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CLICKS IN EAST AFRICAN LANGUAGES

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1. INTRODUCTION

The languages of Southern Africa, in both the Khoisan and Bantu families, are strikingly marked by the presence of click sounds. Among J.A. Louw's seminal contributions to African linguistics are his studies of the processes by which sounds of this type have been adapted from their Khoisan origins and incorporated into the phonology of the Nguni languages. In only one other part of the world can clicks be found as part of the regular phonological system of languages, and this is in East Africa. Here there are three languages with clicks: Dahalo, Hadza and Sandawe. Their locations are indicated on the map in figure 1. The three authors of this article conducted field studies of the phonetics of these languages in Kenya and Tanzania in 1991, making the clicks a focus of special attention. No general discussion of the click sounds in these languages has been published since the survey provided by Tucker, Bryan and Woodburn (1977). We are pleased to offer our own report as an affectionate and respectful tribute to Professor Louw.

In this article we will make the standard distinction between click type and click accompaniment. The click type describes the place of articulation and release of the front closure of the click, and the click accompaniment describes the remaining properties of its articulation, such as the place and manner of release of the back closure, the accompanying laryngeal actions, and the position of the velum, determining whether the nasal passage is open or closed. These terms are equivalent to the terms 'influx' and 'efflux' used by Beach (1938). A given click consonant is transcribed with one symbol representing the click type, and with one or more other symbols and diacritics representing the accompaniment.

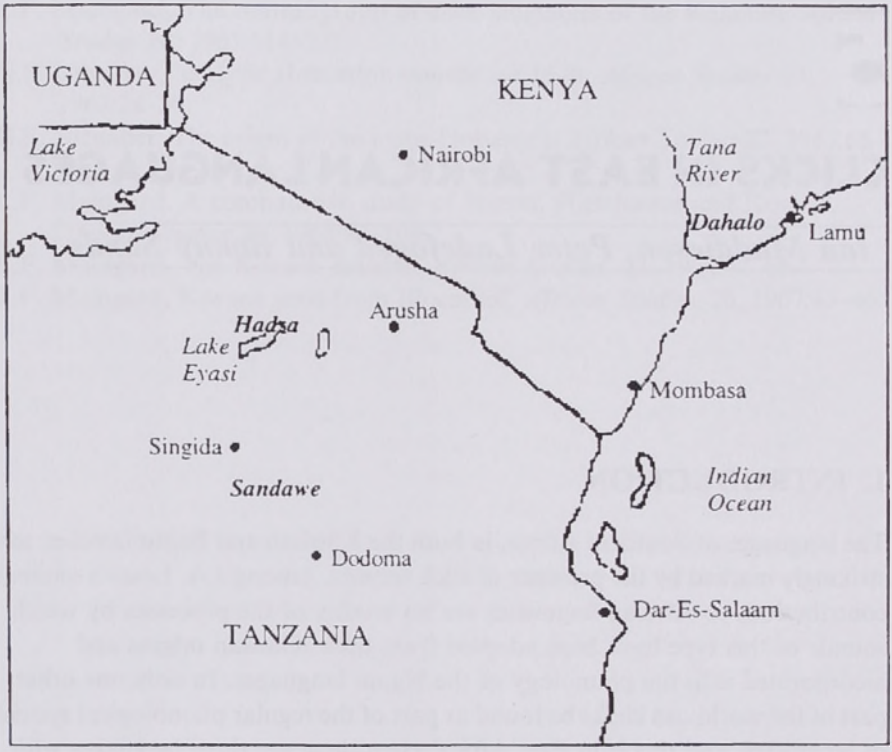

Figure 1: Map showing approximate locations of the Dahalo, Hadza, and Sandawe languages.

The East African click languages use from one to three click types, and from two to five click accompaniments. They confirm some of the typological patterns established on the basis of the Southern African languages, but also contain some surprises, such as the predominance of accompaniments which involve nasalization, and the common occurrence of (post-)alveolar clicks produced with an audible 'tongue slap' against the floor of the mouth. More extended discussion of phonetic aspects of these languages can be found in Maddieson, Spajic, Sands and Ladefoged (1993) for Dahalo, Sands, Maddieson and Ladefoged (1996) for Hadza, and Wright, Maddieson, Sands and Ladefoged (1995) for Sandawe.

2. DAHALO

Dahalo [ɗahaːlo], the most northerly language with clicks, is a Cushitic

language spoken by a small population living on the northern coast of Kenya between Lamu and the mouth of the Tana river. Cushitic is one of the branches of the large Afro-Asiatic family of languages, and is usually subdivided into Central, Eastern and Southern sub-branches. Greenberg (1963) placed Dahalo in the Southern Cushitic group, whose other members are all found in Tanzania. This affiliation is widely accepted (e.g. by Elderkin 1978, Ehret 1980, Nurse 1986), but is questioned by Tosco (1991), who prefers to see Dahalo as a divergent Eastern Cushitic language. But all linguists agree that Dahalo is Cushitic.

Dahalo thus has the distinction of being the only language with clicks that is known not to be Khoisan or Bantu. In addition to an extensive consonant inventory inherited from Cushitic it has a number of phonological characteristics borrowed from languages with which it has been in contact, including members of the Bantu group and Eastern Cushitic languages such as Aweera (Boni). Although there are no nearby languages with clicks, it is assumed that the clicks are also borrowed sounds, taken from a language of which all other trace has now gone. Nothing in the Cushitic inheritance of Dahalo can account for their occurrence.

Dahalo speakers live widely dispersed among populations speaking other languages, such as Swahili, Lower Pokomo and Aweera. Nurse (1986) estimated the number of remaining Dahalo speakers to be under 500, while Tosco (1991) thinks that "the figure of 400 cannot greatly exceed the truth" (p. xi). The estimate of 3 000 speakers cited in Grimes (1992) is wildly excessive. It is likely that the number of competent Dahalo speakers is still declining, as it was a very difficult task to find even six speakers to record for our study, and we did not observe any children acquiring Dahalo; instead Swahili seemed to be the most commonly used language among the younger Dahalo.

The most complete description of Dahalo is the 'Grammatical Sketch' by Tosco (1991). Elderkin (1974) had earlier discussed the phonology and morphology of the language. Analysis and comparison of the lexicon is a major focus of Ehret (1980) and Nurse (1986). Ehret, Elderkin and Nurse (1989) published all the known lexical items of Dahalo.

Dahalo is rich in stop consonants and uses the full range of the usual linguistically employed airstream processes in their production, namely pulmonic egressive (plosives), glottalic egressive (ejectives), glottalic ingressive (implosives) and velaric ingressive (clicks). It has nine types of stops in total: plain voiceless, plain voiced, prenasalized voiced, prenasalized voiceless, voiced implosive, voiceless ejective, prenasalized voiceless ejective, and voiced and voiceless nasalized clicks. These facts place Dahalo in a very rare class of

languages. It is the only language we know of that uses such a wide range of types of stop distinctively.

2.1 Dahalo clicks

In Dahalo, clicks occur in a relatively small number of words – many fewer than in Hadza and Sandawe – but a good proportion of these words would be regarded as belonging to the basic vocabulary with meanings like "saliva", "excrement", "forest", "breast", "star". We elicited as many words as possible containing clicks, but could only obtain 40. These include one, /ŋ̊|át'u/ "constipation", that had not been reported previously in the literature. The glossary in Tosco (1991) lists only 26 words with clicks; Ehret, Elderkin and Nurse (1989) list 58 (19 of which we were unable to elicit).

Dahalo has only one click type, which we transcribe as dental, [|]. A palatogram of the word /ŋ̊|aba/ "good smell" is shown in figure 2. The area covered by the black marking medium indicates where the articulators made contact during the articulation. A sagittal view of the articulation, inferred from the contact pattern and the known shape of the speaker's palate (taken

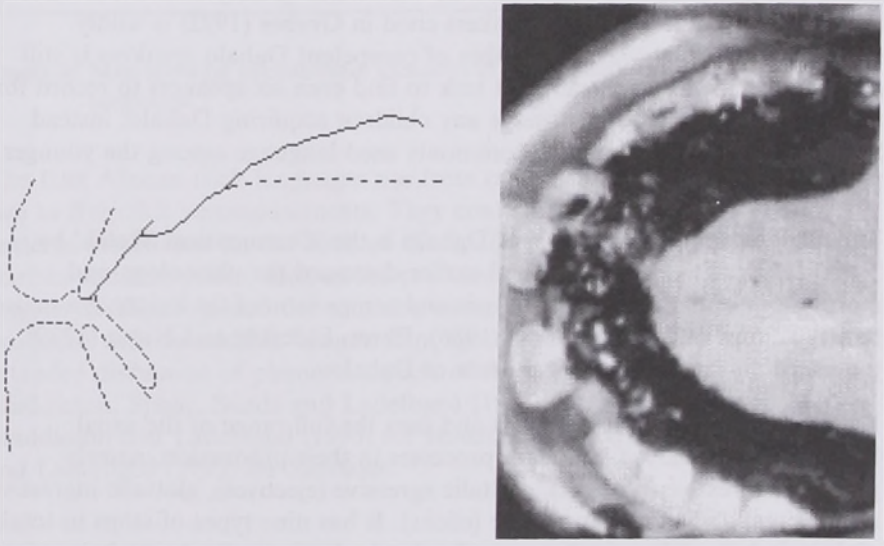

Figure 2: Palatogram and inferred sagittal section for the click in the Dahalo word /ŋ̊|**aba**/ "good smell".

from a cast of his mouth) is drawn above the palatogram. (The palatographic investigation was conducted using the technique described in more detail in Ladefoged (1997) It is interesting to note that the articulation is somewhat intermediate between those seen for the contrasting dental and alveolar plosives of Dahalo. The contact area is broader in the click than we observed for the alveolar plosive, but much less extensive than in the dental plosive. Another noteworthy aspect of the palatogram is the absence of any indication of the contact for the back closure of the click. Clearly this contact must be quite far back on the roof of the mouth and/or quite short in the midsaggital plane. A relatively large pocket of air remains between the two closures during the most constricted phase in the production of this click. This seems to differ from the production of corresponding clicks in languages spoken in Southern Africa, such as !Xóõ (Traill 1985) and Zulu (Doke 1923, 1925, Beach 1938). In these other languages the back closure extends further forward, so that the contact of the back of the tongue reaches about the position of the second or third molars, and its forward edge is visible on palatograms.

