separate control of the root of the tongue; but he did find that there were three independent parameters of tongue shape in Akan. Tiede's (1993) three-dimensional study of pharynx volume using MRI shows further differences between Akan and English. In the pharyngeal region below the epiglottis, Akan shows a positive correlation between the transverse width of the space and tongue root advancement, whereas in English transverse width is negatively correlated with advancement. Accordingly it seems that the situation in English (and other Germanic languages) is not the same as that in West African languages. Although there may be some increase in the height of the tongue accompanying the advancement of the tongue root in Akan, the changes in tongue height are small in comparison with the expansion that occurs in the pharyngeal region. Furthermore, on some occasions there may be virtually no increase in tongue height for [+ATR] vowels, as is shown in the case of the Igbo vowels in figure 9.16. We conclude that the advancement of the tongue root is a separable tongue gesture in languages such as Igbo and Akan. In Germanic languages, however, it is simply one of the concomitants of vowel Height.

If the advancement of the tongue root is an independent gesture that can be learned as part of the sound pattern of a language, then it must have observable acoustic consequences that distinguish it from all other possible ways of achieving similar acoustic effects.

Lindau (1979) has also pointed out that there are differences between ATR and Tense/Lax characterizations of vowels in the acoustic domain. Figure 9.21 shows the acoustic characteristics of ATR differences in a number of languages. The Akan data is from Lindau (1979), the DhoLuo from Jacobson (1978), and the remaining languages are from our own files. It may be seen that in virtually all cases the [+ATR] vowel appears to be raised and advanced in the acoustic space. The only exception is the Ebira lower mid back vowel which is raised, but only very slightly advanced. Among front vowels, pairs of vowels differing in ATR have formant frequency characteristics that are reminiscent of so-called tense-lax pairs of vowels in Germanic languages, such as English *bead-bid; bade-bed;* both retracted tongue root vowels and the lax vowels are lowered and more central in the acoustic space. Among front vowels there is this parallel between [+ ATR] and [-ATR] tongue root vowels on the one hand, and Tense and Lax vowels on the other, but among back vowel pairs

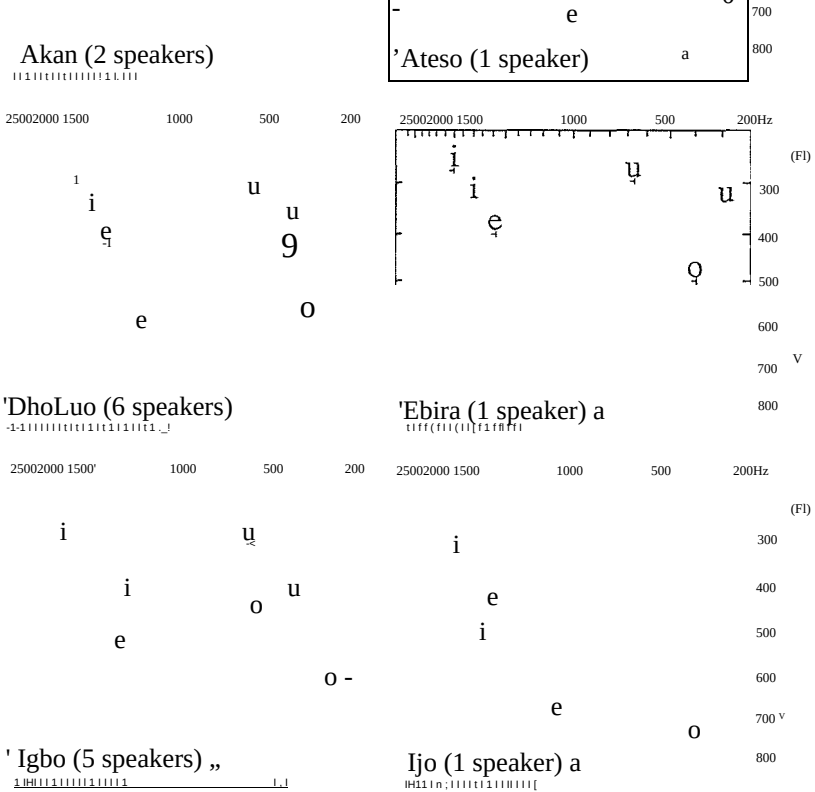

Figure 9.21 The acoustic effects of ATR in a number of languages. Vowels that are [+ ATR] are indicated by the subscript $_{u}$.

