9

Vowels and Vowel-like Articulations

In previous chapters we saw that there are three main aspects of vowel quality: (1) vowel height, which is inversely proportional to the frequency of the first formant; (2) backness, which is proportional to the difference between the frequencies of the second and first formants; and (3) the degree of lip rounding, which usually lowers both the second and the third formants. This chapter will discuss these three features in greater detail and will also consider some additional, less prominent, features of vowel quality.

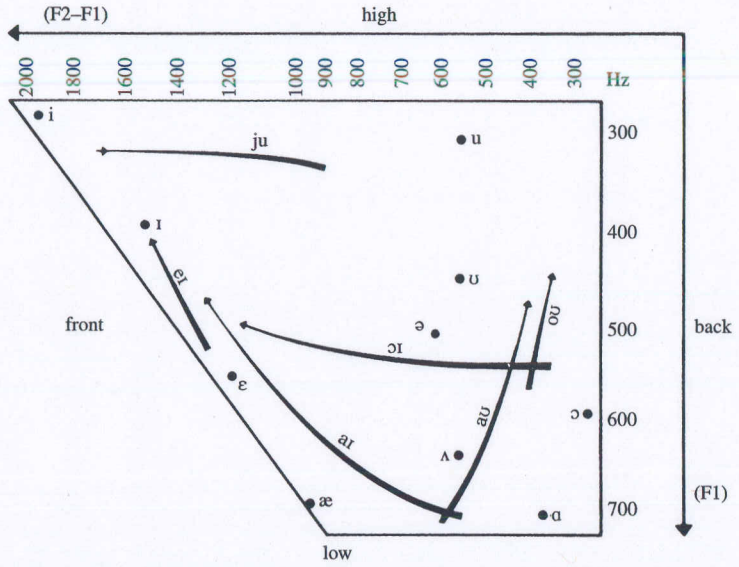
Figure 4.2 in Chapter 4 shows the relative auditory qualities of the English vowels and diphthongs. As I mentioned at that time, the precise locations of the points in this diagram reflected acoustic measurements, not mere auditory impressions. It is, in fact, a formant chart, similar to that shown in Figure 9.1. Some of the acoustic measurements were the formant frequencies reported in Chapter 8. They were supplemented by measurements of the formant frequencies of the other vowels and diphthongs, all taken from published sources. (For bibliographical details, see the Sources at the back of the book.)

Most phoneticians would agree that Figure 9.1 is a fairly accurate reflection of both the way in which American English vowels have traditionally been described and the way in which listeners perceive the relative auditory qualities. During the discussion of this diagram in Chapter 4, you probably made up your own mind as to the extent to which it agrees with your own perception of the relative distance between vowels. But remember that if it seems inaccurate to you, this may be because your accent is not identical to the form of American English represented in the figure.

CARDINAL VOWELS

When describing the vowels that occurred on a particular occasion, one may not have access to measurements of the formant frequencies. Phoneticians who want

FIGURE 9.1 A combined acoustic and auditory representation of some of the vowels of American English. (Compare Figures 4.2 and 8.9.)



to describe the vowels of a certain dialect or of a certain speaker often have to rely on their auditory abilities. They plot the vowels on a vowel chart, so that anybody knowing about vowel charts can see where the points are and can infer the quality of the vowels they are describing.

For a vowel chart to be truly interpretable, the vowels on it must be plotted with reference to certain fixed points. These points must be known to both the people originally plotting the vowels and the people who are going to interpret their descriptions. The space within a vowel chart represents a continuum of possible qualities. Before I can convey anything to you by telling you that a certain vowel is halfway (or a third of the way) between one vowel and another, I must be certain that we both know the exact quality of the vowels that act as reference points. There are several ways in which known fixed points can be provided.

In the first place, we can rely on the fact that a vowel chart shows the limits of possible vowel quality. Thus a point in the extreme upper left corner of the chart represents a vowel with the highest and most front quality possible. If the tongue were moved higher or more forward, a palatal consonant would be produced. A vowel in the extreme lower right corner represents the lowest and most back quality possible. Further movement of the tongue would produce a pharyngeal consonant. Similarly, the points in the other two corners of the diagram represent extreme qualities. We would have some fixed reference point if I could rely on

the fact that you and I both know the sound of the highest and most front possible vowel, the lowest and most back possible vowel, and so on.

This use of a vowel chart is quite satisfactory for the description of vowels that are near the corners of the possible vowel area. But it does not provide enough fixed points for the description of other vowels. Recognizing this problem, the British phonetician Daniel Jones proposed a series of eight **cardinal vowels,** evenly spaced around the outside of the possible vowel area and designed to act as fixed reference points for phoneticians. In no case is the quality of a cardinal vowel exactly the same as that of an English vowel. It can happen that a particular language may have a vowel that is virtually identical with a cardinal vowel. Several of the vowels of a conservative form of Parisian French are very similar. But by definition the cardinal vowels are arbitrary reference points.

Two of the cardinal vowels are defined in articulatory terms. Cardinal vowel (1) is produced with the lips spread and the tongue as high and far forward as possible without causing audible friction. It is therefore something like the vowel [i], but with a more extreme quality. The symbol for it is also [i].

The other cardinal vowel that is defined in articulatory terms is cardinal vowel (5). This vowel is made with the lips in a neutral position—neither spread nor rounded—and with the tongue as low and as far back as possible. Accordingly, it is something like some forms of the American English vowel [ɑ] as in *father*, *hot* or the British English vowel [ɒ] as in *hot*. The American [ɑ], however, is not usually made with the tongue as far back as possible, and the British [ɒ] usually has slight lip rounding. The symbol for cardinal vowel (5) is [ɑ].

Try to make cardinal vowels (1) and (5) in accordance with these descriptions. Remember to have your lips fully spread when saying [i]. Make sure your tongue is so close to the roof of the mouth that you would produce a voiced palatal fricative [ʝ] if you raised it any higher. Similarly, when producing [ɑ], make sure the tongue is pulled so far down and back in the mouth that you are almost producing a voiced pharyngeal fricative [ʕ] (not to be confused with a glottal stop, which is [ʔ]).

