

*Figure 9.11* Lip positions for ten vowels of laai.: i in tn 'tea', y in yy 'dispute', u in kaluu 'fall down', e in eet 'fishing net', 0 in m00k 'ill', o in ot 'Lobster', y in Tt 'cooking pot', se in mzeaek 'heavy', a in aat 'wounded person', and    in toop 'oven'.

Apart from the small number of 'over-rounding' cases such as Assamese, most languages have vowels which can simply be classified as rounded or unrounded. Even in Assamese, the rounding of p seems to be of the same nature as in other vowels. However, there have been suggestions that there could

labialization (the lips are not protruded as much as for y but are contracted in a very characteristic way)" (Malmberg 1951: 46; our translation). Fant's x-ray data on these vowels, which have been reproduced in small size in many publications (e.g. Fant 1973:11), are reproduced here in figure 9.12 in a larger size. The evidence they provide is not entirely in agreement with Malmberg's 1951 account. At least for this speaker, a is much higher than the mid vowel e:. The three vowels i, y:, a have similar (although not identical) tongue positions; y: has a more open and more protruded lip position; a has a fairly close approximation of the upper and lower lip, but without protrusion. In measurements of labial gestures of eight speakers of Swedish, Linker (1982) found that the same distinctions applied to her subjects. McAllister, Lubker and Carlson (1974), who came to a similar conclusion, also note that these high vowels have a consonantal offglide in Swedish; the offglide for y is the protruded semivowel q, whereas a has an offglide that they symbolize 0. Vanvik (1972) also noted that u and a in Standard Norwegian share the same lip position, whereas the third vowel y has protrusion.

All these observations, together with our own investigations of these languages, lead us to conclude that there are two lip position parameters for vowels, vertical lip compression and protrusion. In most languages these parameters are implemented jointly (and, also, linked to the front-back dimension), and it is sufficient to distinguish rounded (either compressed or protruded) vowels from unrounded vowels. In a small number of languages the two parameters are independently controlled. Some languages may choose to use lip compression rather than the form of rounding that has lip protrusion. Edwin Pulleyblank (personal communication) notes that Japanese u can be regarded as having compressed lips rather than being simply unrounded. This vowel shows its labiality by the fact that it alternates with w in verbal inflections. Pulleyblank also notes that the Japanese allophone of h that occurs before u is bilabial J>, with what we here call compressed, rather than protruded, lips. We have not investigated the acoustic characteristics of lip compression. They are presumably similar to those of lip rounding and protrusion insofar as any decrease in lip aperture tends to lower all formant frequencies, but compression and protrusion differ with respect to their distinct effects on the length of the vocal tract.

*Figure 9.12 X-ray tracings of Swedish high front vowels differing in lip position, y has (horizontal) lip rounding and protrusion; a has (vertical) lip compression (based on data in Fant 1973).*

*Table 9.7 The major features of vowel quality*

HEIGHT	BACKNESS	ROUNDING	
		COMPRESSION	PROTRUSION
[high]	[front]	[compressed]	[protruded]
[mid-high]	[central]	[separated]	[retracted]
[mid]	[back]		
[mid-low]			
[low]			

Table 9.7 summarizes the major vowel features and the major phonetic categories possible within each of these features. It should be noted that Height and Backness are multi-valued, and cannot be adequately represented in binary terms.

The features and categories listed in table 9.7 might be taken to imply that there are  $5 \times 3 \times 2 \times 2 = 60$  possible vowels differing only in the values of the major features of vowel quality. However, a number of combinations are so unlikely to occur that they might well be considered to be impossible. For example, there is no known language, and almost certainly could not be a language, which contrasts four lip positions among front low vowels; and it seems equally unlikely that there could be a language that contrasts five degrees of height among back unrounded vowels. It follows that the values shown in table 9.7 substantially over-represent the phonological possibilities.

