Nawrocka-Fisiak and Krassowska (1977).

post-alveolar (palato-alveolar). It is therefore appropriate to refer to ? as a palatalized post-alveolar, with the IP A term alveolo-palatal being a possible alternative. We are thus making a distinction between three post-alveolar sibilant gestures: flat post-alveolar (retroflex) $; domed post-alveolar (palato-alveolar) j-, and palatalized post-alveolar (alveolo-palatal) C-

There are a number of other fricatives that have to be compared with these English and Standard Chinese sounds. The Polish fricatives exemplified in table 5.4 have many similarities but also some differences from the Standard Chinese sibilants. A great deal of data on the acoustic structure of the Polish fricatives has been given by Kudela (1968). Additional data can be found in Jassem (1962). We will concentrate here on the articulatory gestures required for these sounds, relying largely on the descriptions by Puppel, Nawrocka-Fisiak and Krassowska. (1977). They use the symbols s z s z s z for sounds which we symbolise by s z c z 5 z. (Throughout the following discussion we will use our symbols not theirs, even when directly quoting from them.) Diagrams based on their x-ray tracings of the voiced sounds are shown in figure 5.11. Again it is clear that these three pairs of sounds are all strident fricatives with the teeth close together.

The authors note that:

> The Polish sounds s and z belong to dentalized sounds, i.e. those which are articulated in the alveolar region but with the blade of the tongue being very close to the inner side of the upper front teeth. Thus, the hissing effect is very strong. However, the English counterparts are articulated more in the purely alveolar region. Thus, in English, the tongue is more retracted for the articulation of these sounds.

From their diagrams it is clear that the sounds are s and z and not s and z, and thus differ from the corresponding sounds in English and Standard Chinese.

In describing s and z Puppel et al. say: "The narrowing is made by the tip of the tongue and the blade of the tongue, and the alveolar ridge. The narrowing, as compared with that for s and z, is a bit more open. The lips are protruded

in the alveolar region. They also belong to those sounds which are slightly dentalized." We would also point out the more complex obstruction caused by the close approximation of the upper lip with both the lower lip and the lower teeth in these sounds, making them somewhat rounded.

We do not know what Puppel et al. mean when they say that these sounds are "slightly dentalized." Nor, judging from the illustrations, do we consider the tip of the tongue to be involved in making the constriction. But the tip of the tongue is slightly retracted from the lower teeth, so that there is a small sublingual cavity. These sounds seem to us to be produced in a similar way to the Standard Chinese laminal post-alveolar (retroflex) sibilants. They differ in that Standard Chinese 5 is not rounded (except before rounded vowels and semivowels) and has a larger sublingual cavity. These two differences tend to cancel one another, in that the addition of lip rounding or the introduction of a larger sublingual cavity both have very similar effects, thus making these Polish and Chinese sounds auditorily very similar.

The third pair of Polish fricatives, <; and z, involve an articulatory gesture which is very similar to that in the Standard Chinese sound for which we have used the symbol c. Puppel et al. describe the Polish sounds as follows: "The sounds are produced with the body of the tongue in the front position. The tongue is tense and the lips are spread. The air escapes through a very narrow channel made between the post-alveolar region of the palate and the middle of the tongue ... the lips are slightly spread." When Puppel et al. specify that the body of the tongue is in the front position, they presumably mean that the sound is palatalized. From the illustrations in figure 5.11 it is clear that the gesture for Polish z is very similar to those for Chinese <; (at least for speakers A and C in figure 5.9).

The well known Dravidian and Indo-Aryan languages of India also have apical or laminal retroflex sibilants. An example of a Tamil sibilant that we would symbolize as $ is shown in figure 5.12 (based on x-ray data in Svarny and Zvelebil 1955). The articulation appears to be further back than the post-alveolar sibilants in Standard Chinese and Polish. But, as we have remarked before, there are no absolute landmarks in the vocal tract, so it is difficult to compare articulatory data from one person with that from another, just as it is difficult to compare acoustic data from different individuals. We will classify

Figure 5.12 The articulatory gesture involved in Tamil $ in pa? a as indicated by x-ray data given in Svamy and Zvelebil (1955).