Cardinal vowels (2), (3), and (4) are defined as front vowels that form a series of auditorily equidistant steps between numbers (1) and (5). As we saw in the previous chapter, the acoustic definition of front vowels is that the distance between formant one and formant two is as great as possible. We can also specify in acoustic terms what is meant by auditorily equidistant steps. It implies that when these five vowels are plotted on a formant chart of the kind we have been discussing, they will be represented by points that are equal distances apart. (There are some complications in this respect that we will discuss later.)

Cardinal vowels (6), (7), and (8) are defined as vowels that continue from number (5), with the same-size steps as in the first part of the series, but are as back as possible (that is, with as small a distance as possible between formants one and two). In order to continue with these same-size steps, the back vowels

have to become not only increasingly higher but also increasingly more rounded. As a result, cardinal vowel (8) is in fact the highest, most back, most rounded possible vowel—even though it is not defined in this way.

The symbols for cardinal vowels (2), (3), and (4) are [e, ɛ, a] respectively. The symbols for cardinal vowels (6), (7), and (8) are [ɔ, o, u]. Most of these vowels have qualities something like those of the English vowels we have been symbolizing in a similar way. In accordance with the principles of the IPA, the symbols chosen for most of the English vowels are those of the nearest cardinal vowels. The major exception is the vowel in *fat*, which, following the tradition of many English-speaking phoneticians, has been symbolized by [æ] rather than [a].

The cardinal vowel system has been extensively used by phoneticians in the description of a wide variety of languages. There are, however, a number of difficulties in this respect. First, as Daniel Jones said in *An Outline of English Phonetics* (London: Heffer, 1957): "The values of the cardinal vowels cannot be learned from written descriptions; they should be learned by oral instruction from a teacher who knows them." It was for this reason that I did not suggest you try to produce a complete series of cardinal vowels immediately after reading the descriptions given above. Listen to the recordings of cardinal vowels on the CD, and try to find someone who can listen critically to your imitations of them. With a good assistant it is possible to learn to produce them with a fair degree of accuracy.

D 9.1

A second problem with the cardinal vowel system is the notion of auditory equidistance between the vowels. The traditional description of the cardinal vowels arranges them on a plot as shown in Figure 9.2, in which the points are not equidistant. Cardinal vowels (5), (6), (7), and (8) are much closer together than (1), (2), (3), (4), and (5). This plot is somewhat in agreement with the notion that vowel height corresponds inversely to the frequency of formant one, and backness corresponds to the distance between formant two and formant one. The line on the left-hand side of the figure slants because the degree of the distance between formants one and two decreases in going from [i] to [ɑ]. It is comparatively straight on the right-hand side because the distance between the first two formants is much the same for these vowels; both formant one and formant two go steadily down from [ɑ] to [u].

Another problem with the cardinal vowel system is that there has been a great deal of confusion over whether vowels are being described in terms of tongue height or in terms of acoustic properties. Many phoneticians, and many textbooks on phonetics, talk about diagrams such as Figure 9.2 as if they specified the highest point of the tongue. The distance between the points representing the back vowels is therefore said to be less because the movements of the tongue are said to be less (which is not actually true). The differences in auditory quality are presumed to be the same in both front and back vowels, despite the supposed smaller movements of the tongue in back vowels, because back vowels also have increasing lip rounding. But diagrams such as Figures 9.1 and 9.2 do not really specify the position of the highest point of the tongue. Figure 9.3 shows

FIGURE 9.2 The cardinal vowels.

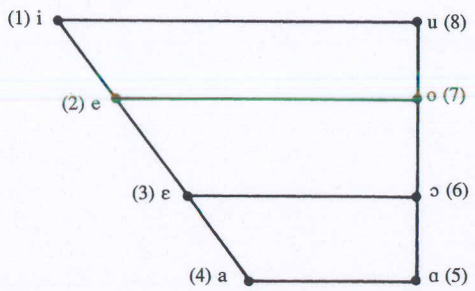
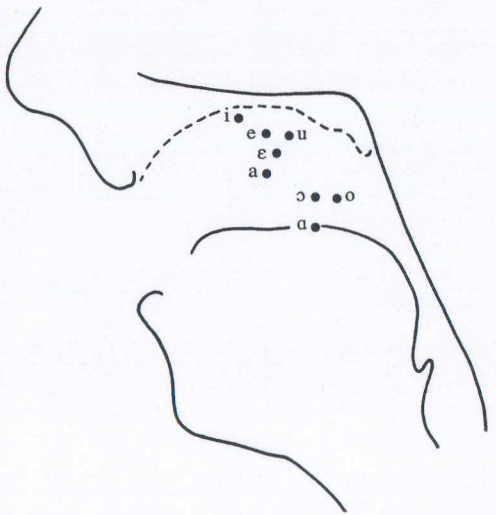


FIGURE 9.3 The highest points of the tongue as shown in a published set of x-rays of cardinal vowels (see Sources). The outline of the upper surface of the vocal tract is not clear on the x-rays and is, therefore, estimated.



the relative positions of the highest point of the tongue in a set of cardinal vowels. These positions form an outline very different from that in Figure 9.2. The same point can be made by referring to Figures 1.8 and 1.9, which show the articulatory positions of some of the vowels in Figure 9.1. The position of the highest point of the tongue is not a valid indicator of vowel quality. I have tried to avoid describing vowels in terms of tongue height, using instead the term vowel height—meaning an auditory quality that can be specified in acoustic rather than articulatory terms.

Despite all these problems, the cardinal vowel system has worked fairly successfully. It allowed the vowels of a large number of languages and dialects to be described with far greater precision than by any other method. The descriptions may have been said in the past to be descriptions of tongue height, but in fact phoneticians had all along been making very accurate judgments of the frequency of the first formant and the distance between the frequencies of the second and first formants. Nowadays the best way to describe vowels is by making acoustic analyses of a group of speakers and specifying their mean formant frequencies. But this is not always possible, and the ability to make auditory judgments in terms of a set of reference vowels is still a necessary skill for any phonetician.

SECONDARY CARDINAL VOWELS

The cardinal vowels have increasing degrees of lip rounding, [i] having spread lips, [ɑ] having a neutral lip position, and [u] being fully rounded. If we consider vowels to be specifiable in terms of three dimensions, this implies that the cardinal vowels fall on a plane in this three-dimensional space, as shown in Figure 9.4. Most of the vowels of English would also fall on this plane, although for many speakers of American English, [u] is a back vowel that is comparatively unrounded. As a result, F2 is comparatively high, and the location on the chart appears to be farther forward than it would be if it were rounded.

