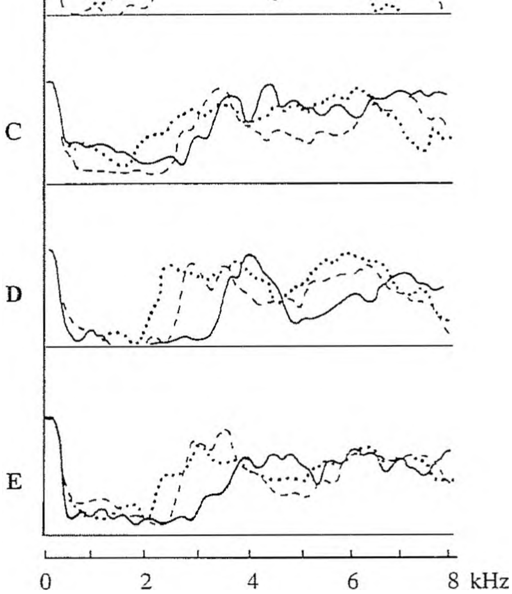

Figure 5.29 Spectra of Swedish s (solid line), c (dashed line), and s (dotted line) before a: as produced by five speakers designated A-E (after Lindblad 1980).

sharp lower frequency cut off, as there is in the palatal fricative <; opposite it on the lower right side; c differs from c by having a higher mean spectral energy. Hie rounded fricatives in the upper right part of the figure have a strong low frequency peak. Both p and fj also have a low frequency peak, as well as a considerable amount of energy in the region just above 4 kHz.

The technique of investigating the acoustics of fricatives by using a single speaker to produce a wide range of fricatives, employed by Lindblad for Swedish, enables speaker-dependent variables to be controlled. Studies of this

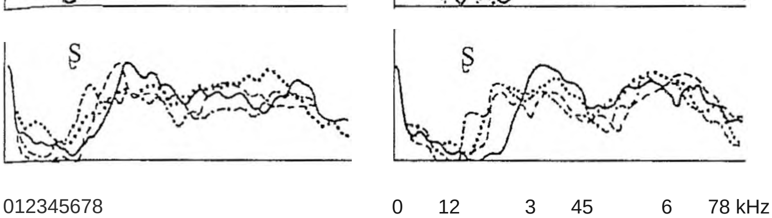

Figure 5.30 Spectra of Swedish s, c, and 5 before i: (solid line), y: (dashed line) and before u: (dashed and dotted line) as produced by two speakers A and B (after Lindblad 1980).

kind include Strevens (I960), Jassem (1962), and Shadle (1985). Shadle analyzed sustained productions of the fricatives <J>, f, 0, s, J, x as spoken by three male and three female "phoneticians or speech researchers familiar with the phonemes." She again found "tremendous variation in spectral shape" between speakers. However, in her later work she and her co-authors note that "simple measures such as frequency range for high amplitude regions are likely to be highly variable," and have shown that it is possible "to locate low amplitude but consistent spectral peaks, and to discover their cavity affiliation." (Shadle, Badin and Moulinier 1991:44).

A comparison of a larger range of sounds is presented by Jassem (1968), who considered the acoustic structure of a number of fricatives in different languages. Spectra of 12 of these sounds are reproduced in figure 5.32. When considering Jassem's findings, it must be remembered (as he himself emphasizes) that the data represent fricatives as produced by only a single speaker; but, nevertheless, this speaker (Jassem) is "well acquainted with these sounds through contact with languages in which they occur and / or through exhaustive phonetic training" (Jassem 1968). There is little more that we need say about f, 6, apart from noting their comparatively flat spectrum. All the sibilants have a relatively sharp low frequency cut off that is higher in frequency in proportion as the sibilant is more front in articulation (as we have noted above). The palatal fricative c in Jassem's spectra seems to be similar to the alveolo-palatal fricative c in Lindblad's pronunciation shown in figure 5.31, being marked by a particularly strong localized spectral peak. Conversely, the alveole-