Table 5.5 Words illustrating contrasts among Toda sibilants

LAMINAL **ALVEOLAR**	APICAL **POST-ALVEOLAR**	LAMINAL **POST-ALVEOLAR**	SUB-APICAL **PALATAL**
kois 'money'	po:s 'milk'	po:J 'language'	po:s (place name)

Tamil ? as a laminal post-alveolar, but reserve judgment on whether it really is equivalent to the Standard Chinese and Polish sounds that we have symbolized in the same way.

One of the most remarkable sets of sibilant contrasts occurs in another Dravidian language, Toda, which was well described by Emeneau (1984), and has recently been studied by Shalev, Ladefoged and Bhaskararao (1994). The analysis presented here is based on the same fieldwork as reported in this latter work, but differs from its conclusions in some details. Toda has four different articulatory gestures for sibilant fricatives, whereas the other Dravidian languages have only three. Words illustrating the Toda contrasts are shown in table 5.5.

Figures 5.13-5.16 show the palatograms, linguograms and sagittal reconstructions of the four sibilants from one speaker. The pictures were reproduced life size, and lined up so that the front incisors are in line with the incisors on the sagittal section (which, since it was traced from a dental impression of the speaker's mouth, was also life size). Like many of the Toda, this speaker has a deep palate. As the shape of the palate is known from the dental impressions, the height of the contact at the sides can be observed on the palatograms. We have used this information to make a rough estimate of the position of the center of the tongue (shown by a grey line). Note that the dark marks on the speaker's front teeth in these photographs are betel juice stains, and are not the result of tongue contact.

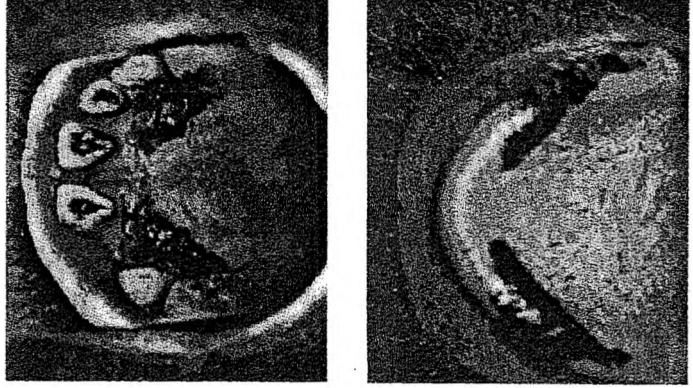


Figure 5.13 Palatographic and linguographic records of the Toda word ko:s 'money'. The solid lines on the sagittal section show the known shape of the palate and the observed position of the sides of the tongue. The grey line indicates estimated positions of the lips and the center of the tongue.

Toda s has a laminal alveolar articulation. Emeneau (1984) describes it as being "post-dental (pre-alveolar)", and we agree in that the constriction might be said to be closer to the teeth than in English s, but it is in the alveolar region. What is most remarkable about this sound is that it is clearly laminal, but nevertheless there is only a narrow part of the blade of the tongue contacting the roof of the mouth. Similar narrow contact areas on the blade of the tongue were observed for all three subjects for whom we have palatographic records. The sides of the tongue touch the hard palate well above the level of the molar teeth. We do not know whether the center of the tongue is hollowed, but from the fact that the distance between the points of contact on the alveolar ridge is slightly smaller than the distance between the comparable points on the tongue, and from direct observation of the production of this sound, we believe that the tongue is slightly grooved, so that it might be in the position shown in the diagram.