They do not, however, allow for all the phonetic possibilities. In order to describe phonetic differences among vowel qualities that occur in different languages, a far greater number of distinctions must be considered. Disner

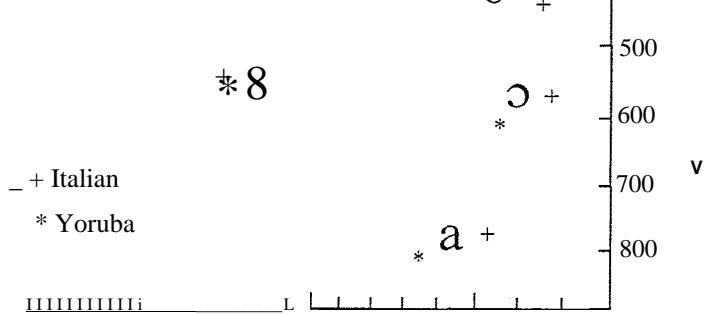


Figure 9.13 Mean formant frequencies of the vowels of Yoruba and Italian (based on data in Disner 1983).

(1983), for example, has shown that there are many small phonetic differences among the vowels that occur in different languages. Using her work, Ladefoged (1984) discussed systematic phonetic differences between two 7-vowel languages, Italian and Yoruba, both of which have vowels that may be represented as i, e, e, a, , o, u. The mean formant frequencies of 25 speakers of Italian and 10 speakers of Yoruba are shown in figure 9.13. In this figure Italian vowels are marked by + and Yoruba vowels by \*. The vowels of Italian are relatively evenly distributed; but in Yoruba e and o are much closer to i and u than to e and a respectively. The uneven distribution of the Yoruba vowels may be attributed to historical facts concerning the way in which the vowels of the original 9- or 10-vowel system (Fresco 1970) have merged to produce the current 7-vowel Yoruba system. The earlier system may have involved an additional vowel parameter, the position of the tongue root (+ ATR), which we will discuss later. Synchronically, however, Yoruba vowels can be described using only the major features of vowel quality which we have been discussing in the preceding sections. The set of terms given in table 9.7 is adequate for specifying the phonological contrasts within each of these languages, but not for discussing the phonetic differences between them.

## 9.2 Additional Vowel Features

The Yoruba and Italian differences, and many similar variations in vowel quality such as those among Germanic languages discussed by Disner (1983), are all examples of variations in the phonetic values of what we have called major vowel features. We will now turn to other ways in which vowels differ, considering mainly how these additional vowel properties may be used to form phonological contrasts within a language. We will refer to these additional properties of vowels as the minor vowel features. Table 9.8 lists a number of additional properties that have been observed. As may be seen, they fall into four groups. The first, and by far the most commonly found of the minor vowel features is nasalization. The remaining additional vowel features fall into three main groups: those that involve special gestures of the tongue and associated structures; those that involve different phonation types; and those that involve differences in the time domain, producing variations in length and diphthongization.

### *Nasalized vowels*

The most common minor vowel feature is nasalization, with more than one language in five using this possibility (Maddieson 1984a). The most frequent nasalized vowels are i/ a, u, the counterparts of the most frequent oral vowels i, a, u. Nasalization appears to be a binary feature from a phonological point of view. But there are surface phonetic contrasts between oral, lightly nasalized, and heavily nasalized vowels in some languages. This usually occurs when a language with a phonological contrast between oral and nasalized vowels in addition has oral vowels that are contextually nasalized when adjacent to a nasal consonant. An example is shown in figure 9.14, (after Cohn 1990) comparing the nasal flow patterns of the French words *bonnet*, *nonnette*, and *non-entre* ('cap', 'young nun', 'non-entity'). The volume of air flowing through the nose can be taken as a measure of the degree of nasality when there are comparable oral articulations. Vowel (1) is an oral vowel before a nasal consonant,

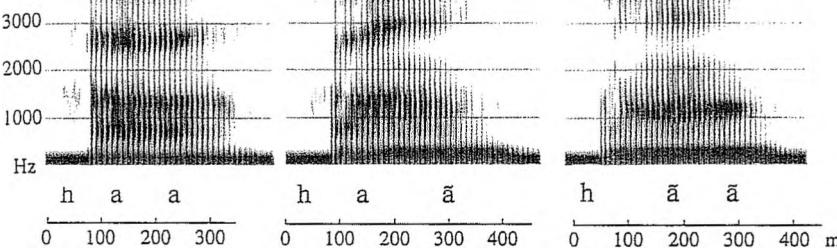


Figure 9.15 Spectrograms of the three Chinan tec words in table 9.9.

resulting in the last part of the vowel being contextually nasalized; vowel (2) is considerably more nasalized, as it is between two nasal consonants; but it is not as nasalized as vowel (3), a phonologically nasalized vowel, in the same context.