advancement. This gesture takes several different forms, resulting in vowels that are variously called pharyngealized, epiglottalized, sphincteric or strident. Among the languages which have been described as having pharyngealized vowels is Even, a Tungus language of North-Central Siberia (Novikova 1960). This language has two sets of vowels as exemplified by the words in table 9.10. The vowels in the set labeled pharyngealized all have a narrower pharyngeal passage and a raised larynx. Tracings of x-rays of the vocal tract shape in these vowels are shown in figure 9.22. (As drawn in the originals these tracings imply that all these vowels are nasalized. That seems unlikely, and we do not know what to make of it. Obviously, we should be cautious in fully accepting the validity of the rest of the indicated vocal tract shape.) There is considerable similarity between these pairs of vowels and those we have been discussing in Akan. Furthermore, it is interesting to note that the two sets of vowels in Even also constitute vowel harmony sets in much the same way as the two sets in Akan: roots must contain vowels that are all of one set or the other.

Despite these similarities, both the examination of the x-ray tracings and Novikova's comments on the acoustic characteristics of these vowels suggest that there is a greater degree of pharyngeal narrowing in Even than in Akan. We will therefore consider these vowels to be characterized by pharyngealization rather than by ATR. Vowels with even more retraction of the tongue root occur primarily in two language families: Caucasian and Khoisan. In Caucasian languages such as Tsakhur and Udi each of the five vowels i, e, a, o, u has a pharyngealized counterpart (Catford, ms in preparation). Tsakhur also has a sixth vowel, which Catford symbolizes v, that has a

Table 9.10 Words illustrating plain and pharyngealized vowels in Even (Novikova 1960)

PLAIN		PHARYNGEALIZED	
isli	. 'plucked'	fsli^{s}	'reached'
US	'weapons'	U'S	'guilt'
Oj	'summit'	a J	'clothing'
akan	'older sister'	akan	'older brother'

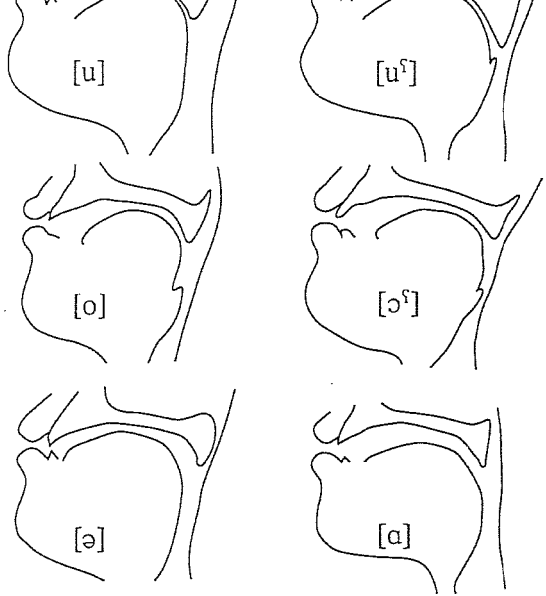

Figure 9.22 X-ray tracings of plain and pharyngealized vowels in Even (based on data in Novikova 1960).

pharyngealized counterpart (and Udi has three other vowels that do not have such counterparts). Catford reports formant frequencies for all these vowels. The most noticeable point in the acoustic structure is that the frequency of the third formant is markedly lower in the pharyngealized vowels. The frequency of the first formant is also somewhat higher.

X-rays of Tsakhur and Udi pharyngealized vowels are shown in figure 9.23. In addition Gaprindashvili (1966) has published some x-rays of pharyngealized vowels in two different dialects of Dargi. These all show that there is considerable narrowing in the pharynx near the tip of the epiglottis.