As an aid in the description of vowels with different degrees of lip rounding, there is a series of secondary cardinal vowels numbered (9) through (16). These vowels differ from the eight primary cardinal vowels in having an opposite amount of lip rounding. Cardinal vowel (9) is defined as a vowel with the same tongue position as cardinal vowel (1), but with closely rounded lips. Cardinal vowels (10) through (16) have the same tongue positions as cardinal vowels (2) through (8), but continually decreasing—instead of increasing—lip rounding. Cardinal vowel (16), therefore, is an unrounded version of cardinal vowel (8).

Figure 9.5 shows the symbols for these vowels, together with some additional symbols for central vowels. The symbols [ɨ] and [ʉ] are used for unrounded and rounded vowels midway between cardinal vowels (1) and (8). The symbol [ə] is not defined in terms of cardinal vowels but is used, as we have seen, for a range of mid-central vowels. In addition, note that the symbol [ʌ], which is the symbol for an unrounded cardinal vowel (6), is often used for a lowered mid-central vowel.

Even if you cannot make a complete set of the primary cardinal vowels, you should try to make some of the secondary cardinal vowels. Practice rounding and unrounding your lips while saying cardinal vowel (1), so that you say [iy iy iy]. Make sure you maintain an absolutely constant tongue position and move only your lips. Next, repeat this exercise with cardinal vowel (2) or some similar

FIGURE 9.4 A three-dimensional representation of the vowel space, showing that the cardinal vowels fall on a plane that cuts across the space.

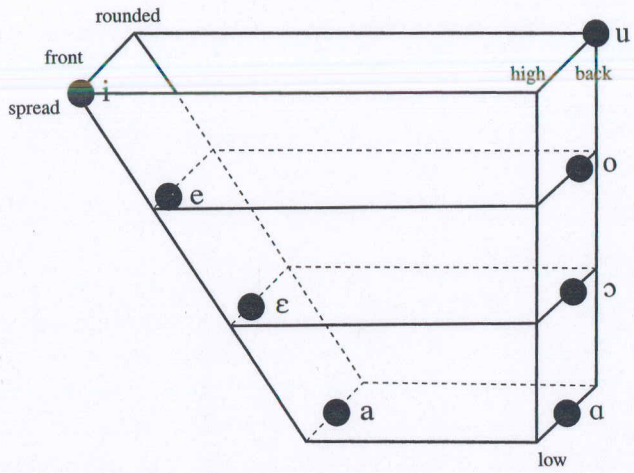
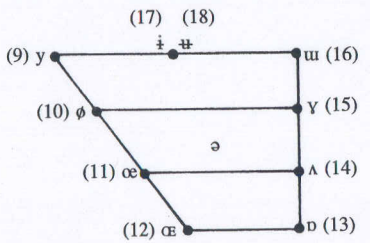


FIGURE 9.5 The symbols for some secondary cardinal vowels and some central vowels.



vowel of the [e] type. Remember that the rounding for [ø] is not as close as that for [y]. Last, try unrounding cardinal vowel (8), producing [ɯɯ ɯɯ ɯɯ]. The usual difficulty here is in maintaining a sufficiently back tongue position, as most dialects of English do not have a very back variety of [u]. Note also that the secondary cardinal vowels you learn to produce by doing these exercises are arbitrary reference points and not necessarily the same as the vowels in any particular language. However, the vowels [y] and [ø] are fairly similar to the French front rounded vowels that occur in *tu* [ty] 'you' and *peu* [pø] 'small'.

Distances on an appropriately scaled acoustic vowel chart such as that in Figure 8.6 are similar to auditory distances for vowels in the plane of the cardinal vowels. But this is not so for vowels with degrees of rounding unlike those of

the nearest cardinal vowels. Front vowels that are rounded or back vowels that are unrounded will be misplaced on a chart if we rely simply on acoustic criteria. The degree of rounding is an independent dimension that must be stated separately from the degree of height (the inverse of the first formant) and the degree of backness (the distance between formant two and formant one). The perspective of the vowel space in Figure 9.4 was chosen to reflect the formant frequencies of the secondary cardinal vowels as much as possible. Secondary cardinal vowel [y] will have a lower formant two, bringing it more to the right of the figure, and secondary cardinal vowel [ɯ] will have a higher formant two, bringing it more to the left. But the first formant of each of these vowels is much the same as the corresponding primary cardinal vowel.

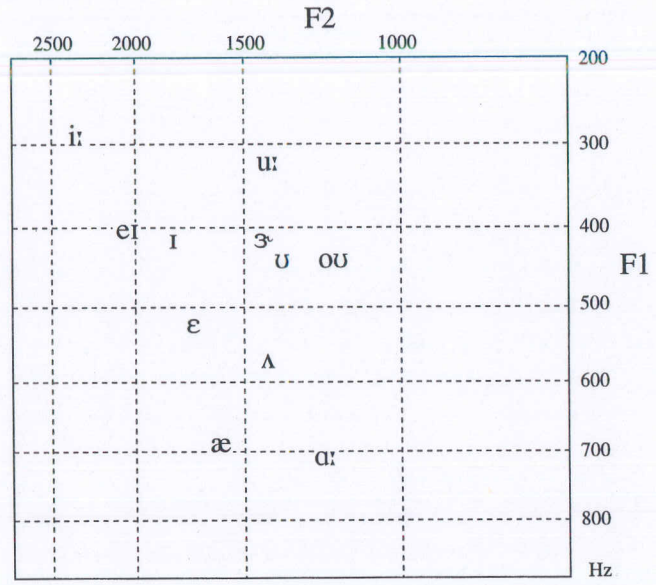
VOWELS IN OTHER ACCENTS OF ENGLISH

For those who do not know the cardinal vowels, an alternative method of describing vowels is to use as reference points the vowels of a particular dialect of a language that is known to both the person making the description and the person reading the description. This is what I have been trying to do in reference to the vowels of American English as shown in Figure 9.1. If you and I both know what these vowels sound like, then the points on Figure 9.1 provide good reference points. When I remark, for example, that in some forms of New Zealand English the vowel in *sacks* is similar to the American English [ɛ] vowel in *sex*, then you should be able to pronounce this word in this particular way. (You can listen to a sample of New Zealand English in the recordings for transcription in the Appendix. Note the pronunciation of *rat*.)