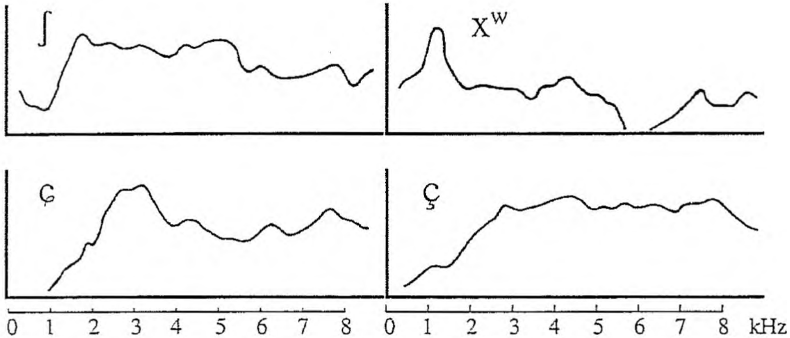

Figure 5.31 The sibilant fricatives that occur in different Swedish dialects as prononounced in their 'cardinal' versions by Lindblad (1980). (Lindblad uses different symbols, here turned into their 1PA equivalents.)

palatal fricative c in Jassem's spectra seems to be similar to the palatal fricative c in Lindblad's, being relatively flat. The more back, fricatives, x, z, h, have a spectral peak that decreases in frequency as the place of articulation approaches the glottis, and additional peaks in the higher part of the spectrum.

5.5 Laryngeal Settings and other Modifications of Fricatives

The majority of fricatives are voiceless and we have used voiceless examples in most of the previous discussion, with fewer mentions of their voiced counterparts. The greater frequency of voiceless fricatives in the world's languages may be due to the fact that the strong low-frequency energy that results from voicing tends to mask the lower-amplitude frication noise in the higher frequency range. Also the flow impedance at the

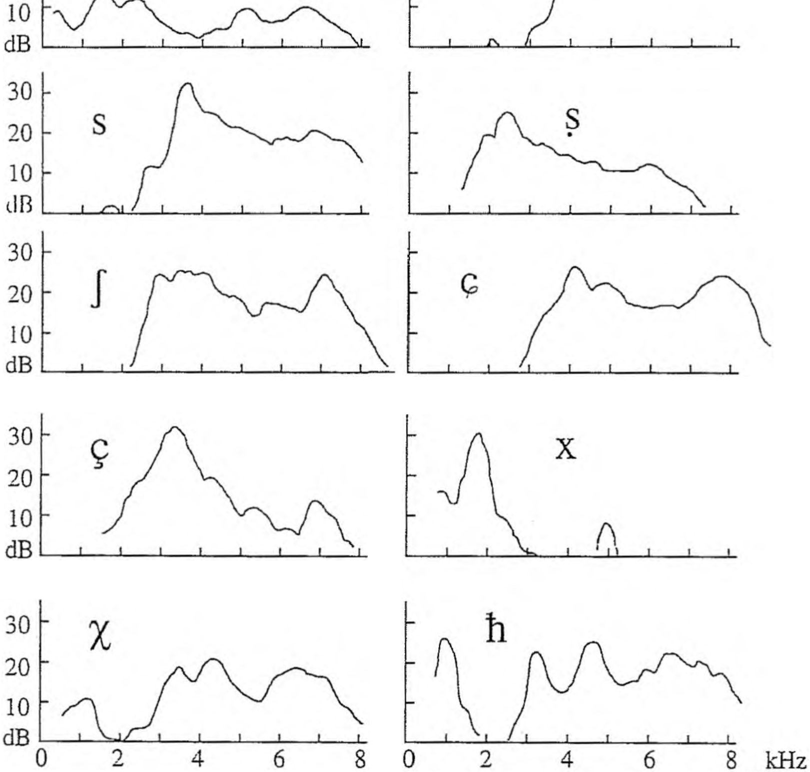

Figure 5.32 Spectra of 12 fricatives as produced by Jassem (1968).

denotes a fortis articulation.) Hausa has a form of s that may be laryngealized, but is usually ejective, as we will discuss below. Apart from these two languages, only four languages with laryngealized fricatives are listed in Maddieson (1984a), and none of them has more than one such sound. A voiceless laryngealized fricative s is reported in Southern Nambiquara (Price 1976) and Siona (Wheeler and Wheeler 1962), which may well be similar to the Korean s*. Wapishana (Tracy 1972) has z, and Sui (Li 1948) has y. There are no languages listed with breathy voiced fricatives. However, voiced fricatives in Wu dialects produce the same tonal effects as the stops with breathy release. It is therefore likely that they share this characteristic with the stops.

All the fricatives we have been discussing so far have used the pulmonic airstream mechanism, but glottalic egressive (ejective) fricatives also occur. Yapese, Tlingit, Hausa, and Amharic are among the languages that have ejective fricatives. Words illustrating pulmonic and ejective fricatives in Tlingit are shown in table 5.11.