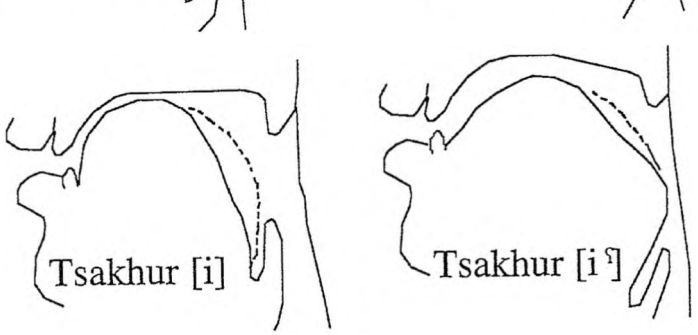

Figure 9.23 X-ray tracings of plain and pharyngealized vowels in Tsakhur and Udi (based on data in Catford ms in preparation, and Dzhejranishvili 1959). Tire original sources are not completely explicit, but the dashed lines presumably represent raised portions of the sides of the tongue.

Table 9.11 Additional vowel properties in 1X60. (See text for an explanation of the phonetic notation)

PLAIN	**k‖aa**	'camelthom tree'
PHARYNGEALIZED	**qa'a**	'long ago'
STRIDENT	**?q!ao**	'base'
BREATHY VOICED	**k!ao**	'slope'

What is equally interesting is that the whole front part of the tongue is bunched up, with a pronounced hollowing of the part of the tongue below the uvula. This results in the vocal tract having three cavities rather than just the usual front and back cavities produced by a single constriction. As Catford (1988a) has noted, a similar vocal tract configuration also occurs in some American English rhotic vowels, which like the Caucasian vowels, have a low F3.

There are also pharyngealized vowels in some of the Khoisan languages. In these languages only the back vowels a, o, u have pharyngealized counterparts; but there are additional contrasts among vowels (which we will discuss later), as shown for the vowel a in table 9.11. Traill (1985) has given good descriptions of all these sounds. Figure 9.24 is based on tracings from his

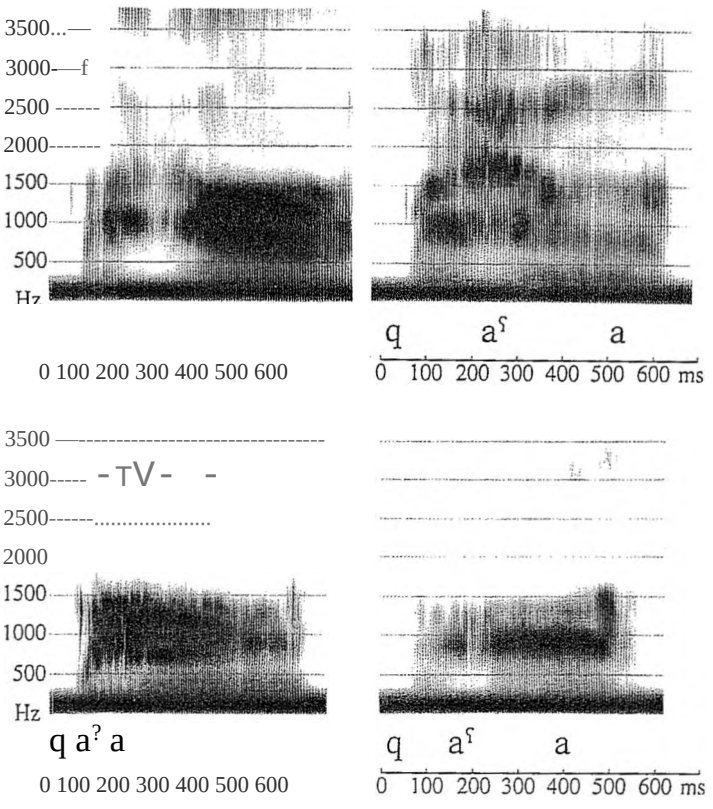

Figure 9.25 Spectrograms of the word qa'a as pronounced by four speakers of !X66, showing a pharyngealized vowel, followed by a non-pharyngealized vowel.