Any language will serve to provide known reference points. For example, when teaching English as a second language, one might use the vowels of the first language of the students as reference points for comparison with the dialect of English that one is trying to teach. If a chart of the vowels of this language is not available, then the instructor's first step should be to make one. This will involve either comparing the vowels of this language with the vowels of some language known to the instructor for which there is a chart available, or making a recording of the vowels of the language in question and analyzing them using a program such as WaveSurfer, which is on the top level of the CD.

There are published descriptions of the auditory quality of the vowels in a large number of languages. There are also several sets of acoustic measurements available. We can now make precise statements about many accents of English by reference to the average formant frequencies of groups of speakers. The accent of American English represented in Figure 9.1 is fairly conservative, typical perhaps of senior newscasters. The first two formants of a group

FIGURE 9.6 A plot of the first two formants of the vowels of a group of Californian English speakers.



of university students in California are shown in Figure 9.6. We have already noted that this accent does not contrast the vowels in *cot* and *caught*—they are both [ɑ]. Now we can see that younger Californians have a higher vowel (lower first formant) in [eɪ] than in [ɪ]. The high back vowels seem more front in that they have a higher second formant. In the case of the vowel [ʊ] as in *good*, this is largely a matter of unrounding. This vowel is often pronounced with spread lips.

Another change is going on in a number of northern cities in the United States, such as Pittsburgh and Detroit. As you can see from Figure 9.7, in this accent [æ] has been raised (formant one has decreased) so that it is very close to [ɛ]. The back vowels have a lower second formant, making them all farther back than in Californian English. This accent does distinguish [ɑ] and [ɔ].

Finally, among accents of English, consider the vowels in Figure 9.8, which are the mean of a group of BBC English speakers. The main feature to be noted here is the distinction between the three back vowels [ɑ] as in *father*, *cart*, [ɒ] as in *bother*, *cot*, and [ɔ] as in *author*, *caught*. Note also that [ʌ] has a very low position in comparison with most forms of American English. British English speakers distinguish the vowel [ʌ] in *cut* from the vowel [ɜ] in *curt* (which does not have any *r*-coloring) mainly by the frequency of the first formant.

FIGURE 9.7 A plot of the first two formants of the vowels of (U.S.) northern cities English.

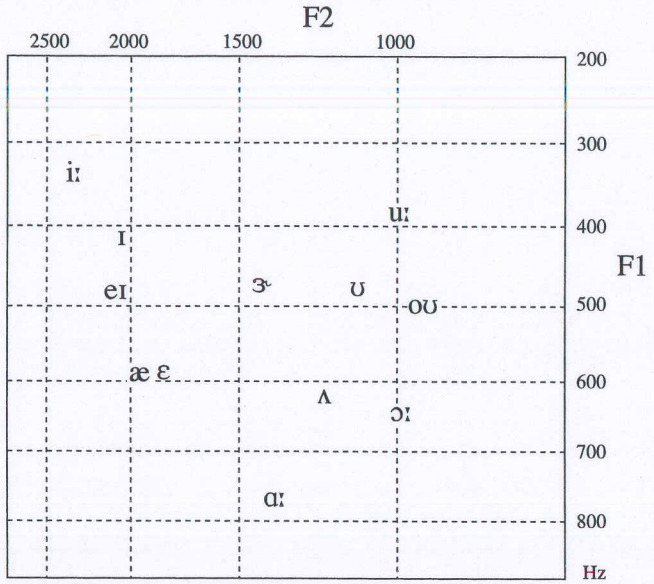
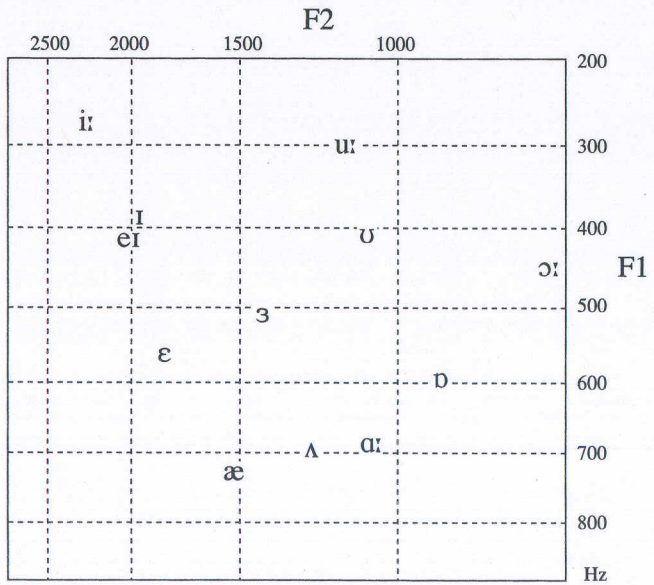


FIGURE 9.8 A plot of the first two formants of the vowels of BBC English.



VOWELS IN OTHER LANGUAGES

Next we will consider the vowels of three other languages for which acoustic measurements are available. Vowel charts for all three languages are shown in Figure 9.9. The sources for the data are listed at the end of the book.