The laminal contact for s contrasts with the apical contact for s in the same

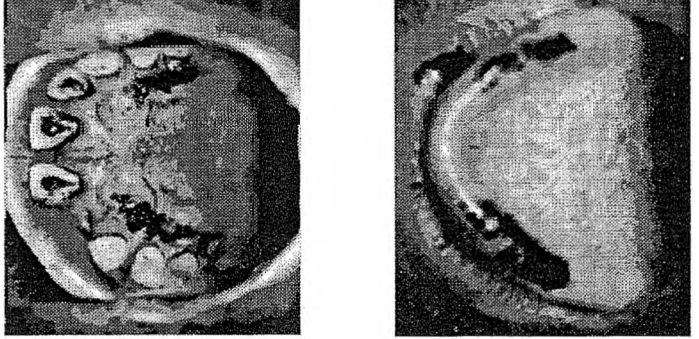


Figure 5.14 Palatographic and linguographic records of the Toda word po:s 'milk'. The solid lines on the sagittal section show the known shape of the palate and the observed position of the sides of the tongue. Dotted and grey lines indicate estimated positions of the lips and the center of the tongue.

language. This sound, which is illustrated in figure 5.14, is an apical sibilant. The two sounds also differ in that s has a wider channel for the airstream, and is articulated slightly further back, on the center of the alveolar ridge, making it post-alveolar. The contact areas at the side of the mouth are closer to the molar teeth, indicating a generally lower position for the tongue. There may also be some hollowing of the tongue in this sound, but it is not as extensive as in J.

The third Toda fricative, J, is a laminal post-alveolar, i.e. a palato-alveolar sibilant, with more contact of the tongue with the palate than either of the preceding sibilants, as can be seen in figure 5.15. The laminal tongue constriction is similar to that in Toda s, but involves a narrower channel, with the tongue sides being much higher in the mouth. The tongue is domed up towards the roof of the mouth, in a way somewhat similar to that in English J.

The final sibilant in Toda is s, a sub-apical palatal fricative, a genuinely retroflex gesture, as illustrated in figure 5.16. It is rather different from the Tamil gesture seen in figure 5.12. The contact is between the underside of the

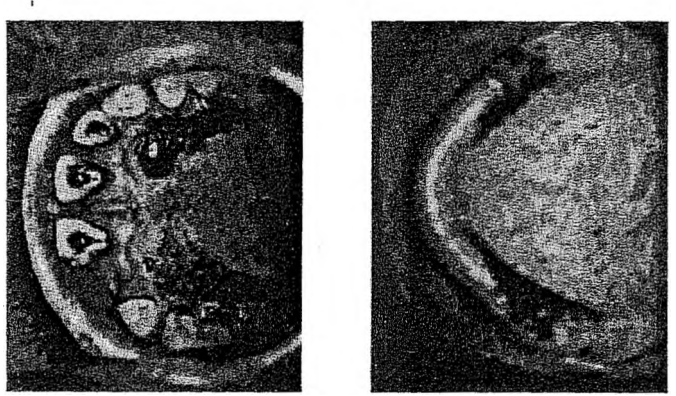


figure 5.15 Palatographic and linguographic records of the Toda word po:J 'language'. The solid lines on the sagittal section show the known shape of the palate and the observed position of the sides of the tongue. Dotted and grey lines indicate estimated positions of the lips and the center of the tongue.

tip of the tongue (so that it is not all visible in the linguogram) and a point on the roof of the mouth behind the post-alveolar region.

So that all these Toda sibilant fricatives might be compared, the tongue positions shown in the preceding diagrams have been superimposed in figure 5.17. The major point to note is that only one of these sounds, the sub-apical palatal (retroflex) sibilant, can be readily described in terms of the modal possibilities for places of articulation that were listed in chapter 2. Each of the others involves subtle distinctions in tongue shape relative to the teeth. We have described each of these fricatives in articulatory terms, but they do not all exemplify the modal possibilities associated with these terms.

The situation in Caucasian languages is also very complex, although for these languages Catford (1983 and personal communications) has given excellent accounts of some of the phonetic data available. Catford (ms in preparation) has described what we would call five different primary articulatory gestures (i.e. without considering secondary articulations, or different