Hausa ejective fricatives are illustrated in figure 5.33, which shows a spectrogram of the Hausa phrase s’uns’a: je: ne 'They are birds'. Both examples of ejective s’ are accompanied by a rising movement of the closed larynx, followed by its subsequent return to its normal speech position. This up-and-down movement is probably responsible for the movement of the point of articulation in the gesture which causes a variation of the pole frequency associated with the fricative noise. The variations in frequency can be clearly seen in the medial s’ and are also evident in the initial s’. We have seen similar variations in ejective s’ in other languages. The upward movement of the glottis in an ejective is achieved by raising the hyoid bone. This action will also produce an upward and forward movement of the body of the tongue. The resulting more forward articulation of the s’ will have a higher frequency, as the cavity in front of the constriction -will be smaller. When the larynx falls, the reverse process occurs, and the pole frequency is lowered. Figure 5.33 also shows that there is an interval of about 40 ms between the end of the medial fricative noise and the release of the glottal stop, and a further short interval before the vocal folds start vibrating.

The occurrence of prenasalized fricatives is noted in chapter 4 and lateral fricatives are discussed in chapter 6.

		VELAR		UVULAR
PULMONIC sa: 'be narrow'	xa:t 'stick out from'	x"a:s 'hang'	X«t 'multiply'	Z^rl 'shake, tremble'
EJECTIVE s'a: 'claim' (property)	x'art 'file'	x^{w}'a:s'k 'be numb'	Z'ed' 'gnaw, chew'	X^{w}'a:s' 'become bald'

5.6 Phonological Features for Fricatives

We will now consider how all these fricatives can be classified within each language in terms of features. We will start by considering the features that are necessary to classify fricatives as distinct from other sounds. Then, assuming the validity of the distinction between sibilants and non-sibilants within

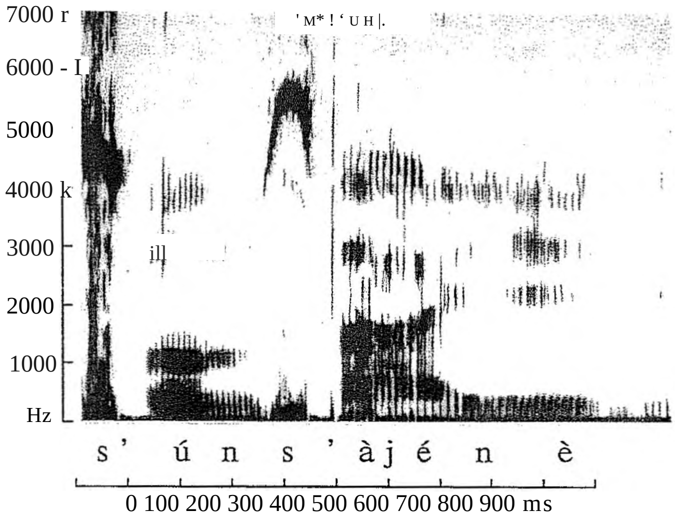

Figure 5.33 A spectrogram of the Hausa phrase s'uns'a: je: ne "They are birds'.

possibilities (notated A_o, Af and A_{max}) which are similar to Ladefoged's principal values. Most feature theories allow for a further distinction among fricatives. Both from a phonological and from a phonetic point of view, the appropriate division is into sibilant (obstacle) and non-sibilant (non-obstacle) fricatives. We can see no reason for grouping f, v along with s, z, f, 3 and the other sibilant fricatives, as proposed by Chomsky and Halle (1968) on the basis of purported similarities of constriction length. It is far preferable to divide fricatives into sibilants and non-sibilants as indicated at the beginning of this chapter in table 5.1.

The further differentiation of fricative sounds involves what is traditionally called the place of articulation. As we noted in the last chapter, the place features can be thought of as specifying the direction of the movement, and the shape of the moving articulator. For many non-sibilant fricatives, the direction of the movement and the general cavity shape is much the same as in the corresponding stop. However, the extent of the movement and its temporal organization is always very different; fricative transitions are slower than those for the corresponding stops. Fricatives require the specification of a separate, intrinsic, timing pattern.