Spanish has a very simple system, contrasting only five vowels. Note that the symbols used in broad transcriptions of Spanish are [i, e, a, o, u]. Obviously, these symbols do not have the same values in Spanish as they do in English or in descriptions of cardinal vowels. CD 9.2

Japanese also has a set of five vowels. In a broad phonetic transcription, these might also have been transcribed [i, e, a, o, u]. But in a narrower transcription that reflects the phonetic quality of the vowels more accurately, the high back vowel could be transcribed as [ɯ], as has been done in Figure 9.9. The point representing this vowel has been distinguished from the others. It has been marked by an asterisk to show that this vowel does not have the lip rounding associated with the primary cardinal vowel in this area. It is not, however, really unrounded. The lips are fairly close together. In a more detailed phonetic analysis one could say that there are two types of lip movements. In one the corners of the lips are brought forward, so that they are somewhat protruded, and in the other they are simply narrowed vertically so that they may be said to be compressed. Note also that [e] in Japanese is slightly lower than it is in Spanish. This is the kind of small difference between vowels that is easily and conveniently expressible in terms of vowel charts. CD 9.3

Also shown in Figure 9.9 are the vowels of a conservative form of Danish. (Danish is changing rapidly, and the young Danes have different vowel qualities.) Asterisks have been used to represent the quality of some of the Danish vowels in Figure 9.9, but in this case it is to indicate that those vowels differ from the primary cardinal vowels in the area by having more rather than less lip rounding. Danish contrasts three front rounded vowels in words such as *dyr* / dyːr / 'expensive', *dør* / døːr / 'dies', and *dør* (same spelling) / dœːr / 'door'. (As you CD 9.4

FIGURE 9.9 The vowels of Spanish, Japanese, and Danish. Front rounded vowels and back unrounded vowels are indicated by asterisks.

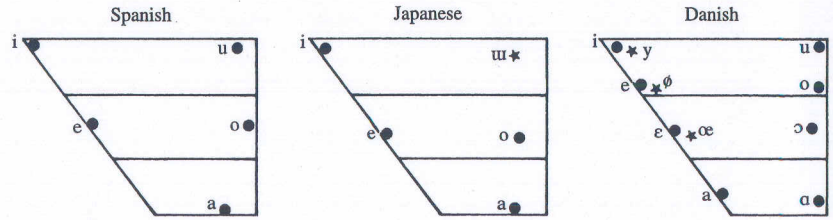


TABLE 9.1 Contrasts in vowel length in Danish.

viːdə	*hvide*	'white'	vilə	*vilde*	'wild'	viːlə	*hvile*	'rest'
veːdə	*hvede*	'wheat'	menə	*minde*	'remind'	meːnə	*mene*	'mean'
vɛːdə	*væde*	'wet'	lɛsə	*læsse*	'load'	lɛːsə	*læse*	'read'
væːdə	*vade*	'wade'	mæsə	*masse*	'mass'	mæːsə	*mase*	'mash'

can hear in the recording of these words on the CD, Danish / r / is realized as a pharyngeal approximant.) All the Danish vowels shown in Figure 9.9 can occur in long or short form. The front vowels, which are on the CD, are illustrated in Table 9.1. The qualities of most of the short vowels are very similar to those of the long vowels, but in the case of [a, ɔ, o], the short versions are slightly lower and more centralized.

The three charts in Figure 9.9 are good examples of the way in which vowels may be described. They are in part descriptions of the relative auditory quality, in part articulatory descriptions. For the vowels in which the lip rounding is the same as that of the primary cardinal vowels, they reflect the acoustic data exactly. In these cases they are equivalent to plots of the first formant frequency against the difference between the frequencies of the second and first formants.

Front rounded and back unrounded vowels cannot be represented on a vowel chart that assumes the degree of lip rounding is like that of the primary cardinal vowels. In describing these other vowels, the degree of lip rounding must also be specified. One way of doing this is to use asterisks rather than ordinary points. The asterisks indicate that the lip rounding is more like that of the secondary cardinal vowels than that of the primary ones. The locations of the asterisks indicate the vowel qualities in much the same way as the points indicate the qualities of the other vowels. It is as if they show what the formant frequencies would have been had the lip rounding been like that of the primary cardinal vowels.

When we consider the actual formant frequencies of front rounded vowels and back unrounded vowels, we can see why these vowels are not quite so common in most languages. Adding lip rounding to front vowels lowers the higher formants. As a result, a high front rounded [y] sounds as if it were between [i] and [u], as we noted at the end of the preceding section when discussing Figure 9.4. Similarly, [œ], which is the front rounded vowel corresponding to [ɛ], has a lower formant two than [ɛ]. When its formants are plotted on a chart, it appears nearer the center. Conversely, removing lip rounding from the back vowel [u] to produce [ɯ] raises formant two, so that it would also be nearer the center of a formant chart. If the vowels of a language are to be maximally distinct from one another, then the front vowels will have to be unrounded, the back vowels rounded.

One of the forces acting on languages may be called the principle of *sufficient perceptual separation*, whereby the sounds of a language are kept acoustically

distinct to make it easier for the listener to distinguish one from another. As a result of this principle, in by far the majority of languages the degree of lip rounding can be predicted from the degree of backness and, to a lesser extent, the degree of height. Front vowels are usually unrounded and back vowels are usually rounded, with the degree of rounding increasing with the degree of height. In this way the vowels of a language are kept maximally distinct. Front rounded vowels occur in a number of well-known languages spoken in Europe, such as French, German, Dutch, and Swedish (all of which can be found on the CD), but, in accordance with the notions of perceptual separation, they are not particularly common among the languages of the world.

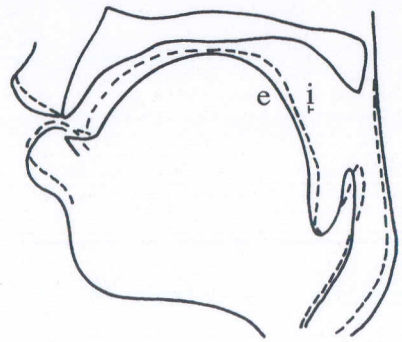
CD Ig. Index

ADVANCED TONGUE ROOT (ATR)

Differences in vowel quality can usually be described in terms of variations in the degrees of height, backness, and lip rounding. But in some languages, there are differences in vowel quality that cannot be described in these terms. For example, in Akan, a West African language spoken mainly in Ghana, there are two sets of vowels that you can hear on the CD. They differ primarily in the size of the pharynx. In the one set, there are vowels in which the root of the tongue is drawn forward and the larynx is lowered, so that the part of the vocal tract in the pharynx is considerably enlarged. These vowels are called **advanced tongue root** (or, more simply, **+ATR**) vowels. In the other set, there are vowels in which there is no advancement of the tongue root or lowering of the larynx (–ATR vowels). Figure 9.10 shows the shape of the vocal tract in two Akan vowels that differ in this way. In the +ATR vowel [e], the whole tongue is bunched up

CD 9.5

FIGURE 9.10 Narrow (–ATR, broken line) and wide (+ATR, solid line) vowels in Akan, a language spoken in Ghana.



lengthwise in comparison with the –ATR vowel, here symbolized as [ɻ]. We should also note that not all speakers of Akan make a distinction between these two vowels in this way. Some seem to rely more on movements of the root of the tongue, and others more on differences in larynx height. What matters for the distinction between the two sets of vowels is that one should have a comparatively large pharyngeal cavity and the other a comparatively small one.