In Dahalo clicks the accompaniment is always a nasalized one, but may be voiced or voiceless, with the voiceless option occurring much more frequently. Time-aligned waveforms and spectrograms illustrating the voicing difference in the nasal accompaniments to the clicks are shown in figures 3 and 4. In the example in figure 3, /ŋ̊ǀaba/"forest", the voiced nasal starts substantially before the click burst and continues to be held for a short interval after the click release occurs, while in /ŋ̊ǀabate/ "good smell(ing)" in figure 4 a delay of about 30 ms occurs between the click burst and the onset of voicing. Voiceless nasalization can be auditorily detected principally through its coarticulatory effect on adjoining vowels, which display a brief nasal on- or off-glide or receive light nasalization. The nasalization is always present with the click, rather than being present only "wherever a vowel immediately precedes", as suggested by Elderkin (1992:112). In this token of /ŋ̊ǀabate/ it is possible to see in the waveform that at the onset to the vowel following the click there is a short voiced consonantal nasal portion before the back velar contact is broken.

It should be noted that considerable fluctuation was observed in the voicing of the voiced nasalized click accompaniment. Although certain words, such as /ŋǀaba/ "forest", were almost invariably pronounced with voicing, others, such as /ŋǀuʔite/ "bitter" varied even for the same speaker. Furthermore, many tokens were recorded in which voice onset and click release are almost simultaneous; it was difficult to classify these as either clearly voiced or voiceless. The speakers recorded at Kipini showed greater variation than those recorded at Witu. Since these speakers were younger, it is possible that the voicing distinction in words with clicks is in the process of being lost in favour of uniform voicelessness.

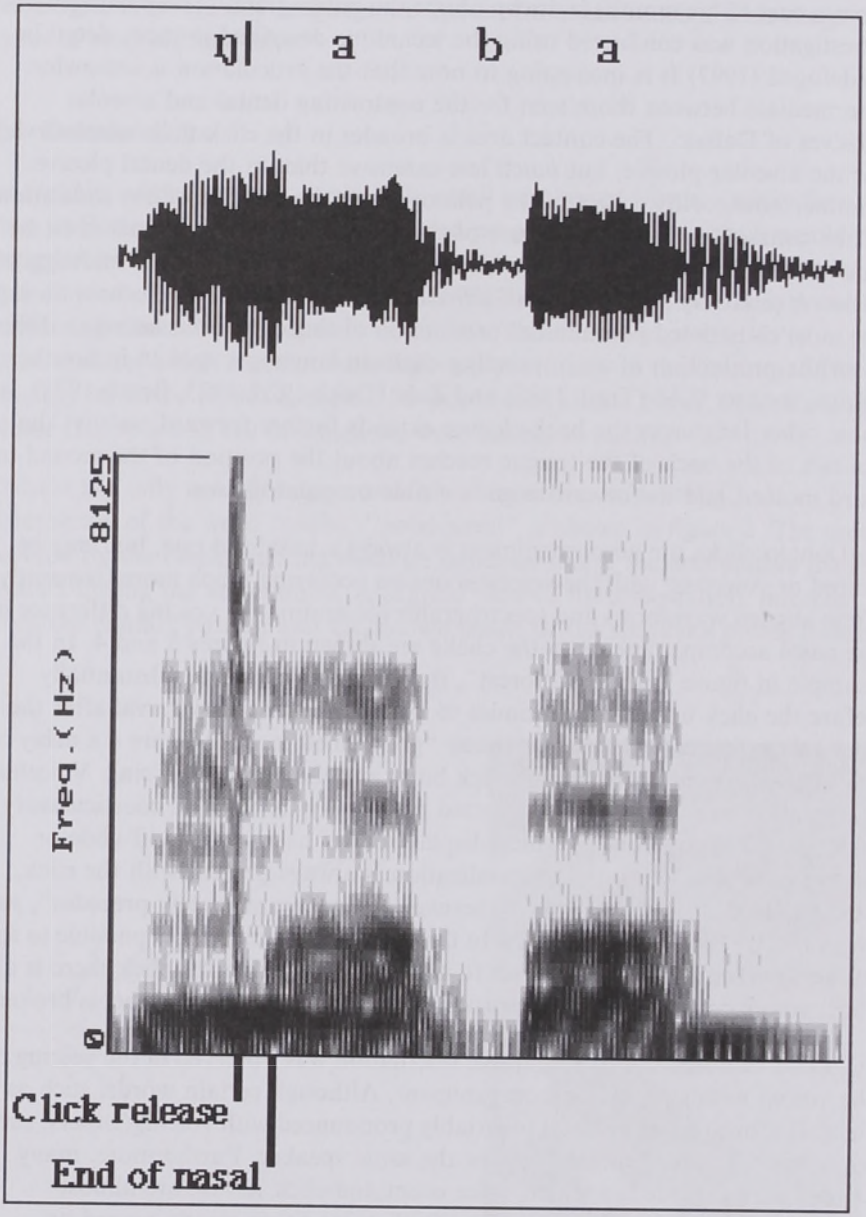

Figure 3: Spectrogram and waveform of a click with voiced nasalized accompaniment in the Dahalo word /ŋ̥|**aba**/ "forest"

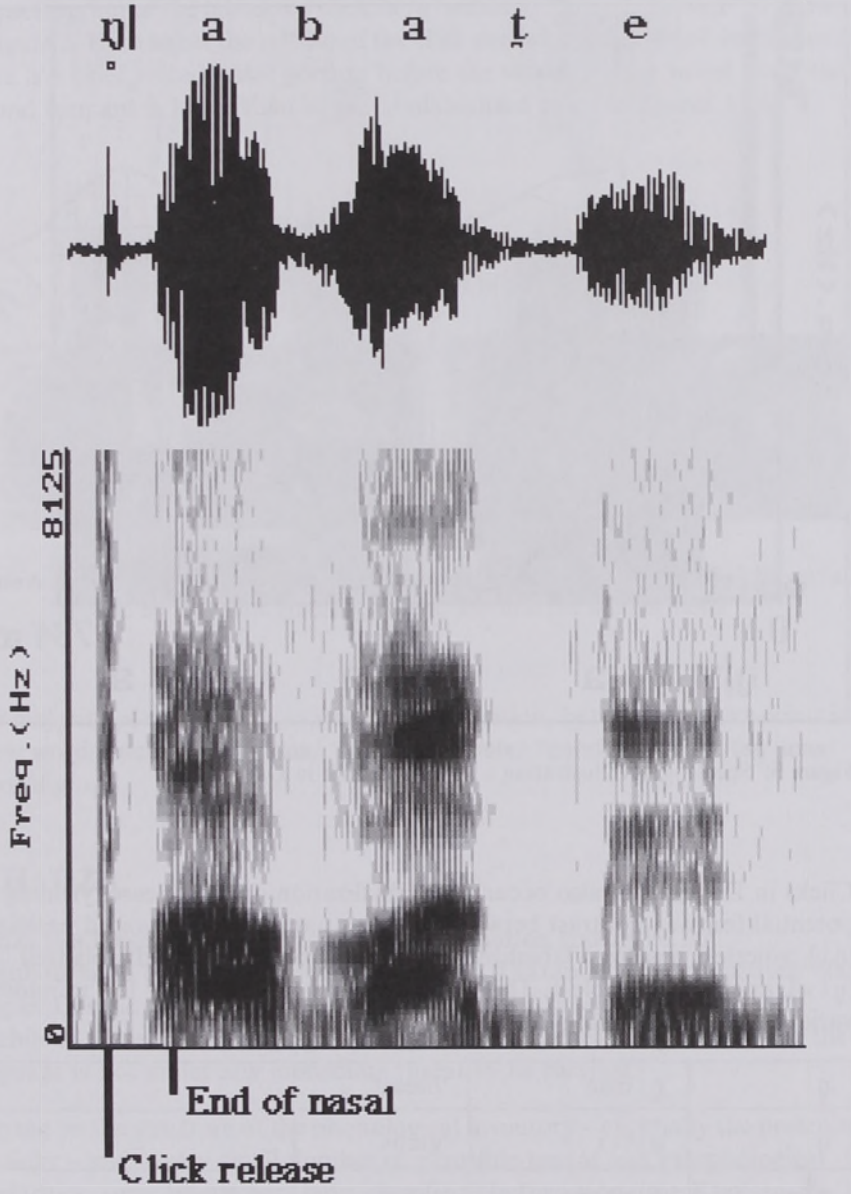

Figure 4: Spectrogram and waveform of a click with voiceless nasalized accompaniment in the Dahalo word /ŋ̊|**abate**/ "good smell(ing)"

