Figure 8.4 Palatograms, linguograms and inferred sagittal view of the alveolo-palatal click in the word 'cut' rj!e?e 'cut' as spoken by two male Hadza speakers.

comparison with the !X66 clicks shown in figure 8.3, it is possible that the back closure does not extend as far forward in Hadza, meaning that the cavity enclosed may be larger. As in other languages, the front closure of these ! clicks in Hadza tends to be made at a less anterior place of articulation than the | click, and is typically more apical. This is certainly the case for speaker 1, but speaker 2 shows more similarity in his articulations for | and !. Our linguograms for speaker 2 show front closure contact on the tongue to be similar in length and location for both | and !, but the dental click differs in the shape of the area in the middle of the tongue which did not make contact with the roof of the mouth. In the dental click, this area is tapered toward the front, whereas ! displays a more rectangular shape for the corresponding area. Neither of these two Hadza speakers nor the three speakers of Sandawe for whom we have palatographic records have a sub-apical articulation.

We have noted, as have Sands (1991), Traill (1992) and Ladefoged and Traill (1994), that writers on clicks have described the ! click type in a large number of different ways. In the preceding paragraphs we noted that for some speakers in some languages this click may involve a laminal articulation, whereas for others it is apical or sub-apical. We suspect that the laminal articulation of ! can occur only in languages that do not have a contrasting palatal click ± of the type we will discuss below. Except for Traill's data on !X66, we do not have any data (cine-radiology or dynamic palatography) which show the place of articulation on the roof of the mouth at the moment of the release of the click. Considering all the varieties of ! clicks that have been observed, many of them being differences among individual speakers of the same language, we think it best to use the term alveolar to describe these clicks, noting, however, that it should not be interpreted too specifically. We should also note that in each of the languages we have investigated with a ! click, at least some speakers make this sound with an apical (or sub-apical) contact in the alveolar region. In the

Khoisan languages of Southern Africa it is always made in this way, and for these languages ! can be considered simply as an apical click.

The 4= click type shown in the fourth row of figure 8.2 has been called denti-alveolar (Beach 1938) or alveolar (Doke 1925, Kohler 1981). These descriptions seems to us to focus on the wrong aspect of the articulation, and we will refer to it as palatal. This, as table 8.1 shows, is a return to the term used by Bleek and Lloyd (1911) and other early writers such as Kronlein (1889). It is true that the tip and blade of the tongue are in contact with the teeth and alveolar ridge, but the forward edge of the click cavity is much further back; and this is the relevant factor. Traill's cine-radiology data also demonstrate how the location of the click cavity alters during the production of this click. Comparison of the left and right sides of figure 8.2 shows that the contact made by the blade of the tongue moved further back while the suction was being developed. This is a common but by no means invariable feature of this click type (see Traill 1985: 127). At the moment of the release of the click, there is no doubt that should be described as a palatal sound.

The other striking aspect of the f click type is the small size of the cavity between the two closures during the maximal occlusion. The short length of this cavity in the sagittal plane and its shallow depth can be seen in figure 8.2. Palatograms of five !X6o speakers in Traill (1985), which formed the basis for figure 8.5, as well as a palatogram of a Nama speaker in Beach (1938: 77) make clear that the cavity is also narrowed by extensive contact along the lateral margins. The cavity in this click type before expansion is thus the smallest of any type even being zero for speaker one. Because this cavity is so small a comparatively small movement of the tongue will create a sufficient volume change to produce the negative pressure required in a click.