In English, no pairs of vowels are distinguished simply by this tongue gesture, although tongue root position varies to some extent in conjunction with vowel height. The tense high vowels [i] and [u], as in *heed* and *who'd*, have a more advanced tongue root than the lax mid-high vowels [ɪ] and [ʊ], as in *hid* and *hood*. However, the distinction between +ATR vowels and –ATR vowels is not the same as the distinction between tense and lax vowels in English, which was discussed in Chapter 4. The two sets of English vowels are divided by phonological considerations, such as the fact that lax vowels can occur before [ŋ] and tense vowels cannot, rather than by a particular tongue gesture or shape of the vocal tract.

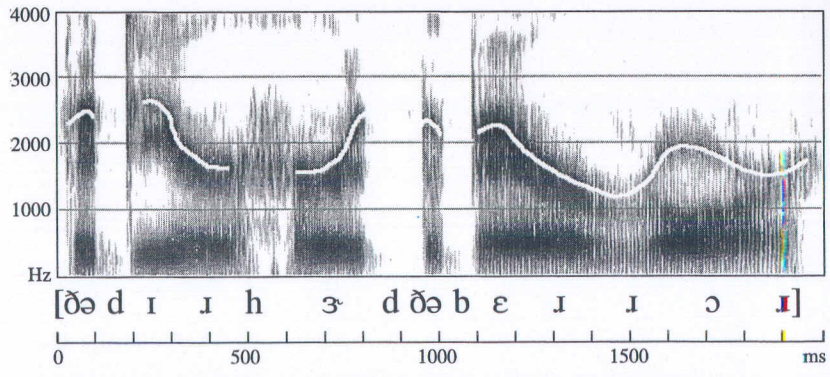
RHOTACIZED VOWELS

As we saw in Chapter 4, many forms of American English have rhotacized vowels in words such as *sir, cur, bird*. We also noted that *r*-coloring can be produced in more than one way. Figure 9.11 shows the tongue positions of three different forms of American English [ɝ]. Some speakers use one of these, others another. As shown by the heavy black line, the gesture can involve the tongue being bunched up in the center of the mouth, with the tip down and pulled back from the lower teeth. An important feature of this kind of rhotic articulation is that there is also a slight narrowing of the pharyngeal cavity. A second possibility, shown by the thin black line, is a gesture in which the tip of the tongue is raised to near the back of the alveolar ridge, forming a post-alveolar approximant. This is accompanied by a narrowing of the pharyngeal cavity at a slightly higher level. The third possibility, the gray line, is shown in the figure to indicate that there may be in-between positions. If you are a speaker of this form of American English, see if you can determine which of these articulations you use, One way of getting helpful information is to insert a toothpick between the teeth while you hold the position for the vowel [ɝ]. Does the toothpick touch the upper surface of your tongue, or is your tongue tip raised so that it touches the tip or the undersurface of the blade of the tongue? It seems likely (see Sources) that about 60 percent of speakers have the tip up, 35 percent have a bunched tongue position with the tip down, and the remainder, a small number, have an intermediate position. You can hear an American English speaker producing rhotacized vowels among those recorded for Chapter 2 on the CD. This speaker has his tongue bunched up with the tip down and (almost certainly, although I have no x-ray or other evidence) a constriction in the pharynx.

Rhotacization is an auditory quality, which, like height and backness, is most appropriately defined in acoustic terms. In a rhotacized vowel (or portion of a vowel) there is a marked lowering of the frequency of the third formant. The frequencies of the first two formants determine the vowel height and backness. The frequency of the third formant conveys comparatively little information about either of these aspects of vowel quality. If you look back at Figure 8.3, you will see that throughout the whole series of non-rhotacized vowels the third formant falls only slightly. But, as you can see in Figure 9.12, there is a large fall in the

FIGURE 9.11 Possible tongue positions for the vowel [ɝ] in American English. The tongue-tip-up post-alveolar approximant (thin black line) is the most common, followed by the bunched tongue (solid black line). The gray line indicates possible intermediate positions.

FIGURE 9.12 A spectrogram showing the lowering of the frequency of the third formant (and the second formant) during rhotacized sounds in a sentence in American English.



frequency of the third formant in words such as *deer* and *bear*, in which the ends of the vowels are considerably rhotacized in many forms of American English. Furthermore, throughout most of the word *heard*, the third formant may be low, indicating that even at the beginning of the vowel there is a rhotacized quality.

NASALIZATION

In all the vowels we have been considering in this chapter so far, the soft palate has been raised so that there is a velic closure, and air does not flow out through the nose. Vowels will be **nasalized** if the soft palate is lowered to allow part of the airstream to escape through the nose. The diacritic [˜] may be placed over any vowel to indicate that it is nasalized. Vowels of this kind are commonly called **nasal vowels.**

Learn to produce a variety of nasalized vowels. Start by saying the low vowel [æ̃] as in *man* [mæ̃n]. Alternate a series of nasalized and non-nasalized vowels, saying [æ æ̃ æ æ̃ æ æ̃]. You should be able to feel your soft palate moving up and down when you say these vowels. Try to say a whole series of nasalized vowels [ĩ ẽ ɛ̃ ã ɑ̃ ɔ̃ õ ũ]. Alternate each of these vowels with its non-nasalized counterpart. Many languages have contrasts between nasal and oral vowels. French contrasts are illustrated on the CD.

D 9.7

Consonants such as [m, n, ŋ] are, of course, nasals, but they are not *nasalized*, since this term implies that part of the air goes out through the nose and part through the mouth. Contrasts between nasalized and non-nasalized consonants probably do not occur in any language, but some consonants, such as [w, j, ɹ, l], may be nasalized if they occur next to nasalized vowels. In Yoruba, the word for 'they' is [w̃ɔ́], with the whole syllable being nasalized.