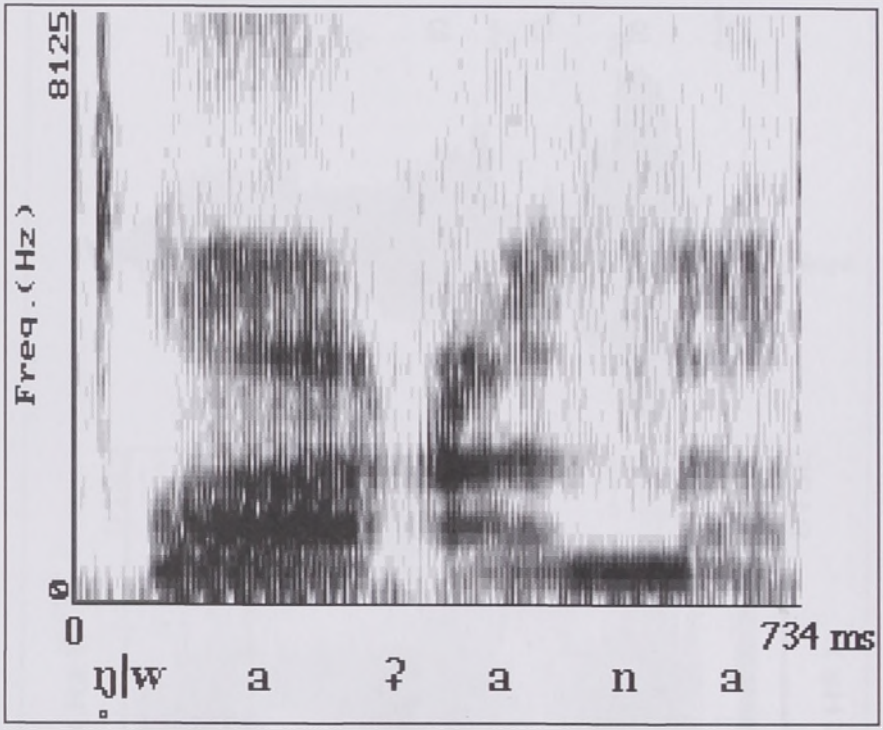

Figure 5: Spectrogram illustrating a labialized click in Dahalo

Clicks in Dahalo can also occur with labialization on the release, yielding a potential fourway contrast between voiceless nasalized [ŋ̊|], voiced nasalized [ŋ|], voiceless nasalized labialized [ŋ̊|w], and voiced nasalized labialized [ŋ|w], as shown in table 1. The labialized cases are extremely few in number; variability in maintaining labialization was also noted.

ŋ̊|	ŋ̊| óːne	'breast'	
ŋ	ŋ| iːtʼi	'gums'	
ŋ̊|w	ŋ̊| waɲi ŋ̊| wáːʔana	'saliva'	in Kipini in Witu
ŋ|w			no examples in our data

Table 1: Words illustrating clicks in Dahalo

A spectrogram of the labialized click in /ŋ͡ǀwaːana/ "knead massage" is shown in figure 5. Here again the release of the click precedes the onset of voicing and there is a brief voiced nasal portion before the vowel. At the vowel onset the second formant is lower than in the nonlabialized cases in figures 3 and 4.

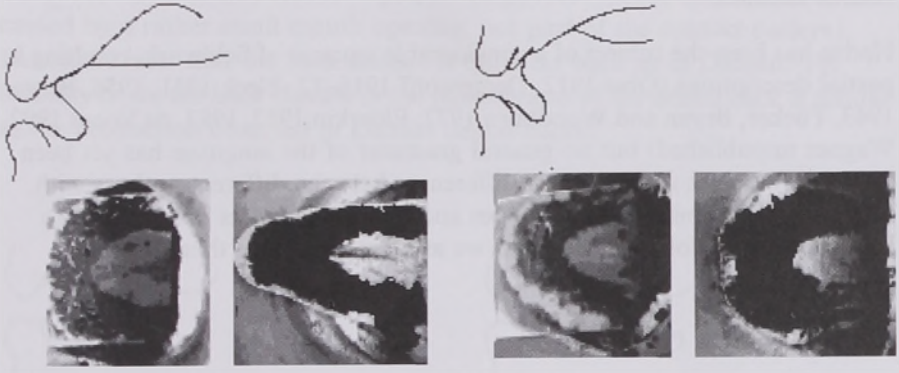

Figure 6: Palatograms and linguograms of a dental click in the word [ŋ͡ǀ**aha**] 'forget' as spoken by two male Hadza speakers, and inferred sagittal views

The majority of clicks occur in word initial position, but medial clicks occur in a few words such as /**Haŋ͡ǀana**/ "lick", /**meŋ͡ǀete**/ "carefully" and /**fuŋ͡ǀinna**/ "root/dig/up".

3. HADZA

Hadza is a language of uncertain genetic affiliation spoken in the neighbourhood of Lake Eyasi in north-central Tanzania by approximately 800 people. Despite the small number of speakers and the strong influence of Swahili as the national language, young children are learning Hadza and the language is not under any immediate threat to its survival.

Relying on the structure of the phonological inventory – especially the presence of clicks – and a very small number of plausible lexical and morphological similarities, some researchers have classified Hadza among the Khoisan languages (Bleek 1931, Greenberg 1963, Ehret 1986). Others maintain that it is a language isolate (Woodburn 1962, Elderkin 1983) or that it cannot be classified on the basis of present knowledge (Sands, to appear 1998). There is no evidence that clicks are a borrowed feature of the phonology of Hadza; neither the language-internal distribution of the clicks nor the ability to

identify their source in external loans points in this direction. Despite the relative geographic proximity of Hadza and Sandawe there are very few similarities in their vocabularies to suggest either a genetic relationship between these two languages or close contact in the past. Neither is there any good evidence that Hadza belongs in the Niger-Congo, Nilo-Saharan or Afro-Asiatic families.

Hadza has been the subject of a considerable amount of fieldwork, resulting in partial descriptions (Obst 1912, Dempwolff 1916–17, Bleek 1931, 1956, Berger 1943, Tucker, Bryan and Woodburn 1977, Elderkin 1982, 1983, de Voogt 1992, Wagner unpublished) but no general grammar of the language has yet been written. There are some notable differences between different authors with respect to the numbers of click types and accompaniments posited for the language. In the following sections we attempt to resolve these conflicts.

3.1 Hadza click types

Hadza has three click types, dental, lateral and alveolar. Some earlier descriptions reported a larger number of types. Bleek (1956, but based on fieldwork conducted in the late 1920s and early 1930s) transcribed a fourth click type with the symbol [ǂ]. In Nama and other Southern African Khoisan languages the click transcribed with this symbol has a more forward point of release and usually greater affrication than [!] (Ladefoged & Traill 1994, Ladefoged & Maddieson 1966). Greenberg (1963) followed Bleek in reporting four click types in Hadza. All the words which Bleek transcribed with the [ǂ] click have been been transcribed by us or Sands (1992 ms) as containing other sounds, such as [!], [ǁ], and [kˈ]. The recognition of a [ǂ] click type therefore appears to be due to errors of transcription; it is unlikely that it has disappeared through a set of diverse linguistic changes occurring over the sixty years separating Bleek's and our fieldwork.

Tucker, Bryan and Woodburn (1977) in addition transcribe a bilabial click and a "flapped" version of the [!] click, which they transcribed [!!]. The two words they give as examples of the bilabial click are in greetings; they also indicate that these words may be produced with a dental click. Our consultants had aspirated bilabial stops in these words. Neither a bilabial nor a dental click was considered an acceptable substitute for the pulmonic stop. We will consider later the occurrence of a flapped version of the [!] click.

The articulation of the dental clicks [ǀ] is illustrated in figure 6, which shows palatograms and linguograms of the front articulation in a dental click, as produced by two speakers. This can be described as having a laminal coronal articulation with a closure extending from the upper teeth to the alveolar ridge.

A sagittal view of the maximum area of the front contact for each speaker, inferred from the information in the palatograms and linguograms and casts of the speakers' palates, is shown above the palatograms. The location of the back closure of the click cannot be seen on these palatograms and linguograms (the dark areas toward the back, i.e. right, of the pictures for speaker 2 are shadows caused by a rather small mouth opening, not part of the contact pattern). Hence, we infer that the back closure is quite far back as in Dahalo. The inability to see the back closure in the palatograms of the dental click is similar to the production observed in Dahalo dental clicks.

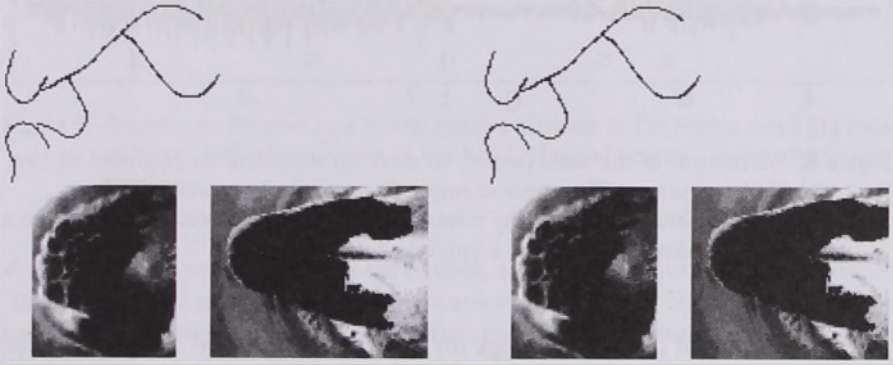

Figure 7: Palatograms, linguograms and inferred sagittal view of the alveolar click in the word [ŋ!eʔe] 'to cut' as spoken by two male Hadza speakers

Palatograms, linguograms and inferred sagittal sections of the front articulation of the [!] click type are shown in figure 7. We describe this click type as alveolar since the front closure of these clicks is made at a less anterior place of articulation than the [|] type; it might even be labelled post-alveolar. It is typically also more apical. This is certainly the case for speaker 2, who shows a contact area on the tongue for [!] that is approximately half the size of that for [|]. Speaker 1 shows more similarity in his articulations for [!] and [|]. The linguograms for speaker 1 show front closure contact on the tongue to be similar in length and location for both [!] and [|], but these clicks differ 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 clicks, this area is tapered toward the front, whereas the alveolar click displays a more rectangular shape for the corresponding area. These linguograms and palatograms suggest that, at the midline, the tongue behind the contact is more sharply lowered for the alveolar than for the dental click.