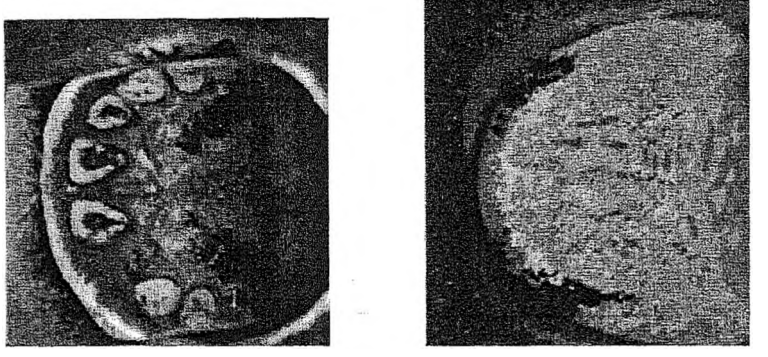


Figure 5.16 Palatographic and linguographic records of the Toda word po:g (place name). The solid lines on the sagittal section show the known shape of the palate and the observed position of the sides of the tongue. Dotted lines indicate estimated positions of the lips and the center of the tongue.

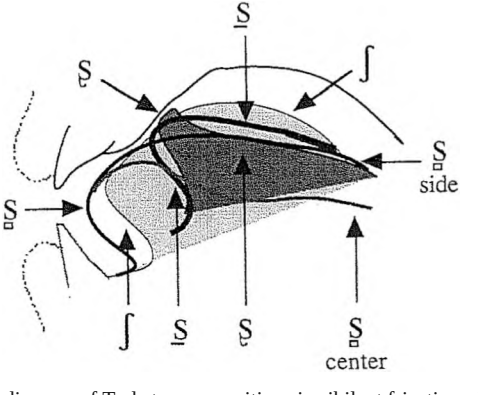


Figure 5.17 A composite diagram of Toda tongue positions in sibilant fricatives. In the case of s the center and sides of the tongue have been shown separately. The position of the center and sides is taken to be much the same for the other sounds, and only one tongue line is shown for each of them.

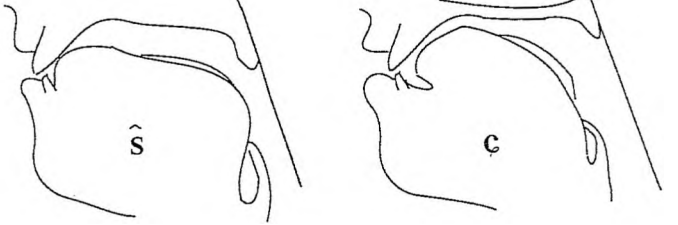
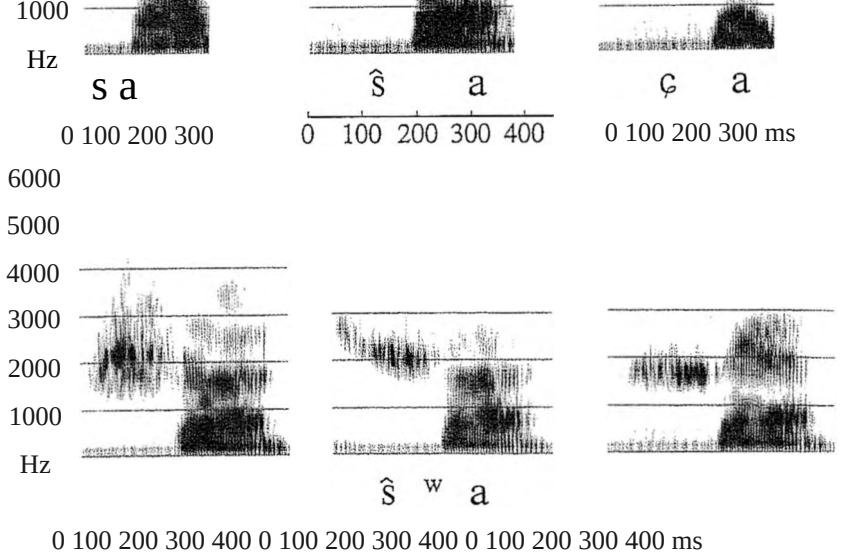


figure 5.18 The four contrasting gestures for the sibilant fricatives in the Bzyb dialect of Abkhaz, based on x-ray tracings from Bgazhba (1964) and interpretive comments by Catford (ms in preparation);

states of the glottis) for sibilant fricatives in North West Caucasian languages, such as Ubykh and Abkhaz. Four of these sounds, s J ? c, are similar to sounds that we have symbolized this way in other languages. The fifth sound, which Catford symbolizes as s, he describes as "acoustically and physiologically between a typical s and a typical J," calling it a "hissing-hushing sound." He goes on to say: "In its production the tip of the tongue rests against ... the lower teeth (as for a laminal s), but the main articulatory channel is at the back of the alveolar ridge (as for a lamino-post-alveolar J)." It is therefore like / (and 5 and c) in that its constriction is in the post-alveolar region; but it is like laminal s in that the tip of the tongue rests against the lower teeth so that there is no sublingual cavity.