The places of articulation discussed in chapter 2 can be used in a fairly straightforward way for classifying the articulatory gestures in most non-sibilant fricatives. But, for sibilant fricatives (and also for sibilant affricates) further distinctions are made by using different shapes of the articulator. We propose that, in addition to the features Fricative and Sibilant, the phonological classification of fricatives will require a feature specifying these different tongue shapes. Among alveolars we have noted that some of them have a deep groove in the tongue, whereas others do not. This suggests that there might be a feature Shape, with possible values flat and grooved. This feature might also be used for distinguishing post-alveolar sibilants, in which there are two further values, domed and palatalized. Chinese and Polish so-called retroflex s is a laminal flat post-alveolar; Toda and (for some speakers) English palato-alveolar J is a laminal domed post-alveolar; and Chinese and Polish alveolo-palatal c is a laminal palatalized post-alveolar. The four possibilities for the Shape feature, grooved, flat, domed and palatalized, form a mutually exclusive set. There is also another possibility among post-alveolar sibilants which specifies not the shape of the tongue behind the point of maximum constriction, but tative descriptions of this information remains a challenge to phoneticians. As a result, more subtle variations in articulatory posture can be perceived. This is all the more the case with sibilants, as differences in the angle at which the air strikes the obstacle and the velocity of the airflow can cause large spectral differences. The distinctions required for describing fricatives are thus more elaborate than those which will adequately characterize stop contrasts. The consequence of this fact is that there is no uniform transformation between the vocal tract shape of a fricative and that for a stop, even if the primary place is the same.

In this chapter we will review all of the various types of segments which have a lateral component. Laterals are usually defined as those sounds which are produced with an occlusion somewhere along the mid-sagittal line of the vocal tract but with airflow around one or both sides of the occlusion. We will define laterals slightly differently; they are sounds in which the tongue is contracted in such a way as to narrow its profile from side to side so that a greater volume of air flows around one or both sides than over the center of the tongue. In most laterals there is in fact no central escape of air, but our definition does not require the presence of a central occlusion, and will allow for some central airflow.

The common types of laterals, voiced lateral approximants, have traditionally been grouped with rhotics (r-sounds) under the name of 'liquids'. The core membership of the class of rhotics is formed by segments in which there is a single or repeated brief contact between the tongue and a point on the upper surface of the vocal tract, i.e. principally apical trills, taps and flaps. Laterals and rhotics are grouped together because they share certain phonetic and phonological similarities. Phonetically they are among the most sonorous of oral consonants. And liquids often form a special class in the phonotactics of a language; for example, segments of this class are often those with the greatest freedom to occur in consonant clusters (for more discussion of these similarities see Bhat 1974). Furthermore, quite a few languages have a single underlying liquid phoneme which varies between a lateral and a rhotic pronunciation. We note the validity of the liquid grouping but have chosen to devote separate chapters to laterals and rhotics. Rhotics and related sounds are discussed in chapter 7. We will also discuss the relation between laterals and rhotics in that chapter.

Most lateral segments in the world's languages are made with an occlusion in the dental/alveolar region (Maddieson 1984a). Palatographic and x-ray studies of several languages have shown that in many cases the occlusion is limited to a few millimeters on the alveolar ridge in the area behind the incisors and perhaps extending to the premolars. It does not extend back to the molar regions but instead the body of the tongue is relatively low in the mouth behind the closure, permitting lateral air escape as far forward as the front of the palatal region. Figure 6.1 compares the articulatory position for 1 with that for t for a German and a Standard Chinese speaker by means of palatograms and sagittal x-ray tracings from Wangler (1961) and Zhou and Wu (1963) respectively. The contact indicating sealing of the closure around the sides of the palate seen in the palatograms of t in the lower half of the figure is missing in the palatograms of 1. The x-rays indicate that, although the tongue tip makes contact at a fairly similar location for t and 1, the profile of the tongue behind the closure differs, so the tongue is lower in the mouth below the front palate area for the lateral. Note that the jaw is also more open for I than for t. This low position facilitates the lateral escape of air. Similar differences in the tongue profile can be seen in published data on a number of other languages with dental or alveolar stops and laterals. In the German 1 there is also a much wider pharynx than is seen in the stop.

Though this articulatory pattern of a quite limited medial closure restricted to the front of the mouth is common for dental and alveolar laterals, it is by no means universal. The area of contact may extend further back in the mouth than occurs in the examples in figure 6.1, meaning that the lateral escape is located further back. It is also possible for the closure at the front to be incomplete. Balasubramanian (1972) includes palatograms of the long alveolar lateral 1 of Tamil which show a more extended lateral contact on the right-hand side of the palate. Bella (1981) shows bilateral contact back to the third molars for a Russian speaker. Figure 6.2 shows retracings of three palatograms of a Gonja speaker (from Painter 1970) producing alveolar laterals. In each case, these laterals are produced with a small escape channel at the front to the left of the medial line. The main lateral escape is further back. In figure 6.2 (a) it is on the left in the mid-palatal region. In figure 6.2 (b) and (c) the escape around the