to be the same as in the two Caucasian languages. We have heard recordings of all these languages, and have ourselves worked with speakers of 1X66 and other Khoisan languages. Figure 9.25 shows spectrograms of the word qaʳa as pronounced by four speakers of 1X66. This word is especially interesting because it contains two vowels that are the same except for the pharyngealization that occurs on the first. The acoustic effects of pharyngealization are observable in only the first part of the word. The lowering of the third formant is similar to that reported in the Caucasian languages; but in the Khoisan examples, there is also a considerable *raising* of the lower formants, accompanied by a diminution of the energy around 400-700 Hz. This is comparable to the acoustic effects seen in pharyngeal consonants and discussed in chapter 2.

Strident vowels

The Khoisan pharyngealized vowels that we have been discussing so far are not the so-called strident vowels of these languages. Traill (1985) suggests that the strident vowels may be regarded phonologically as pharyngealized breathy voiced vowels. He goes on, however, to emphasize that the vocal tract shape is not the same as in the pharyngealized vowels, and the laryngeal action is very different from that in breathy voiced vowels. It is clear that from a phonetic point of view strident vowels are best considered as involving a distinct articulatory mechanism of their own, which he has labelled 'sphincteric' (Traill 1986).

Traill (1985, 1986) has provided a great deal of valuable data on these vowels. Figure 9.26 shows, in addition to the plain and pharyngealized vowels discussed above, the strident vowels which, for want of better symbols, we will represent by a and u. Traill, in accordance with his phonological analysis, transcribes them as ah and uh. It is clear that the whole body of the tongue is much lower for the strident vowels. In addition the back wall of the pharynx, which is shown by the dashed line, is drawn forward, and, "the epiglottis vibrates rapidly during these sounds" (Trail 1985).

More details are apparent from the enhanced x-ray of Traill's own pronunciation of a strident vowel shown in figure 9.27. Only the pharyngeal and

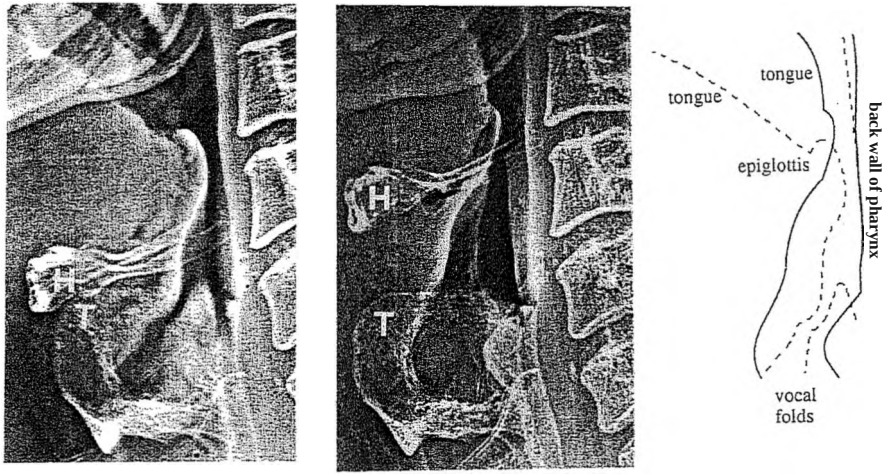

Figure 9.27 Photographs (courtesy of A. Traill) illustrating his pronunciation of a strident vowel in !X6o (compare Traill 1985). The center photograph shows the larynx and the pharyngeal area when at rest and that on the left shows the phonation of a strident vowel. The diagram on the right shows the two tongue positions superimposed, with the dashed lines indicating the strident vowel. An H in both photographs marks the hyoid bone, and a T marks the thyroid cartilage.

laryngeal areas of the vocal tract are shown. The right-hand part of this figure shows our tracings (from the original photographs) of the shape of the vocal tract. In addition to the constriction at the root of the glottis, shown in figure 9.26, there is also a major constriction between the part of the tongue below the epiglottis and the tips of the arytenoid cartilages in the upper part of the larynx. As may be seen by comparison of the two photographs, this constriction is achieved by pulling the hyoid bone (marked by H) and the thyroid cartilage (marked by T) closer together. A constriction of this kind does not occur in the pharyngealized vowels of !X6o or other Khoisan languages, and is also not apparent in any of the data that we have seen showing the pharyngealized