Using surface phonetic contrasts such as those shown in table 9.9, Merrifield (1963) and Ladefoged (1971) noted three degrees of contrastive nasality in Palantla Chinantec, which were described as oral, lightly nasalized and heavily nasalized. This claim was supported by airflow data (recorded by W. S-Y. Wang and Peter Ladefoged; unfortunately this data is no longer available) showing that there was a higher maximum rate of nasal airflow in the fully nasalized vowels than in the lightly nasalized vowels. Auditory and acoustic analysis of such items show clear differences between the two types of nasalized vowels in the relative timing of the onset and offset of nasality. The vowels that were described as lightly nasalized are in fact audibly nasalized through only the latter part of their duration. Figure 9.15 shows spectrograms of the words in table 9.9. In the first word, with a fully oral vowel, the first two formants are very close together with the center between them being at about 1000 Hz. Both these formants are of approximately equal intensity. At the beginning of the second word the first two formants are in the same position, but the first is weaker than the second due to the incidence of a nasal zero. The

vowel like that in the first word followed by a vowel that is more like the third. A better description of the three Chinantec contrasts might be as being between oral vowels, oral-nasal diphthongs and nasalized vowels.

### *Advanced tongue root*

There are fashions in the descriptions of vowels, resulting in some of the terms in table 9.8 being more discussed at certain times than others. For the last decade or so, the most discussed of the minor vowel features has been ATR (Advanced Tongue Root). For many years before that it was the Tense/Lax opposition; and earlier still, at the end of the last century, dichotomies such as Narrow/Wide and Primary/Wide were used. There is some overlap in the usage of each of these terms. We will begin by considering sets of vowels that can be said to differ in ATR; later we will compare these vowels with those that are said to be Tense as opposed to Lax.

Many West African languages have vowels that differ in the position of the tongue root (Ladefoged 1964). This difference is often most obvious in the case of high vowels. Tracings of the vocal tract shape in Igbo high vowels as shown by x-ray cinematography are given in figure 9.16. In each of these pairs the height of the tongue is very much the same. This is true irrespective of which of the two classic measures of tongue height is used, the location of the highest point of the tongue, or the height of the tongue body as a whole. Clearly, the most striking difference is that the root of the tongue is more retracted in the one case than in the other.

Another language in which there are two sets of vowels differing in ATR is Akan. Diagrams of the vocal tract shape (redrawn from data in Lindau 1975) are shown in figure 9.17. As Lindau has pointed out, in this language (and probably in most languages in which ATR distinguishes two sets of vowels), the difference is not simply in the tongue root gesture, but in the enlargement of the whole pharyngeal cavity, partly by the movement of the tongue root, but also by the lowering of the larynx. Lindau suggests that the term Expanded is the most appropriate name for this feature. The lowering of the larynx sometimes results in these vowels having a slightly breathy quality.

Figure 9.16 Tracings from x-ray cinematography films of Igbo vowels i as in obi (obi in the standard Igbo orthograph}) 'heart'; i as in ubl (ubi)poverty of ability'; u as in iby Cibu) 'weight'; and u as in obO (pbu)'itis'. In accordance with current IPA usage <sub>H</sub> and <sub>—</sub> are used to indicate Advanced and Retracted Tongue Root, respectively.

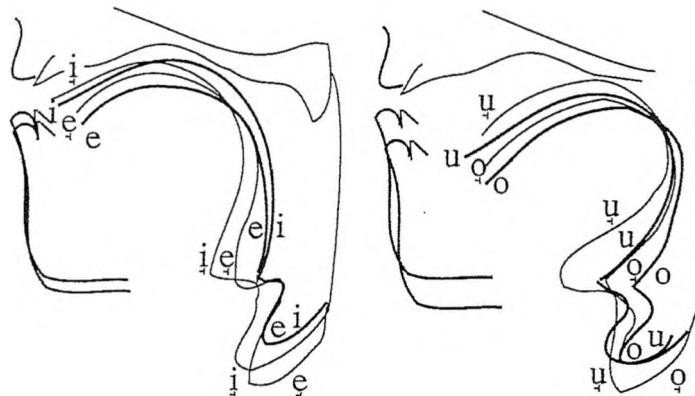


figure 9.17 The articulatory positions in non-low vowels of the Akyem dialect of Akan, based on Lindau (1975). Front vowels are in the left panel, back vowels in the right panel. Advanced Tongue Root vowels are shown by the lighter lines. The positions for the lips are estimated.