Figure 5.18 shows the four contrasting gestures in the Bzyb dialect of Abkhaz, based on x-ray tracings in Bgazhba (1964) and the interpretive comments in Catford (ms in preparation). The constriction for s (at the top left of the figure) is in the alveolar region, on the front part of the alveolar ridge. The blade of the tongue is close to the alveolar ridge, and the tip of the tongue is on the floor of the mouth. The three other sounds all have constrictions on the middle of the alveolar ridge, in what we are calling the post-alveolar region. <; has the front of the tongue raised, making it a laminal palatalized post-alveolar (alveolo-palatal) sibilant, s is made with the tip of the tongue, so it is an apical



Figlire 5.19 Spectrograms of Ubykh syllables containing the voiceless sibilants in table 5.6.

Table 5.6 Words illustrating contrasts among Ubykh sibilants

	LAMINAL **DENTI-ALVEOLAR**	LAMINAL CLOSED **POST-ALVEOLAR**	LAMINAL **POST-ALVEOLAR**	APICAL **POST-ALVEOLAR**
PLAIN **VOICELESS**	saiba 'why'	S3 'three'	qaqa 'mother-in-law'	5 a 'head'
PLAIN **VOICED**	za 'one'	zaza 'kidney'	zawa 'shadow'	7^ 'firewood'
ROUNDED **VOICELESS**		asʷa 'white'	cʷa 'sea'	
ROUNDED **VOICED**		azʷan 'it boils'	az”an 'it roasts'	

nearer 3000 Hz in its unrounded form. When it is labialized (as in the middle of the bottom row), the energy is more tightly constrained in a lower region, around 2000 Hz. The other laminal post-alveolar, c, has energy in an even lower region, around 2500 Hz when unrounded, and well below 2000 Hz when rounded. Lastly, the apical post-alveolar ʔ (at the left of the bottom row) has the lowest frequency of all the unrounded sibilants, with its center at only a little above 2000 Hz. As may be seen from the examples in the bottom row, adding rounding causes the fricative energy to be contained in a narrower band.

Catford (ms in preparation) also has a similar description of the acoustic data, based on his analysis of a number of the Caucasian languages. The general pattern is one in which the lower cut-off frequency gets lower as the cavity in front of the constriction gets bigger. In the languages he examined, s generally had a higher cut-off frequency and a higher range than the other post-alveolars. Catford's data suggest that ʃ, which does not ocur in Ubykh and Abkhaz, differs from ʂ and ɕ by having a broader frequency range and perhaps by an intermediate cut-off frequency. Among the unrounded fricatives, ʃ has the lowest cut-off and the lowest range. The rounded sibilants have both lower cut-off frequencies, and considerably smaller ranges.

There may be sibilant fricatives in which the primary articulatory constriction is as far back as the palatal region. The descriptions are not completely clear, but what might be regarded as voiceless palatal sibilants may occur in Gununa-Kena (Gerzenstein 1968), and voiced palatal sibilants in Muinane (Walton and Walton 1967) and Cofan (Borman 1962). We neither have nor know of instrumental data on these languages. Although some palatal fricatives may, like the sibilants, have a high pitched sound, they are not obstacle fricatives and are therefore not what we would call sibilants.

In summary, the seven articulatory gestures for sibilants in table 5.1 will accommodate all the sibilants we have been discussing, but only with some difficulty. On some occasions we need to make clear whether we are describing apical or laminal sibilants, as shown in table 5.7. The first sound listed, s, is the same in both table 5.1 and table 5.7. Following Bright (1978), we regard the dental sibilant as being apical. In general, specification of the apical/laminal