SUMMARY OF VOWEL QUALITY

Table 9.2 summarizes the discussion of vowels. There are two features of vowel quality—height and backness—that are used to contrast one vowel with another in nearly every language, and there are four other features that are used less frequently. Of the six features, the first three in the table reflect auditory properties, each of which may be produced in more than one way from an articulatory point of view, and the remaining three reflect relatively invariant articulatory properties with complex acoustic correlates that differ from vowel to vowel. Thus lip rounding generally lowers the second formant, but in the case of high front vowels it is predominantly the third formant that is lowered; similarly, ATR and nasalization affect different formants in different vowels.

TABLE 9.2 The features of vowel quality.

Quality	Correlates
height	frequency of formant one
backness	difference between frequencies of formant two and formant one
rhotacization	frequency of formant three
rounding	lip position
ATR	width of the pharynx
nasalization	position of the soft palate

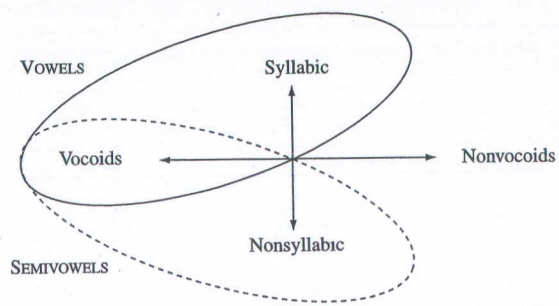
SEMIVOWELS

Without being too precise about the meaning of the terms syllable and syllabic (a matter we will discuss in the next chapter), we can say that all sounds function either as the peaks of syllables or at the syllable margins. Vowels are clearly at the peaks of syllables and are syllabic. Consonants are generally not syllabic, although some consonants such as [l] and [n] can be syllabic in words like *shuttle* ['ʃʌtl̩] and button ['bʌʔn̩]. We can also divide sounds into those that have no obstruction in the center of the mouth, which may be called **vocoids,** and those that have an obstruction. The latter group, which will include most consonants, may be called nonvocoids. This gives us a pair of divisions that we can arrange as shown in Figure 9.13.

Given this division, we can define vowels as syllabic vocoids and **semivowels** as nonsyllabic vocoids. The term semiconsonant is sometimes used for syllabic nonvocoids, but we will refer to them simply as syllabic consonants. Similarly, nonvocoids are sometimes called true consonants, a term that could be applicable whether they are syllabic or not.

Here we are concerned with semivowels, which are vocoids that function as the beginning or end of a syllable. When at the beginning of a syllable, a semivowel usually consists of a rapid glide from a high vowel position to that of the

FIGURE 9.13 Vowels are syllabic vocoids, semivowels are nonsyllabic vocoids, and nonvocoids, whether syllabic or not, are consonants.



following vowel. The semivowels in English are [j] and [w], which are like nonsyllabic versions of the English high vowels [i] and [u], respectively. In some languages (for example, French), there are the three high vowels [i, u, y]. In some of these languages there is also a semivowel corresponding to the high front rounded vowel [y]. The symbol for this sound is [ɥ], an inverted letter *h*. Examples of words contrasting the three semivowels in French are given in Table 9.3.

Earlier in this chapter we noted that Japanese has a high unrounded vowel [ɯ]. It does not have spread lips like [i] but lips that are fairly close together, compressed vertically, with the corners neither drawn back as in a spread vowel nor pulled together as in a rounded vowel. There is a Japanese semivowel bearing the same relation to this vowel as [w] does to [u] in English. The symbol for this semivowel is [ɯ̯].

The gesture for a semivowel is like that for an approximant in that it can be considered to have a particular place of articulation, like other consonants. We have already noted that [j] is a palatal approximant, and [w] is a labial-velar approximant. The semivowel [ɥ] is a labial-palatal approximant. We have not discussed this place of articulation before because approximants are almost the only sounds that are made in this region. The semivowel [ɯ̯] is a velar approximant.

When learning to produce the distinction between the French sounds / w / and / ɥ /, note that the English / w / is in between the two French sounds. It is not the same as French / w /. It is, of course, also true that / u / in English is in between the two French sounds [u] and [y]. As is often the case, when a language does not have to distinguish between two possibilities, it produces a sound that is in between the two. Recall, for example, the quality of English vowels before [ŋ] and before [ɹ], where there are no oppositions between tense and lax vowels.

To produce the French sound / w / as in *oui* [wi] 'yes', start from a high rounded vowel that is fully back, like a cardinal [u]. Glide from this vowel very rapidly to the following vowel. The result will be similar but not identical to the English word *we* [wi]. Now try to say the French sound [ɥ] as in *huit* [ɥit] 'eight'. This time start from the secondary cardinal vowel [y], and glide rapidly to the following vowel.

It is also possible to consider the common form of English [ɹ], as in *red*, as a semivowel. In the same way as [w] may be said to be a nonsyllabic counterpart of [u], so [ɹ] as in *red* may be said to be a nonsyllabic version of the vowel in American English *fur*. From a phonetic point of view, regarding [ɹ] in *red* as a

TABLE 9.3 Contrasts involving palatal, labial-palatal, and labial-velar approximants in French.

Palatal		Labial-Palatal		Labial-Velar	
mjɛt	'crumb'	mɥɛt	'mute'	mwɛt	'sea gull'
lje	'tied'	lɥi	'him'	lwi	'Louis'
		ɥit	'eight'	wi	'yes'

semivowel may be a valid description. But from a phonological point of view, it may not be appropriate in describing the sound patterns that occur in English.

SECONDARY ARTICULATORY GESTURES

It is appropriate to consider secondary articulations in conjunction with vowels because they can usually be described as added vowel-like articulations. Formally defined, a **secondary articulation** is a gesture with a lesser degree of closure occurring at the same time as another (primary) gesture. We will consider four types of secondary articulation.

Palatalization is the addition of a high front tongue gesture, like that in [i], to another gesture. Russian and other Slavic languages have a series of palatalized consonants that contrast with their nonpalatalized counterparts. Palatalization can be symbolized by [ʲ] after a symbol. Russian words illustrating palatalized sounds are given in Table 9.4.