Acoustic analysis also shows why retracted tongue root vowels have sometimes been described as having a difference in voice quality (e.g by Berry 1955). Figure 9.18 shows the spectra of a pair of Degema vowels with similar formant frequencies, the retracted tongue root front vowel i, and the advanced tongue root front vowel i. The auditory qualities of these two vowels are similar; but the advanced tongue root vowel sounds 'brighter' because of the greater amount of energy in the higher part of the spectrum. There is a noticeable difference in the bandwidths of the formants; those of the advanced tongue root vowel are narrower, probably because there is greater tension of the vocal tract

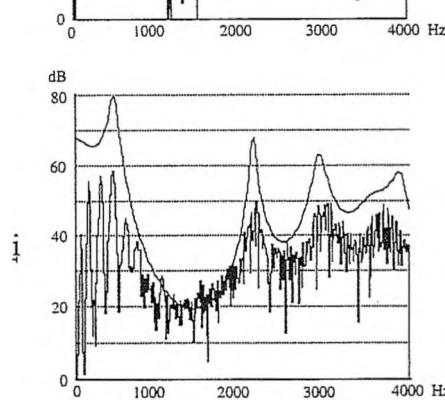


Figure 9.18 Spectra of the Degema vowels i and i.

walls and fewer acoustic losses in the region of the resonances. This would also add to the 'brighter' tone of this vowel. Similar differences in bandwidth have been found with ATR contrasts in Akan (Hess 1992). However we should point out that in most cases that we have heard, the West African languages using ATR do not have markedly different voice qualities.

### *Tense/Lax and ATR*

The Akan vowels in figure 9.17 also differ in the height of the tongue in the front part of the oral cavity. This leads us to consider whether the differences between [+ATR] and [-ATR] vowels are the same as the differences between so-called Tense and Lax vowels, which may also differ in both the height of the tongue and the position of the root of the tongue. There are differences of this kind in Germanic languages, as exemplified by pairs of English words such as *heed-hid* and *bait-bet*. Following Jones (1956) and a long British tradition, we regard the members of these pairs of vowels as being

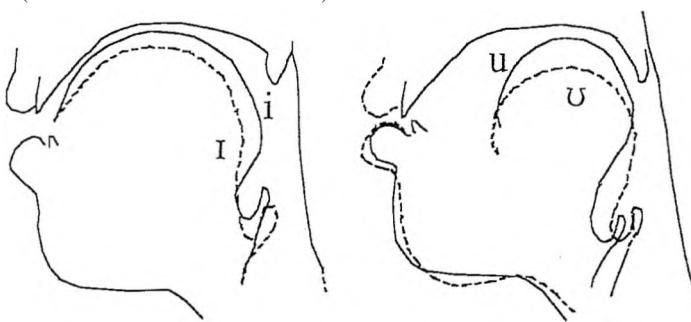


Figure 9.20 X-ray tracings of the articulatory positions in some so-called Tense/Lax pairs of vowels in German (after Bolla and Valaczkai 1986).

distinguished by variations of the major vowel qualities. Height and Backness (and perhaps Rounding). We note, of course, that the differences may involve diphthongization implemented through variation in Height and the members of each pair also differ in length. But we do not find it necessary to consider any additional parameters such as tenseness.

We recognize, however, that there is also a long tradition in which these vowels are considered as being distinguished by the feature Tense (e.g. by Bloch and Trager 1942, and by Chomsky and Halle 1968). This leads us to consider two related questions that might be asked at this point. Firstly, are we correct in our phonetic characterization of these vowels as differing only in the regular vowel dimensions of Height and Backness (and Rounding), plus Length? Secondly, are ATR variations the same as Tense/Lax variations? We can get a partial answer to these questions by comparing the vocal tract shapes shown for the Igbo vowels in figure 9.16 and the Akan vowels in figure 9.17, with the pairs of English vowels shown in figure 9.19 or the pairs of German vowels in figure 9.20. In Igbo and Akan the tongue height is not correlated with the tongue root position. In English the position of the tongue root is correlated with the tongue height (more so for the back vowels than for the front). In