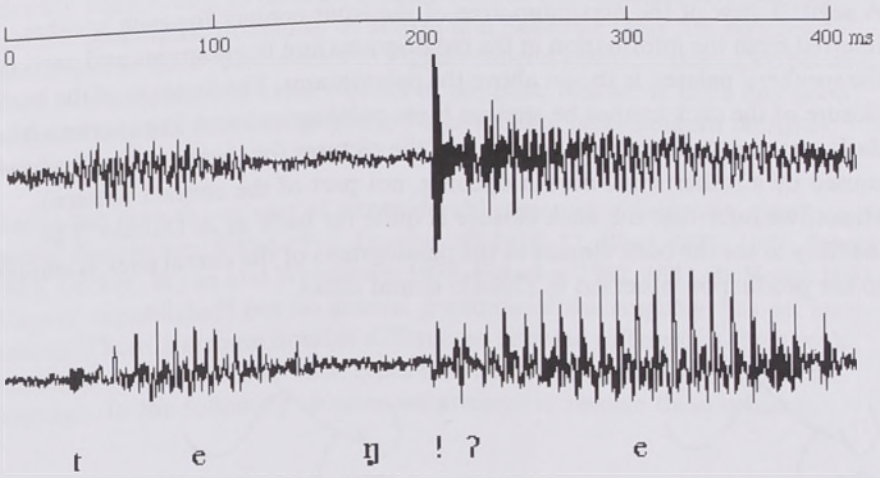

Figure 8: Waveforms of the word [**teŋ!'e**] 'to carry on shoulders' as produced by two Hadza speakers. The upper example (from a female speaker) shows a high-amplitude burst for the release of this click; the lower example (from a male speaker) shows a low-amplitude burst

The palatogram of the alveolar click for speaker 1 shows that contact was also made against the back of the front teeth, yet this contact does not extend to the base of these teeth at the gumline. The blackened area on the front teeth must be the result of a separate and lighter contact than the principal one in the alveolar region, otherwise we would expect a continuous contact area extending over the dental and alveolar regions. The contact pattern does not indicate a broad laminal denti-alveolar articulation, but is more likely to be the result of the tip of the tongue quickly flipping against the teeth after the front contact closure is released.

The alveolar click [!] in Hadza was observed to vary a great deal in terms of how forcefully it was produced by speakers. In some instances the amplitude of the click release was very low, as if the click were produced with very little suction. This differs from the production of the similarly transcribed click in Xhosa and Zulu or Southern African Khoisan languages such as !Xóõ and !Xũ, which is typically very loud and salient (Traill 1994, Snyman 1978). Waveforms illustrating strong and weak productions of this click are shown in figure 8. In the high-amplitude production of this click at the top of the figure the burst is much louder than the surrounding vowels; in low-amplitude productions, the burst can have less energy than the surrounding vowels, as in the token illustrated in the lower part of the figure.

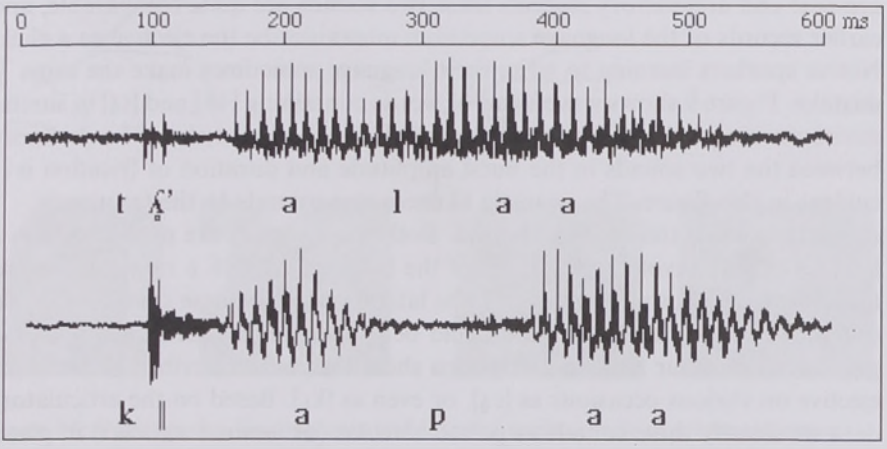

Figure 9: Waveforms illustrating a lateral ejective affricate in the Hadza word [[**tʎ̊'ala-a**] 'dove' and a lateral click in the word [**kǁapa-a**] 'stump', spoken by female speakers

A notable allophonic variant of the [!] click was observed at times from most of the Hadza speakers we heard. In this variant, the normal click release is quite quiet but the tongue tip makes a forceful contact with the bottom of the mouth after the release of the front click closure. The release of the front click closure and the contact with the bottom of the mouth is one continuous, ballistic movement, with the underside of the tip of the tongue making a percussive sound as it strikes the floor of the mouth. This version of the [!] click is thus similar to the sound sometimes made by speakers of non-click languages trying to imitate the sound made by the shoes of a trotting horse. This is presumably the articulation which Tucker, Bryan and Woodburn (1977) characterized as a flapped palato-alveolar click. It is quite clearly a free variant of the unflapped [!] and not a separate phoneme. The only parallel variant reported from any of the Southern African languages with clicks concerns an individual !Xũ speaker, noted as atypical, who used what Doke (1925) called a palato-alveolar flapped click. The tongue front was "flapped smartly to the floor of the mouth, the under-side making a resounding 'smack' behind the lower front teeth and on the floor of the mouth" (Doke 1925: 163). No comparable allophonic variation is noted by current researchers on Southern African languages with clicks (Traill, personal communication), but this kind of production of [!] is quite frequent in Sandawe, and will be discussed further below. A suggested phonetic notation for this variant is [¡].

The third type of click found in Hadza is the lateral click [ǁ] This is especially interesting because of its similarity to the lateral ejective affricate. In many

acoustic and articulatory respects these two sounds are quite comparable, and earlier records of the language sometimes mistranscribe the ejective as a click. Native speakers learning to write their language sometimes make the same mistake. Figure 9 shows waveforms of words containing [kǁ] and [tʂ] in similar environments produced by one of the female speakers recorded. The similarity between the two sounds in the burst amplitude and duration of frication is evident in this figure. The acoustic likeness also extends to the frequency characteristics of the frication period. Both these sounds are produced with a laminal closure involving the front of the tongue and with a ring-like closure along the sides. For many speakers, the lateral release in these sounds occurred quite far back in the mouth, and could be properly characterized as a lateral palatal release. Our field transcriptions show that we transcribed the lateral ejective on various occasions as [cʂ], or even as [kʟ]. Based on the articulatory data we classify these sounds as palato-alveolar (or laminal alveolar) in place. Figure 10 shows palatograms and linguograms of the lateral click for the two speakers, and figure 11 those for the lateral ejective. The absence of any of the marking medium from the tongue tip in the linguograms for speaker 1 shows very clearly that both laterals were made with the tip of the tongue down. The laminal contact is on the teeth and alveolar ridge for the click, but only on the alveolar ridge for the ejective. Unfortunately this speaker did not open his mouth sufficiently when the photograph was taken, and his upper teeth prevent us from seeing the backward extent of the contact in the ejective. For speaker 2, the tongue tip also appears to be down during both laterals. Contact occurred from the bottom of the top front teeth to the back edge of the alveolar ridge, and appears quite similar in position and extent for both sounds.

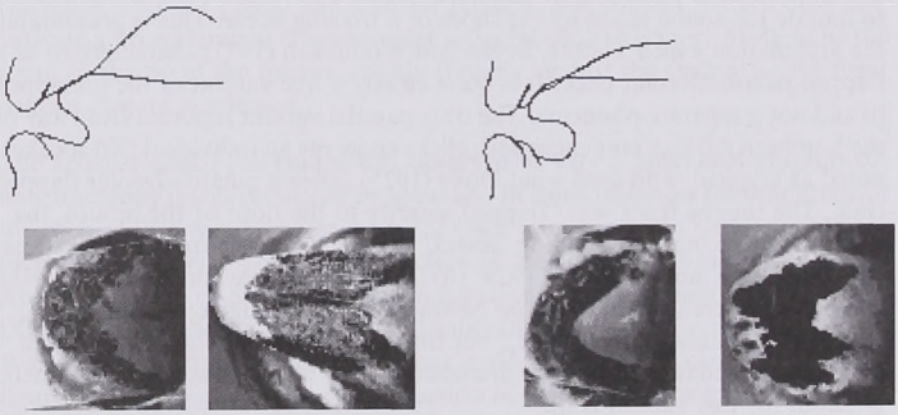

Figure 10: Palatograms, linguograms and inferred sagittal view of a lateral click in the word [ŋǁʔa] 'to scavenge' as spoken by two male Hadza speakers

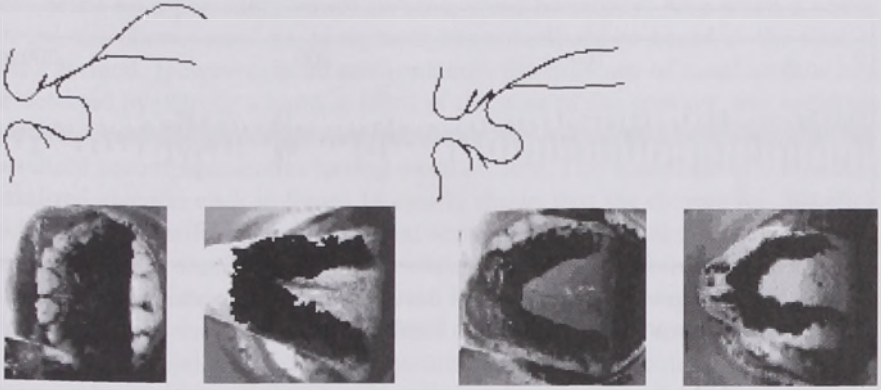

Figure 11: Palatograms, linguograms and inferred sagittal view of a lateral ejective affricate in the word 'bone' [**mitt$\mathfrak{z}$'a**] as spoken by two male Hadza speakers. The inferred position of the tongue is uncertain for speaker 1 as the mouth was not open sufficiently and the extent of contact cannot be seen

3.2 Hadza click accompaniments

In Hadza, each of the three types of clicks, [ǀ,ǁ,!], can have three different accompaniments. There are no plain (i.e. non-nasalized) voiced clicks, and aspiration plays no role in distinguishing between clicks. The first possibility can be regarded as an accompanying voiceless velar stop [k], giving [kǀ,kǁ,k!]. A waveform of a word in Hadza containing an intervocalic dental click with this accompaniment is shown in figure 12. The same accompaniment is also illustrated in figure 9 above. There is a short delay before voicing begins after the click release; we measured the mean VOT as 45.9 ms for 182 tokens of /k!/.