The terms palatalization and palatalized are sometimes used in a slightly different way from the way in which I have been using them so far. Instead of describing a secondary gesture, these terms may describe a process in which the primary gesture is changed so that it becomes more palatal. Thus sounds are said to be palatalized if the point of articulation moves toward the palatal region in some particular circumstance. For example, the English / k / in *key* may be said to be palatalized because, instead of the velar contact of the kind that occurs in *car* [kɑɹ], the place of articulation in *key* is changed so that it is nearer the palatal area. Similarly, palatalization is said to occur when the alveolar fricative [z] in *is* becomes a palato-alveolar fricative in *is she* . . . [ɪʒʃi]. A further extension of the term palatalization occurs in discussions of historical sound change. In Old English the word for *chin* was pronounced with a velar stop [k] at the beginning. The change of this sound into Modern English [tʃ] is said to be one of palatalization, due to the influence of the high front vowel. All these uses of the terms palatalization and palatalized involve descriptions of a process—something becoming something else—rather than a secondary gesture.

TABLE 9.4 Contrasts involving palatalization in Russian.

formə	'form'	fʲərmə	'farm'
vɪtʲ	'to howl'	vʲitʲ	'to weave'
sok	'juice'	sʲok	'he lashed'
zof	'call'	zʲof	'yawn'
pakt	'pact'	pʲatʲ	'five'
bil	'he was'	bʲil	'he stroked'
tot	'that'	tʲotʲə	'aunt'
domə	'at home'	dʲomə	'Dyoma' [nickname]
kuʃətʲ	'to eat'	kʲuvʲətkə	'dish'

CD 9.9

Velarization, the next secondary articulation to be considered, involves raising the back of the tongue. It can be considered as the addition of an [u]-like tongue position, but without the addition of the lip rounding that also occurs in [u]. We have already noted that in many forms of English, syllable final / l / sounds are velarized and may be written [ɬ].

As an exercise, so that you can appreciate how it is possible to add vowel-like articulations to consonants, try saying each of the vowels [i, e, ə, a, ɑ, ɔ, o, u], but with the tip of your tongue on the alveolar ridge. The first of these sounds is, of course, a palatalized sound very similar to [lʲ]. The last of the series is one form of velarized [ɬ]. Make sure you can say each of these sounds before and after different vowels. Now compare palatalized and velarized versions of other sounds in syllables such as [nʲa] and [ɴa]. Remember that [ɴ] with the velarization diacritic [˞] is simply [n] with a superimposed unrounded nonsyllabic [u] glide (that is, an added [ɯ] glide).

Pharyngealization is the superimposition of a narrowing of the pharynx. Since cardinal vowel (5)—[ɑ]—has been defined as the lowest, most back possible vowel without producing pharyngeal friction, pharyngealization may be considered as the superimposition of this vowel quality. The IPA diacritic for symbolizing pharyngealization is [ʕ], exactly as for velarization. If it is necessary to distinguish between these two secondary articulations, then the IPA provides an alternative: using small raised symbols corresponding to velar and pharyngeal fricatives, representing a velarized alveolar nasal as [nˠ] and a pharyngealized alveolar nasal as [nˤ]. Marking velarization and pharyngealization in this way is also preferable when the use of the [˞] diacritic creates a symbol that is hard to decipher.

There is very little difference between velarized and pharyngealized sounds, and no language distinguishes between the two possibilities. In Arabic there is a series of consonants that Arabic scholars call emphatic consonants. Some of these sounds are velarized, and some are pharyngealized. All of them can be symbolized with the IPA diacritic [ʕ]. (Arabic scholars often use a subscript dot [.].) There is some similarity in quality between retroflex stops and velarized or pharyngealized stops, because in all these sounds the front of the tongue is somewhat hollowed.

Labialization, the addition of lip rounding, differs from the other secondary articulations in that it can be combined with any of them. Obviously palatalization, velarization, and pharyngealization involve different tongue shapes that cannot occur simultaneously. But nearly all kinds of consonants can have added lip rounding, including those that already have one of the other secondary articulations. In a sense, even sounds in which the primary articulators are the lips—for example, [p, b, m]—can be said to be labialized if they are made with added rounding and protrusion of the lips. Because labialization is often accompanied by raising the back of the tongue, it is symbolized by a raised [ʷ]. In a more precise system, this might be taken to indicate a secondary articulation that we could call labiovelarization, but this is seldom distinguished from labialization.

TABLE 9.5 Secondary gestures.

Phonetic Term	Brief Description	Symbols
palatalization	raising of the front of the tongue	sʲ lʲ dʲ
velarization	raising of the back of the tongue	sˠ ɬ bˠ
pharyngealization	retracting of the root of the tongue	sˤ ɬ bˤ
labialization	rounding of the lips	sʷ lʷ dʷ

In some languages (for instance, Twi and other Akan languages spoken in Ghana), labialization co-occurs with palatalization. As palatalization is equivalent to the superimposition of a gesture similar to that in [i], labialization plus palatalization is equivalent to the superimposition of a rounded [i]—that is, [y]. As we have seen, the corresponding semivowel is [ɥ]. Accordingly, these secondary articulations may be symbolized by a raised [ᶣ]. Recall the pronunciation of [ɥ] in French words such as *huit* [ɥit] 'eight'. Then try to pronounce the name of one of the dialects of Akan, Twi [tᶣi].

Table 9.5 summarizes the secondary gestures we have been discussing. As in some of the previous summary tables, the terms in Table 9.5 are not all mutually exclusive. A sound may or may not have a secondary articulation such as palatalization, velarization, or pharyngealization; it may or may not be labialized; and it may or may not be nasalized. To demonstrate this for yourself, try to make a voiced alveolar lateral [l] that is also velarized, labialized, and nasalized.

EXERCISES

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

A. Look at the positions of the tongue in the English vowels shown in Figure 1.12. It has been suggested (see Sources) that vowels can be described in terms of three measurements: (1) the area of the vocal tract at the point of maximum constriction; (2) the distance of this point from the glottis; and (3) a measure of the degree of lip opening. Which of the first two corresponds to what is traditionally called vowel height for the vowels in *heed, hid, head, had*?

Which corresponds to vowel height for the vowels in *father, good, food*?

Can these two measurements be used to distinguish front vowels from back vowels?