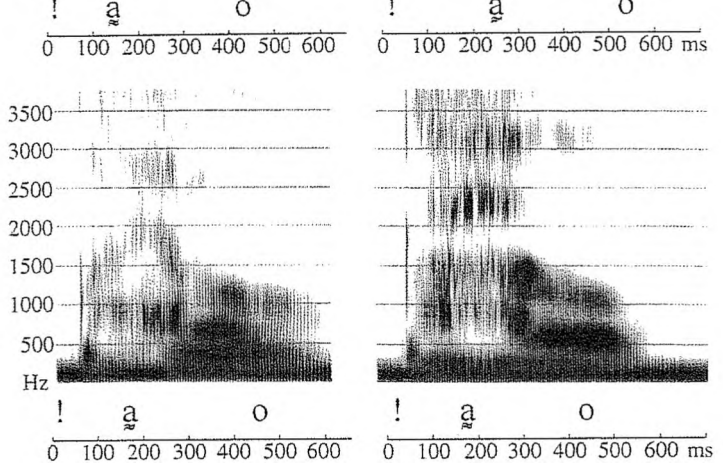

Figure 9.IS Spectrograms of the pronunciation of the word !ao containing the low back strident vowel, spoken by four speakers *of* !X66.

vowels in Caucasian languages. Consequently in table 9.8 we listed strident among those vowel properties that depend on variations in vocal tract shape, although, in fact, it is not simply the vocal tract shape that characterizes these vowels.

As we have seen, strident vowels have a constriction between the part of the tongue below the epiglottis and the tips of the arytenoid cartilages in the upper part of the larynx. This constriction results in these vowels having a specific phonation type. Traill (1985) notes that "the arytenoid cartilages vibrate vigorously." He also notes, however, that the vocal cords themselves do not vibrate during this tight constriction in the upper part of the larynx. This whole shape, in which the vocal cords are stiff and comparatively close together, is certainly not at all like that normally associated with what is called murmur or breathy voice. Figure 9.28 provides acoustic data from our own field recordings of

are very much akin to pharyngealized vowels, and strident vowels might be regarded as a more extreme form of pharyngealized vowels. All these vowels are characterized by some degree of pharyngeal narrowing and larynx raising. Languages seldom use more than one of the three possibilities. We cannot reduce these three possibilities to a single binary contrast because of the contrastive use of plain, pharyngealized and strident vowels in !X6o. But the most suitable phonological parameters to use in describing these vowels are not clear to us at this moment.

Rhotic vowels

As we mentioned above there is yet another class of vowels in which the root of the tongue is often retracted, namely the rhotic (r-colorecl) vowels. These sounds are very unusual, and occur in less than one percent of the world's languages (Maddieson 1984a). They are, however, comparatively well known, in that they occur both in some forms of English, and in some forms of Chinese. The common attribute of all rhotic vowels is in their acoustic structure, rather than in their articulation. Rhotic vowels always have a lowered frequency of the third formant. Sometimes these sounds are produced with the tip of the tongue up, and sometimes with it down; often the tongue is bunched up in the anterior-posterior direction; and there is usually a narrowing of the vocal tract in the region of the epiglottis. As discussed in chapter 7, the syllabic peak in words such as *herd* in many varieties of American English is regarded as a syllabic version of the consonant j, but other vowels often take on a rhotic coloring before j.

What may be a different kind of rhotacization has been reported by Emeneau (1939) in Badaga, a Dravidian language. He suggests that in this language there are five vowel qualities, i, e, a, o, u, each of which can be "normal, half-retroflexed, (or) fully retroflexed." The half-retroflex vowels are described as being "produced with the edges and tip of the tongue retroflexed or curved upward to approach the alveolar ridge, but without touching or causing friction at any point; the front of the blade of the tongue seems to be raised also in this manner of vowel production." His description of the fully retroflexed