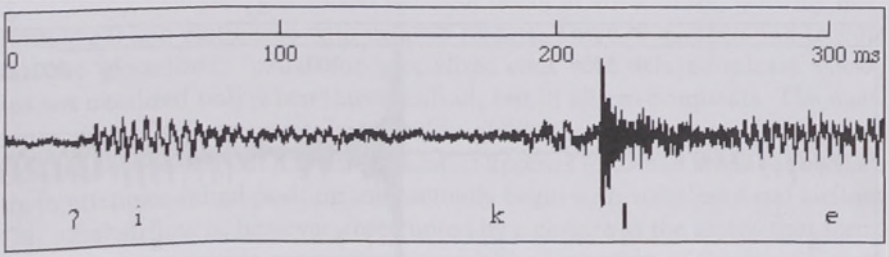

Figure 12: Waveform of a voiceless lateral click in intervocalic position in the Hadza word [**ʔikǁe-ʔe**] 'to close'.

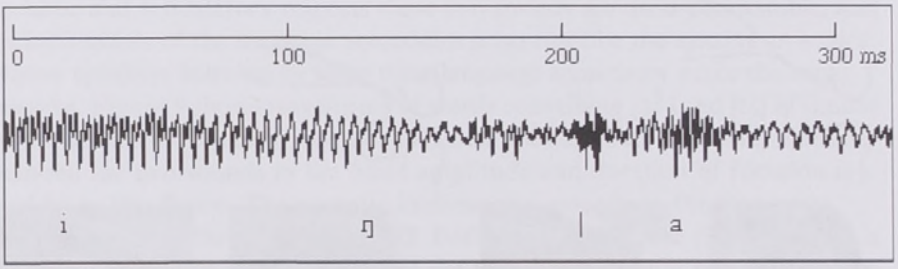

Figure 13: Waveform of voiced nasalized dental click in intervocalic position in the Hadza word [**k|ikiliŋ|a**] 'little finger'

The other two accompaniments involve nasalization of the click. The second possibility is an accompanying voiced velar nasal [ŋ|,ŋ‖,ŋ!]. Voicing continues throughout the production of clicks with this accompaniment, as shown in the waveform of a dental click in figure 13. Some anticipatory nasalization of a preceding vowel occurs before clicks with this accompaniment.

The third accompaniment is more complex; it is both nasalized and glottalized. This voiceless nasal accompaniment is transcribed with [ŋ̊] before and [ʔ] after the click symbol (ŋ̊|ʔ,ŋ̊‖ʔ,ŋ̊!ʔ), although it should be kept in mind that the devoicing is achieved not by opening the vocal folds but by glottalization. The glottalization takes the form of a glottal stop which is formed during the click closure, and released well after the release of the front closure of the click, so that there is a delay before the onset of voicing. We measured the mean VOT as 51.0 ms (s.d. 18.6) for 220 tokens of /ŋ̊!ʔ/. The nasalized nature of this accompaniment can be hard to detect in an utterance-initial click, but in word-medial cases it induces full or partial nasalization of a preceding vowel, as in the word 'rock' [ɦāŋ̊!ʔá-k^{h}o] in figure 14. Similar anticipation of nasalization is

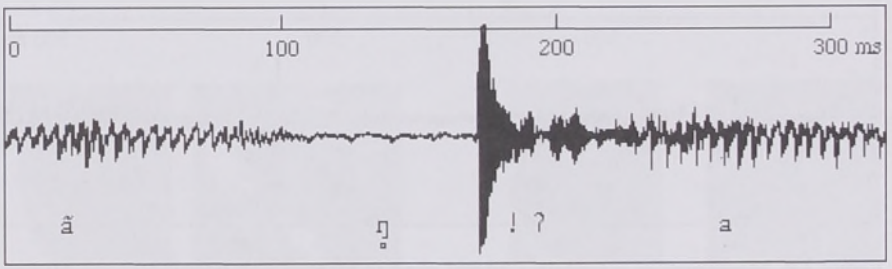

Figure 14: Waveform of voiceless nasalized click in intervocalic position in the Hadza word [**haŋ̊!ʔa-ko**] rock'

also heard on a preceding vowel across a word boundary. Also when a vowel precedes, a short voiced nasal segment can sometimes be heard as the click is being formed. However, in all environments the presence of nasal airflow can be detected by placing a hand in front of the nose of the speaker, and speakers themselves readily identify clicks with either the voiced or the voiceless nasalized accompaniment as having nasal airflow. The waveform of a voiceless nasalized alveolar click in figure 14 clearly shows that the closure for this click lacks voicing. Airflow is interrupted at some point by glottal closure, but when voicing resumes some time after the click is released the following vowel is somewhat nasalized, indicating that the velum remains lowered during the glottalization. Because of similar effects on neighbouring vowels, the voiced and voiceless nasalized click accompaniments can be difficult to distinguish in intervocalic position on first hearing. But as figures 13 and 14 show, the laryngeal contrast between them is not neutralized in this position.

Other researchers have distinguished different sets of accompaniments. Bleek (1956) notes among the click accompaniments velar frication, ejection, and voicing, writing [ǁkx, ǁkʻ, gǁ], etc.

We observed no voiced clicks other than the nasalized ones, and none in which the back closure was released into velar friction. The accompaniment marked as ejective may be the voiceless nasalized accompaniment we have described with its glottal closure component. Other disagreements in the literature also concern the failure to recognize the voiceless nasalized and glottalized accompaniment for what it is. Tucker, Bryan and Woodburn (1977) report 'pausal' (i.e. only utterance-initial) clicks which have a glottalized accompaniment and go on to note that these have nasalized allophones in other positions. Elderkin (1992) also recognizes a glottalized click accompaniment but notes that nasalization "before the glottalized click" is "almost always present". A. de Voogt (1992) transcribes a total of four types of click accompaniment, described respectively as voiced nasalized, aspirated (glottalized), "simple" glottalized (without delay in voice onset, possibly not glottalized) and glottalized with delayed release. These researchers fail to note that the 'glottalized,' 'pausal' or 'glottalized click with delayed release' clicks are not nasalized only when intervocalical, but in all environments. The nasal component of this accompaniment is less auditorily salient when clicks of this type are post-pausal but it is still present. It appears to us that when these clicks are in utterance-initial position they actually begin with voiceless nasal airflow. This nasal airflow is, however, interrupted by a closure at the glottis that seems to be timed to coincide approximately with the formation of the front closure of the click. The initial nasal component is not at all auditorily salient, and this probably accounts for the emphasis given to glottalization in other accounts of Hadza. However, it is in intervocalic cases that the presence of the glottal

closure is particularly apparent as a sharp cut-off of the preceding voicing occurs. But since some audible nasalization always occurs at the release of clicks with this accompaniment, we believe that nasalization should be recognized as an inherent property of the accompaniment.

4. SANDAWE

Like Hadza, Sandawe has no close genetic relationship to any of the other languages of East Africa. Also like Hadza, Sandawe has frequently been classified as a member of the Khoisan family (e.g. by Greenberg 1963). Sands (1998) provides persuasive evidence that in the case of Sandawe this is likely to be correct. There is, however, no good reason to group Sandawe specifically with the Central group of Khoisan, as has sometimes been suggested.

Newman (1991/2) estimated the number of Sandawe as 30 000, but the population may be larger. Estimates projected from the 1967 population census suggest there may be between 70 000 and 90 000. Most Sandawe are speakers of the language. From our own field observations it is obvious that the majority of young children in the Sandawe area are still learning the language, but they (and most adults) are also fluent in Swahili, the national language, and many prefer to use this language. As Swahili is the language of wider contact and is used in education, church services, and for all government business, a relatively rapid loss of the language is a distinct possibility in the coming years.

Dempwolff (1916) provided the first systematic attempt at a description of Sandawe. Copland (1938), largely relying on Dempwolff, made some IPA transcriptions. Significant later contributions were made by Tucker, Bryan and Woodburn (1977) and Elderkin (1989, 1992). Phonetic aspects of the clicks are discussed by de Voogt (1992) in an M.A. thesis. Van de Kimmenade (1954) and Kagaya (1993) are primarily useful as sources of vocabulary. Newman (1970) is also a very valuable source of specialized terminology for cultural items and local flora and fauna. Because quite a large lexicon is known for Sandawe it is possible to reach good estimates of how frequent words with clicks are. Some 20–25% of Sandawe words contain one or more clicks.

4.2 Sandawe click types

All accounts of Sandawe agree that there are three click types in the language. These may be broadly described as dental, post-alveolar, and alveolar lateral. The only difference among investigators is that Kagaya writes ǂ rather than!. As with Hadza, comparisons will also be made with the lateral ejective affricate

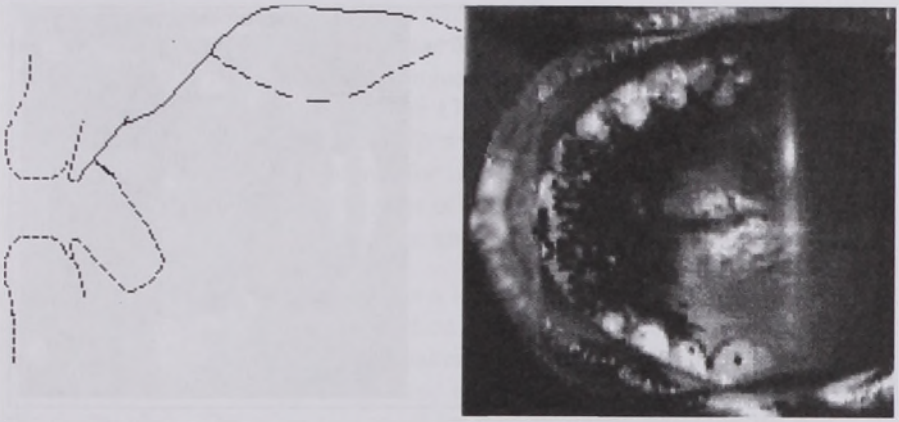

Figure 15: Palatogram (with some highlights removed) and inferred sagittal view of the dental click in [**k** |**a**] 'leaf' as spoken by speaker 1

because of the strong auditory similarity between it and the lateral click, already commented on by Dempwolff.