The lateral click type in the last row of figure 8.2 is also somewhat varied in its place of articulation. The most significant aspect of this click type is, of course, the lateral release, which is usually made by moving one side of the tongue at the level of the molar teeth. There are no reports of a sublaminal version of this click, but the place may be dental, alveolar or post-alveolar. In the Southern African languages the central closure is usually apical alveolar, as

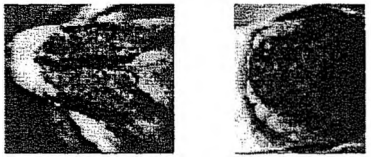

Figure 8.6 Palatogram and linguogram of a lateral click in the word g||a?a 'scavenge' as spoken by a male Hadza speaker (speaker 2 in Figure 8,3 above).

in figure 8.2, and the lateral click | | has a similar front closure just before release to that in the I click; but in Sandawe and Hadza the articulation is similar to that in the palatal lateral ejective cX', which these languages also have. Indeed, the lateral click in these two languages might well be regarded as a lateral version of the =)= click, rather than of the ! click. A palatogram and linguogram of a Hadza lateral click type are shown in figure 8.6. The extensive strictly laminal contact on the tongue is very apparent. Whether the articulation is apical or laminal, lateral clicks in all languages that have been studied have an affricated front release. It is perfectly possible to produce a non-affricated release (as in a sound used by many English speakers to signal approval or surprise), but this does not seem to be used in natural languages.

Apart from differences in the place of articulation and the apical/laminal parameter, the four lingual click types differ in the rate of movement of the front articulatory release. In all the languages that we have heard, the dental and lateral clicks are affricated, whereas the alveolar and palatal clicks are sharply released. In figure 8.2 it can be seen that the affricated click types are those which have a cavity before expansion that is relatively long in the sagittal plane.

We follow Traill (1985) in emphasizing that, for languages that have both alveolar and palatal clicks, the major articulatory distinctions among |, !, ty II are not in the place of articulation on the roof of the mouth, but in the part of

to these conclusions, Traill (1985) was discussing a particular language, !Xóõ, but his findings seem equally applicable to the other click languages that have |, !, ||, ±. Many of the descriptions of clicks in these languages are inadequate because they do not pay sufficient attention to the apical/laminal distinction. Note, however, that the apical/laminal distinction is independent of the affrication of the release.

8.2 Acoustic Properties of Click Types

In the past there have been few attempts to describe clicks from an acoustic perspective. The most important are Kagaya's (1978) study of Naron, and Sands' (1991) study of Xhosa. These authors have described the click types in terms of the general shape of the acoustic spectra of their releases and whether or not they are associated with noise (affricated). The account that follows is based on Ladefoged and Traill (1994). The most convenient way to introduce a discussion about the acoustic properties of clicks is to consider the differences in the waveforms, shown in figure 8.7. We will concentrate on the acoustic structure of the waveform that occurs at the release of the anterior closure. This waveform is determined by the place and manner of the click release, and by the cavity and walls of the vocal tract anterior to the posterior closure. The relevant acoustics of the release of the posterior closure will not be discussed here. They are similar to the releases that occur in other velar and uvular consonants.

There are obvious differences among the waveforms in their duration and noisiness. Click releases, like those of other stops, can be considered to have two acoustic components; a transient which occurs when the articulators come apart, and a noise associated with turbulent flow between the articulators. The transient is due to the rapid rate of change of vocal tract shape; it produces a wave that is like an impulse response of the vocal tract cavity at that time. The wave forms of the alveolar and palatal clicks (in the lower part of the figure 8.7) are dominated by the transient response; they are not accompanied by significant amounts of turbulent noise after the release. The bilabial, dental and

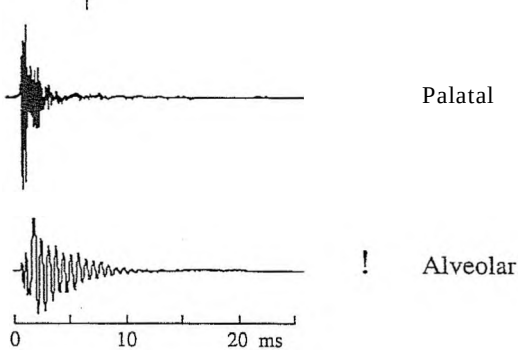

Figure 8.7 Waveforms of the noise bursts for the five 1X66 click types. The two waveforms in the lower part of the figure are dominated by the transient response, those in the upper part have considerable turbulent noise after the release.

