all the sounds that can change the meanings of words.

When two sounds can be used to differentiate words they are said to belong to different **phonemes.** There must be a phonemic difference if two words (such as *white* and *right* or *cat* and *bat*) differ in only a single sound. There are, however, small shades of sounds that cannot be used to distinguish words, such as the differences between the consonants at the beginning and end of the word