A palatogram of one of the speakers' productions of the dental click [|] and the inferred sagittal section based on this palatogram is shown in figure 15. The palatogram shows a contact that extends from the back of the upper teeth to behind the alveolar ridge. Note that the contact in the centre is further forward than at the sides. The contact at the lateral margins is not recorded in this photograph, perhaps because it may have been on the lower edge of the molar teeth. The other speakers' palatograms show a similarly extensive contact. From direct observation, it is our impression that this palatographic pattern reflects a large simultaneous contact area, and not a moving contact of the tongue sweeping over this area. This articulation might therefore be classified as laminal denti-alveolar.

A palatogram and inferred sagittal section of the front articulation of the same speaker's post-alveolar click are shown in figure 16. In this case the closure is made at the back of and just behind the alveolar ridge. The length of the contact from front to back is shorter than that seen in the dental click above, indicating that this closure is more likely to have been made with the tip rather than the blade of the tongue. Another speaker's palatograms showed the closure to be entirely behind the alveolar ridge. As in Hadza, this click type has two rather distinct release patterns in Sandawe. The post-alveolar closure is often released in a way that produces a sharp inrush of air, creating the loud transient associated with canonical click sounds. However, it may also be

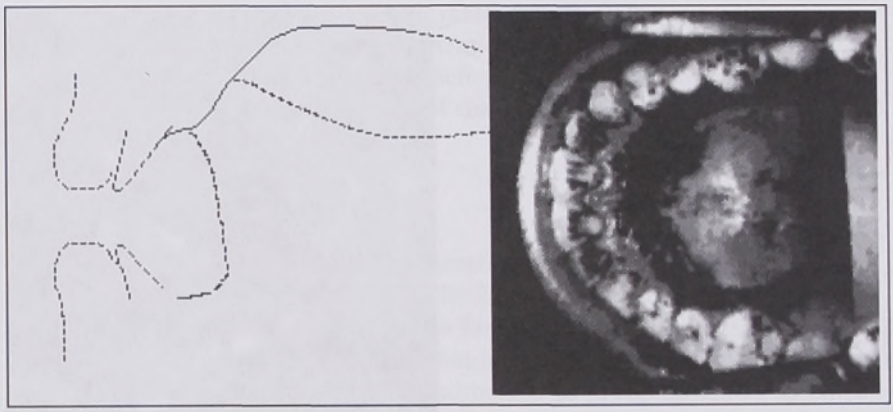

Figure 16: Palatogram and inferred sagittal view of the post-alveolar click in the word [**k!amba**] 'spleen' as spoken by a male Sandawe speaker (speaker 1)

released with a smaller prior expansion of the cavity, so that the breaking of the seal between the tongue and the palate produces only a relatively quiet noise. In this variant the tongue is usually allowed to strike the floor of the mouth after its separation from the roof, and it is this contact that produces the principal audible signal, as in the example in figure 17. We will call this a

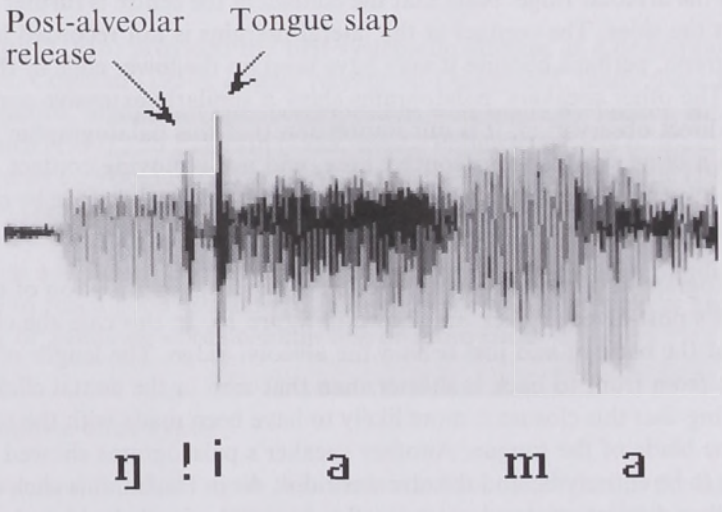

Figure 17: Waveform of the word [**ŋ!ama**] (tree species) spoken by a male Sandawe speaker (speaker 3)

tongue slap, and where appropriate will use the symbol [i] to transcribe the hitting of the tongue against the floor of the mouth. On some occasions both the post-alveolar release and the tongue slap create quite loud acoustic signatures, as in the example in figure 17. There is about a 20 ms delay between post-alveolar release and tongue slap when both are detectable. When the speakers were pronouncing words for our palatographic data collection, they produced the canonical loud variant of this click, so we do not know if the front closures are similar in location and extent between the two variants.

The third click type in Sandawe has a lateral release. Figure 18 shows a palatogram and inferred sagittal section of the front articulation of this click as produced by speaker 1. For this speaker, there is a broad laminal contact that covers the back of the upper teeth and extends behind the alveolar ridge, as in the dental click. The other two speakers who provided palatograms had narrower contact areas which neither included the teeth, nor reached as far back behind the alveolar ridge. As this articulation appears to be more typical, we consider this click type to be best described as an alveolar lateral click.

As noted earlier, Sandawe, like Hadza, has a lateral ejective affricate which is auditorily similar to the lateral click, sufficiently similar so that care was required to avoid transcription errors. The acoustic basis of this similarity in auditory impression is discussed in Wright, Maddieson, Sands and Ladefoged (1995). The contact pattern for the lateral ejective affricate as produced by speaker 1 is shown in figure 19. For this speaker the location and extent of the front closure is very similar for both the lateral click and the lateral ejective affricate.

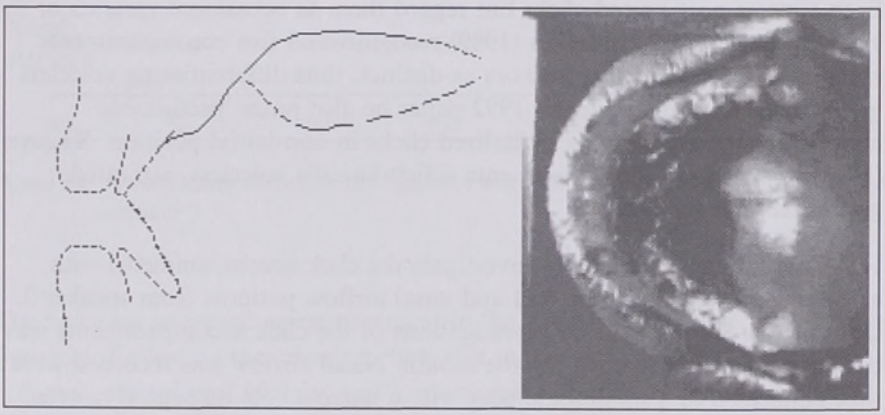

Figure 18: Palatogram and inferred sagittal view of the lateral click in 'warthog' [**k‖aŋ**] as spoken by a male Sandawe speaker (speaker 1)

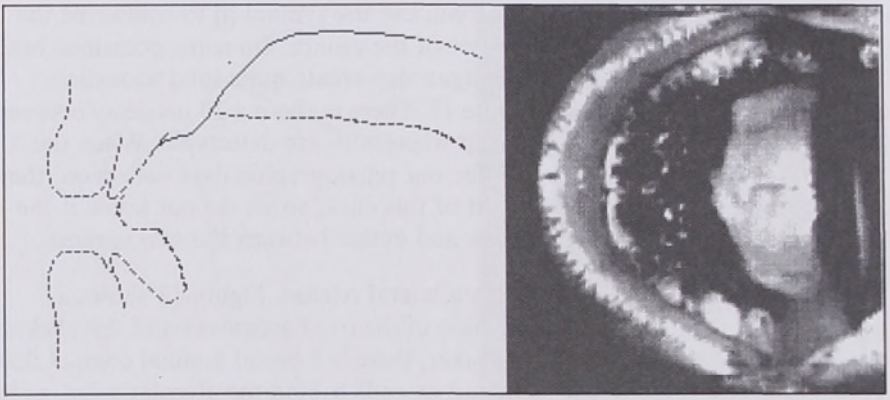

Figure 19: Palatogram and inferred sagittal view of the ejective lateral affricate in the word 'to take' [**tɬ'a**] as spoken by a male Sandawe speaker (speaker 1)

4.2 Sandawe click accompaniments

Previous accounts of the click accompaniments in Sandawe vary somewhat in the number recognized and in their nature. Our research confirms that there are five accompaniments in Sandawe: voiceless unaspirated, voiceless aspirated, voiced nasalized, voiced, and nasalized and glottalized. Dempwolff distinguished four principal accompaniments which may be interpreted as: voiceless unaspirated, voiceless aspirated, glottalized, and voiced nasalized. Tucker, Bryan and Woodburn (1977) report the same four accompaniments. Both sources note voiced clicks but regard them as occasional variants of the voiceless unaspirated. Elderkin (1989) recognizes all five accompaniments mentioned by these earlier authors as distinct, thus differentiating voiceless unaspirated and voiced. In his 1992 paper he also notes 'predictable nasalization' accompanying glottalized clicks in non-initial position. Kagaya (1993) reports four accompaniments which he calls voiceless, aspirated, glottalized and nasalized.