lateral click releases (in the upper part of the figure) are longer and noisier. These differences correspond to the clear auditory differences between these two classes; the abruptly released clicks provide an intense but brief stimulation of the auditory nerve, whereas the noisy clicks provide a sharp onset followed by sustained stimulation. This makes the clicks !, more like the plain stops t, k whereas the noisy clicks O, |, | | are more like the affricates p^>, ts, kx. In the noisy clicks, the tongue (for the dental and lateral clicks) and the lips (for the bilabial click) move more slowly when the front closure is broken and the negative pressure is equalized. Hagman (1977) suggests in his Nama grammar that the affrication of dentals is due more to the fact that the release is made by pulling the tongue away from an irregular surface formed by the teeth, between which there may be gaps, so that the resulting aperture is created in a somewhat piecemeal fashion. This seems an interesting and plausible suggestion, and accounts for the fact that it is difficult to produce a non-affricated dental click, whereas it is much easier to produce non-affricated lateral and bilabial ones. In the abrupt (palatal and alveolar) clicks, the front of the tongue

Another acoustic feature of the abruptly released clicks ! and visible in the waveforms are the damped oscillations, initiated by the transient energy. The noisy clicks have a more random waveform. The waveform of the alveolar click has damped oscillations with a frequency of about 1200 Hz. The palatal click has less clearly visible damped oscillations, with a frequency over 3000 Hz, reflecting the fact that the cavity for the palatal click is smaller than that for the alveolar, as may be seen in figure 8.2.

The spectra of clicks can be divided into three classes, dependent on the general distribution of energy. The dental and palatal clicks have more energy above 2.5 kHz, and the alveolar and lateral clicks have more below it. The spectra of the bilabial click are partly reminiscent of those for the dental click, with a high frequency peak at 3700 Hz, but in addition there is a wide band of intense lower frequencies between about 900 and 1500 Hz. There are two regions of spectral energy because the bilabial click is the only click in which the initial transient and the following noise burst are in different regions.

Finally, in our consideration of the acoustics of clicks, we must emphasize the importance of their intensity. Clicks stand out from the sounds around them. This is partly due to their usually being preceded by silence or low level voicing, and often followed by a voiceless accompaniment. But it is more because many of the clicks contain a great deal of energy compared with the surrounding sounds. As the illustrations in the later part of this chapter will show, they often have a peak to peak voltage ratio that is more than twice that of the following vowel, meaning that they have at least 6 dB greater intensity. (It may be helpful to remember that if one sound is 5 dB greater than another, and has approximately the same frequency components, then it sounds about twice as loud as the other.) This is an important acoustic feature that distinguishes clicks from other consonants. The clicks |,!, || are nearly always more intense than the following vowel. Only the bilabial click normally has much less intensity than the following vowel; but it is, nevertheless, at least as intense as s, the strongest of the other voiceless consonants. As a class clicks are probably the most salient consonants found in a human language. They are easier to identify than non-click consonants, and are virtually never confused with non-click consonants (Ladefoged and Traill 1994). They thus form a robust and perceptually salient class.

There cannot be a click without an accompaniment of some kind, and our transcriptions of individual clicks, as opposed to click types, will always include a way of symbolizing this part of the sound. The posterior closure is usually in the velar region, so that most clicks include a velar plosive k or g or a velar nasal g as one of their attributes.