For Sandawe we were able to investigate the click accompaniments with aerodynamic records of the oral and nasal airflow patterns from speaker 3. Oral airflow for articulatory investigations of the click accompaniments was collected with a mask covering the mouth. Nasal airflow was recorded with a tube connected to a small foam plug with a narrow hole through it inserted in one nostril while the other was pinched closed. The aerodynamic records were produced under difficult field conditions, and flow volumes were not calibrated. However, they provide significant data of a type that is not

elsewhere available, and are particularly useful for determining aspects of the timing of different actions. Two non-consecutive repetitions of each word were recorded and the aerodynamic patterns were very consistent across these repetitions, indicating that this data provides reliable, qualitative information on the production of this speaker.

Figure 20 illustrates a token of a voiceless unaspirated post-alveolar click at the beginning of the word **k!e**: 'termitary, anthill'. The sharp inward air flow at click release is clearly shown in the oral airflow trace, and is followed by low volume egressive flow for the following vowel. The nasal airflow record shows some small perturbations at the beginning of the word but no net flow of air out through the nose. These may reflect movements of the velum during the release of the click. No significant amount of air flows out through the nose during this period or during the vowel. The speaker exhales partly through the nose at the end of the utterance, and the increase from the baseline level of nasal flow is very clear at this point.

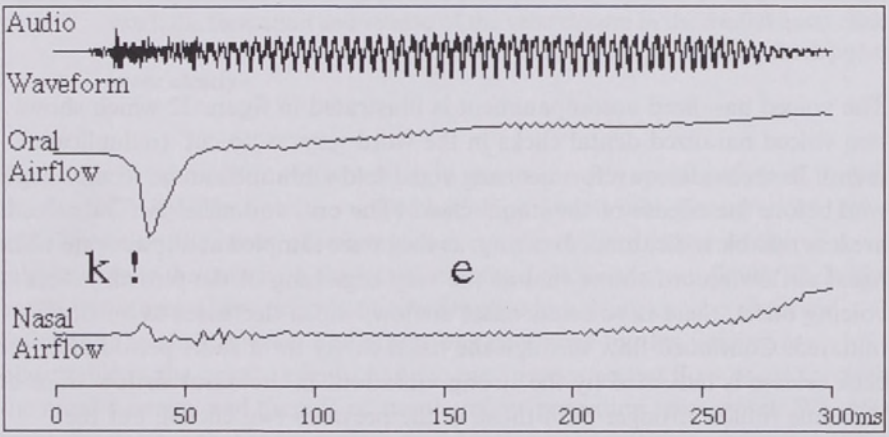

Figure 20: Aerodynamic record of the Sandawe word **k!e**: 'termitary, anthill' spoken by speaker 3

The voiceless aspirated accompaniment in the word **k!^{h}e**ŋ 'tongue' is shown in figure 21. Following the inward airflow due to the click release, there is a high-volume outward oral airflow, and some considerable delay before vocal fold vibration begins for the vowel. Nasal airflow is apparent for the final consonant, but not earlier. This accompaniment is found only in word-initial environments.

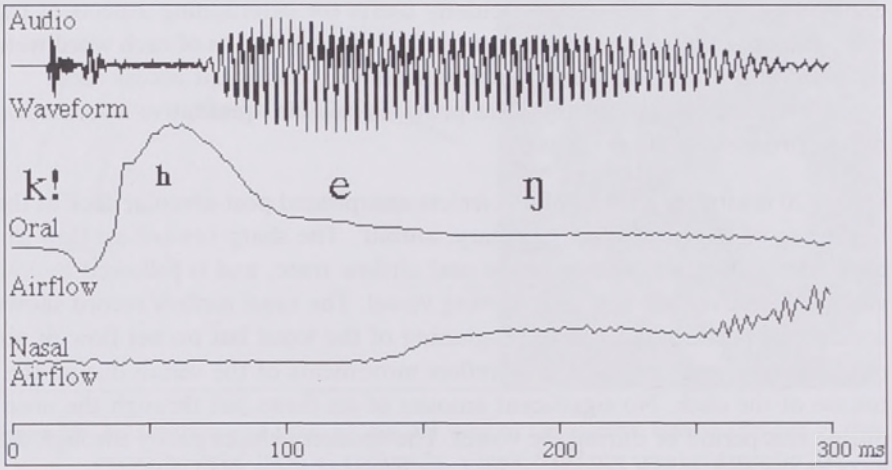

Figure 21: Aerodynamic record of the Sandawe word **k!^{h}eŋ** 'tongue' spoken by speaker 3

The voiced nasalized accompaniment is illustrated in figure 22 which shows two voiced nasalized dental clicks in the word ŋaŋa?o 'to cut' (reduplicated form). In the audio waveform, strong vocal fold vibration can be seen to begin well before the release of the initial click. (The oral and nasal airflow records are less reliable indicators of voicing, as they were sampled at a lower rate.) The nasal airflow record shows that at the very beginning of the record, before voicing onset, there is voiceless nasal airflow, which decreases as voicing is initiated. Continued flow through the nasal cavity for a short period after the click release is indicated by the strong vibrations in the nasal airflow trace at this time (much stronger than those in the previous two clicks), but the following vowel is primarily oral. In the medial nasalized click the onset of the nasal component can be detected from the decrease in the oral flow and the increase in the nasal flow shortly before the time point marked by the first bold vertical bar. This bar marks the point at which the velar closure is made, and it occurs about 100 ms before the click – i.e. the dental – release occurs. The velar nasal continues to be held for about another 100 ms until the time point marked by the second vertical bar on the figure, and thus occupies a good proportion of the duration that might be ascribed to the following [a] vowel. Note that the segment transcribed as a glottal stop in the infinitive ending [?o] does not involve complete vocal fold closure but only a constriction of the folds resulting in reduced air flow.

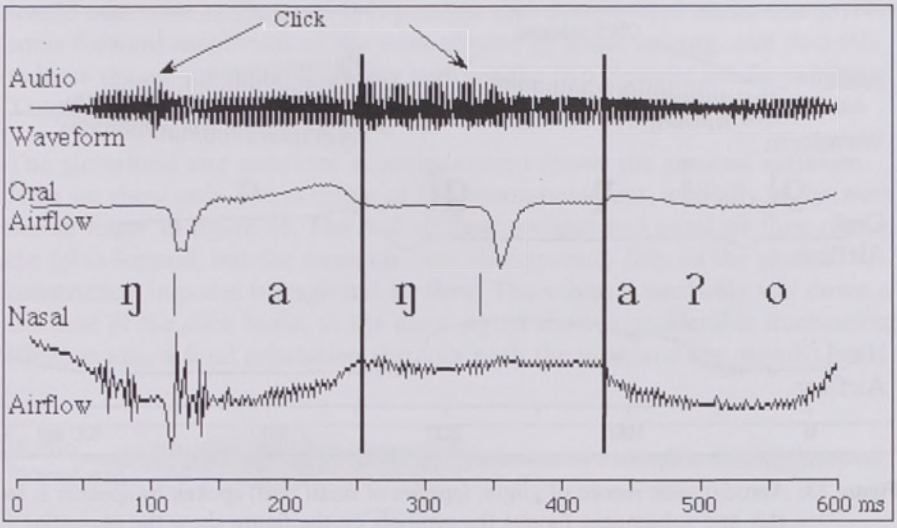

Figure 22: Aerodynamic record of ŋa|ŋa|ʔo 'to cut' spoken by speaker 3. The vertical bars mark the formation and release of the velic closure in the medial nasal click. The scale of the nasal airflow has been increased so as to show these points more clearly

The clicks in figure 23 in the word g|ig|o, the name of a species of small bird in the finch family, illustrate the voiced accompaniment with dental clicks. In initial position the onset of voicing does not occur until closer to the click release than is the case with the initial nasalized click shown in figure 22. In the audio waveform a few periods of low amplitude voicing can be observed following the click release. The vibrations produced by this voicing are observable in the nasal airflow channel, but there is no net flow of air through the nasal passage, and there is no nasal airflow preceding voice onset. We infer from this pattern that the tongue is raised to form the velar closure and that the velum is already raised to close the nasal passage before voicing is initiated. This token thus illustrates a voiced velar stop closure with about 50 ms of vocal fold vibration, which is probably close to the maximum duration that voicing can be sustained when such a configuration exists (Ohala & Riordan 1989). When this closure is released, both oral and nasal closures are broken and there is a phonetically nasalized vowel after the velar release. Because the vowel is a high vowel involving a considerable degree of constriction in the oral cavity, most of the airflow is directed through the nasal cavity.

The second voiced click in this word differs dramatically from the first in being prenasalized. The vowel in the first syllable is very short and is followed by a

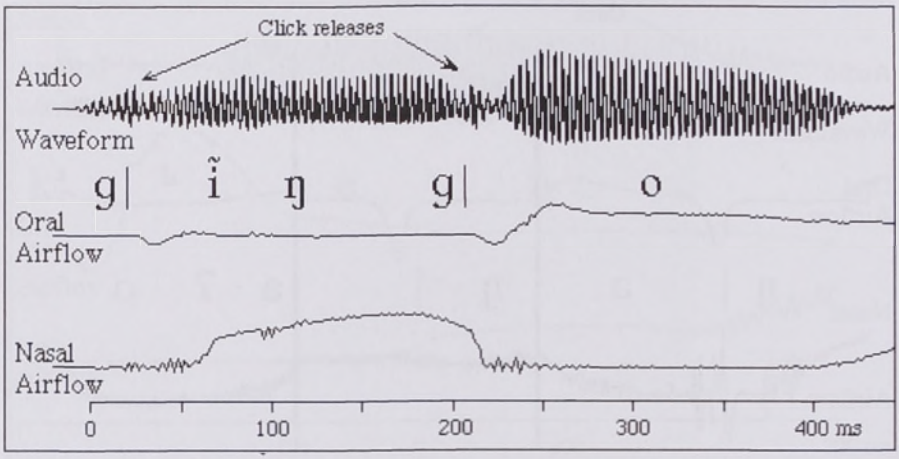

Figure 23: Aerodynamic record of **g|ig|o**, (species of small bird) spoken by speaker 3. In this and subsequent figures the symbols on the figure show the phonetic elements rather than the phonological categories

velar nasal which is part of this second click. There is complementary distribution such that voiced clicks in initial position occur without prenasalization and those in medial position are always prenasalized. In this token the exact time that the velar nasal begins is unclear, but might be around the 100 ms mark. Nasal airflow is shut off shortly before the click release, as shown in the nasal airflow trace and by the sharp reduction in the amplitude of the voicing vibration in the audio waveform. Both velar and velo-pharyngeal closures are maintained for about 50 ms while the dental click release is made. Then the velar closure is released and air directed solely out of the mouth. We suggest that the prenasalization of a medial voiced click is a means of retaining the relatively long lag between the formation of the velar closure and the release of the front closure for a click while enabling voicing to be continuously maintained. By shortening the period during which both the oral and the nasal passages are closed to no more than 50 ms, the speaker avoids an involuntary cessation of vocal fold vibration due to air pressure in the pharyngeal cavity approaching equality with subglottal pressure. In utterance-initial position, the problem is handled differently, by delaying the onset of voicing.

Another striking fact about these voiced clicks is the low oral inflow associated with the click release itself. In voiced velar plosives a forward movement of the location of the closure on the palate can be employed to assist in enlarging the pharyngeal cavity, thus enabling voicing to be sustained for a longer time than

would otherwise be the case. It is possible that these voiced clicks also involve some forward movement of the velar closure to assist voicing, and that this reduces the amount that the cavity between the two closures can be expanded. The result would be a weaker inflow on release, as is shown in this record.

The glottalized and nasalized accompaniment shows the greatest variation. Here we show only one example of this accompaniment, medially in the word **ma|ʔa** 'louse' in figure 24. The oral air flow declines and nasal air flow rises as the [ŋ] is formed, but the nasal air flow subsequently falls as the glottal constriction impedes transglottal air flow. The velum is probably still down at the time of the click burst, as the nasal signal shows considerable fluctuations (there is also a final exhalation through both the nose and the mouth).

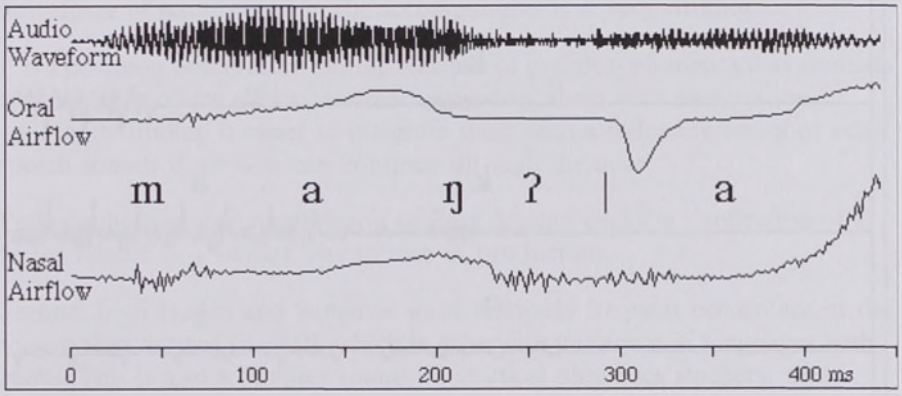

Figure 24: Aerodynamic record of the Sandawe word **ma|ʔa** 'louse' spoken by speaker 3

As Elderkin (1992) notes, audible nasalization here is predictable in the sense that it is always observed before non-initial glottalized clicks. He also notes that it may occur before initial glottalized clicks when they follow a vowel at a word boundary. We therefore do not record it in our phonologically based transcriptions However, we believe that this accompaniment always involves lowering of the velum, even in utterance-initial positions, but that a glottal closure usually prevents any actual escape of air though the nose in initial position.

Sandawe's five click accompaniments are illustrated in figure 25 with expanded waveforms of onsets of words beginning with dental clicks. The three accompaniments which appear voiceless in word-initial position can be divided

into two groups using the well-established measure of voice onset time (VOT). This was measured from the onset of the release transient noise to the beginning of the first identifiable glottal pulse on an expanded waveform display. The mean VOT for 30 tokens (2 repetitions of 3 click types for 5 speakers) of glottalized clicks was 61.2 ms, for aspirated clicks 67.4 ms and for unaspirated clicks 32.0 ms. We had too few tokens of voiced clicks to measure a reliable mean for the duration of their prevoicing, but the mean duration of the prevoicing in nasalized clicks was 52 ms.

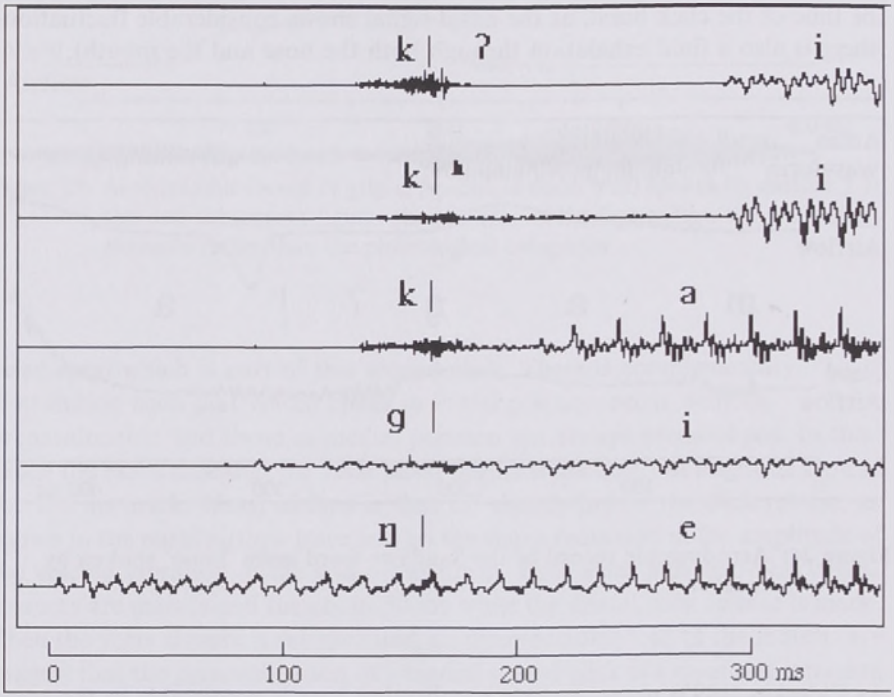

Figure 25: Example waveforms illustrating the five click accompaniments in Sandawe with the dental click type in the words **k|ʔi:** 'snake', **k|ʰia** 'dikdik', **k|:a** 'dikdik', **k|:a** 'leaf', **g|ig|o** 'finch' and **ŋ|eʔo** 'to cut' as spoken by male speaker 2

5. GENERAL CHARACTERISTICS OF EAST AFRICAN CLICK LANGUAGES

There are relatively few languages with clicks and hence a weak foundation for constructing a typology of click inventories. However, the East African

languages which have clicks conform to the few patterns which do seem reliable. For example, they lack bilabial clicks, and this seems to be a click type that only occurs when at least three other types occur. They also conform to a general pattern according to which a larger number of click accompaniments tend to co-occur with a larger number of click types. Dahalo, with fewer click types, also has fewer accompaniments.

The click inventories of the East African languages are not as extensive as in some of the better-known click languages of Southern Africa. In particular, the range of accompaniments to the clicks in Dahalo, Hadza and Sandawe is more limited than that which occurs in many of the Khoisan languages and even in some of the Bantu languages of the same area (Ladefoged & Traill 1994, Ladefoged & Maddieson 1996). But they stand out in two ways: first, the prevalence of nasalization in the accompaniments is very striking.

It is a common observation among teachers of practical phonetics that students learning to produce clicks customarily produce them with nasalization, apparently finding it easier to integrate them with a following vowel or other speech sounds if air flow can continue through the nose.

Perhaps the common nasalization of East African clicks is a reflection of a factor related in a similar way to ease of production.

Second, both Hadza and Sandawe show relatively frequent occurrence of the tongue slap variant (i) of [!], which is otherwise unknown in languages with clicks. This is also a familiar sound to practical phonetics teachers, who frequently elicit this articulation unintentionally as a student's first attempt at a post-alveolar click. In the absence of evidence of contact between Sandawe and Hadza, a general explanation of this phenomenon – perhaps as a form of laxing – should also be sought.

The final striking point, observed with both Hadza and Sandawe, was the auditory similarity between lateral clicks and lateral ejective affricates in these languages. The possibilty of confusing these two productions suggests to us one possible route by which it is possible to imagine a language developing clicks. A failure to recover the correct articulation from the acoustic signal could lead to the click becoming the target in place of the ejective. (We do not have any evidence that this is an actual scenario in these languages.)

ACKNOWLEDGEMENTS

The research reported in this article would not have been possible without the help of many people. We are very grateful to all who assisted in any way, but

especially to the Dahalo, Hadza and Sandawe speakers who shared their knowledge of their languages with us in very generous fashion, particularly Ali Mena, Gudo Mahya and Windolin Pankras. In Kenya we owe a debt of gratitude to Lucia Omondi for assisting with research permission, Nico Kalama for providing essential contacts in Witu, Haji Omar Abdallah and Ebrahim Khamisa for hospitality and research assistance in Kipini, and Ali Mirza for assistance with transportation. We would like to express appreciation to the Tanzanian Commission on Science and Technology for their approval and encouragement for our research in Tanzania, and to the district and provincial authorities in Arusha, Mbulu and Kondoa for approving our project, and to Herman Batibo, Nicholas Blurton Jones, the Catholic Missions at Farkwa and Kurio, Dave and Jen Pearce, and Jeannette Hanby and David Bygott for facilitating our work in various ways. At UCLA, Sinisa Spajic, Richard Wright and Stephan Schütze-Coburn made essential contributions to the analyses presented here. We would also like to acknowledge the generosity of Edward D. Elderkin and Derek Nurse in sharing unpublished work with us. The research reported here was supported by grant BNS-9107004 from the National Science Foundation for research on the phonetic structures of endangered languages.

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