There are three types of variations in the accompaniments of clicks: (1) those associated with activities of the larynx; (2) those associated with the oro-nasal process; and (3) those associated with the place and manner of release of the back closure. Nguni languages such as Zulu and Xhosa use only the first two of these possibilities. The Khoisan languages use all three. We will begin a more detailed study of click accompaniments by considering data from Xhosa, in which there are five different accompaniments for each click. These clicks may be accompanied by a voiceless, or an aspirated, or what we will call a breathy voiced velar plosive k, k^h, g; in addition there may be a voiced velar nasal g, or a breathy voiced velar nasal g. Xhosa clicks have one of three possible anterior releases, dental, alveolar or lateral. Accordingly this language has 15 contrasting clicks as shown in table 8.2.

We can see a number of points about these different accompaniments by considering the waveforms for the alveolar clicks, which are shown in figure 8.8. The voiceless click in the top row has a small amount of aspiration; but it is clearly distinct from the aspirated click in the second row, which has a voice

Table S.2 Words illustrating contrasting clicks in Xhosa

	DENTAL	ALVEOLAR	LATERAL
VOICELESS	ukuk|ola 'to grind fine'	ukuk!o6a 'to break stones'	uk||olo 'peace'
ASPIRATED	ukuk|^{h}61a 'to pick up'	ukuk!^{h}ola 'perfume'	ukuk||^{h}o6a 'to arm oneself'
BREATHY VOICED	ukug|66a 'to be joyful'	ukug'oba 'to scoop'	ukug||oba 'to stir up mud'
VOICED NASAL	ukug|oma 'to admire'	ukuglola 'to climb up'	ukug||i6a 'to put on clothes'
BREATHY VOICED NASAL	ukug|ola 'to be dirty'	ukuglala 'to go straight'	ukug||og||a 'to lie on back knees up'

velar nasal, as do the clicks in the fifth row. The clicks in these two rows are distinguished by the fact that the breathy voiced nasal in the fifth row is a depressor consonant, lowering the tone. Unlike the situation in the case of the accompanying velar stop in the third row, in this case there is sufficient transglottal pressure difference to keep the vocal folds vibrating throughout the click and the following vowel. The breathy voice vibrations are evident in the waveform, which also has a lower fundamental frequency. Again the breathiness is not as strong as it is in the breathy voiced nasals in, for example, Marathi.

There are additional click accompaniments in the Khoisan languages. Nama has clicks accompanied by a glottal stop and clicks with a voiceless nasal accompaniment, which will be discussed below. As it also has three of the possibilities mentioned so far - the nasal, voiceless unaspirated and aspirated accompaniments - there are five different forms of each of the anterior releases. Nama has four types of anterior release (the three in Xhosa and a palatal type), so that there are 20 distinct clicks as shown in table 8.3. Ladefoged and Traill (1984) have given a full account of these Nama clicks.

The clicks in the first, second and fourth rows have similar accompaniments to those in Xhosa, except that, in some dialects of Nama, the aspirated release may be accompanied by velar friction. The third row contains clicks with accompanying voiceless nasal airflow. This property has been discussed elsewhere (Ladefoged and Traill 1984) under the label delayed aspiration. When a vowel precedes clicks with this accompaniment that vowel is nasalized or a short transitional nasal segment is heard (Beach 1938 : 86-7), but in utterance-initial position these clicks are difficult to distinguish from the aspirated (velar affricated) clicks in the second row. The voicing delay (VOT) is very similar. The auditory distinction that is most noticeable is that the aspirated clicks have a very obvious velar release - it is clear that they are accompanied by k^h or even k^x - whereas the velar release is virtually inaudible when there is a voiceless nasal accompaniment. This is because there is no build up of pressure behind the velar closure in these clicks.

The aerodynamic records in figure 8.9 (taken from the same series as that reported in Ladefoged and Traill 1984) show how the contrast is produced for

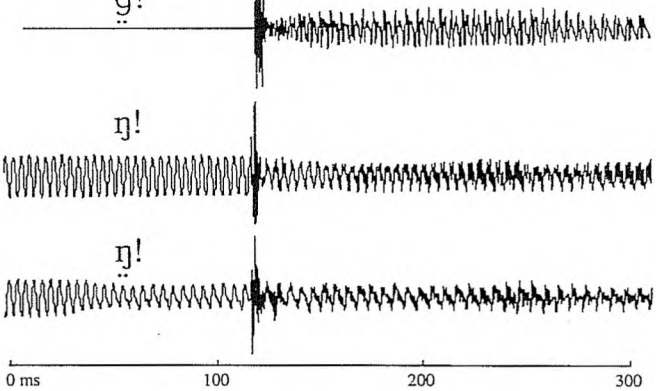

Figure S.8 Waveforms illustrating the five click accompaniments in Xhosa with alveolar clicks.

the words k|^{h}o 'play music' and y|^{h}o 'push into', spoken as citation forms. For the aspirated click (which was, in this case, slightly affricated) on the left of the figure, pressure is built up behind the velar closure during the formation of the click. Then the anterior click release and the velar release occur at almost the same moment (as is the case for most clicks, other than those with a nasal accompaniment, and special cases to be discussed later). There is a rapid flow of air out of the mouth, which falls as the vowel begins. In the click with delayed aspiration on the right of the figure, very little pressure is built up behind the velar closure. This is because, as can be seen in the nasal airflow record, there is voiceless nasal airflow starting just before the click release. When the velar closure is released there is a comparatively small oral airflow, which increases slowly as the nasal airflow diminishes. The clicks in the third row of table 8.3 do not have an audible velar release, because the pressure that might have been built up behind the velar closure has been vented through the nose. Instead of having an aspirated velar stop k^{h} as an accompaniment (as is the case of the clicks in the second row of table 8.2) the clicks in the third row are

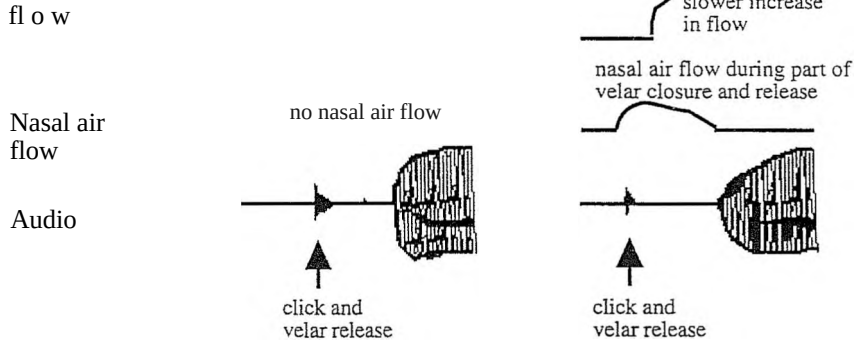

Figure S.9 Aerodynamic records (retouched) illustrating the difference between the aspirated (velar affricated) and voiceless aspirated nasalized (delayed aspirated) clicks in the Nama words k|ʰo 'play music' and rj|ʰo 'push into', pronounced as citation forms. Only the beginning of each word is shown.

Table 8.3 Words illustrating contrasting clicks in Nama. All these words have a high tone

	DENTAL	ALVEOLAR	PALATAL	LATERAL
VOICELESS **UNASPIRATED**	k|oa 'put into'	kloas 'hollow'	kfais 'calling'	k||aros 'writing'
VOICELESS **ASPIRATED**	k|ʰo 'play music'	k!ʰoas -belt'	kfʰaris 'small one'	k||ʰaos 'strike'
VOICELESS **NASAL**	g|ʰo 'push into'	g!ʰas 'narrating'	rjfʰais 'baboon's arse'	rj||ʰaos 'special cooking place'
VOICED **NASAL**	0l° 'measure'	rjloras 'pluck maize'	Ufais 'turtledove'	i)||aes 'pointing'
GLOTTAL **CLOSURE**	k|ˀoa 'sound'	k!ˀoas 'meeting'	k||ˀais 'gold'	k||ˀaos 'reject a present'