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THE PHONETIC STRUCTURES OF HADZA*

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Hadza is one of three East African languages with clicks. Previous field reports on this language have disagreed on several of its phonetic chartacteristics, including the number and nature of the clicks. This paper—based on acoustic and articulatory analyses of data collected in recent fieldwork—presents a more detailed picture than any previous work. Special attention is given to the articulation of the click types and the acoustic features of the click accompaniments, the role of aspiration in distinguishing classes of consonants, and the formant structure of vowels.

1. Introduction

Hadza is a language of uncertain genetic affiliation spoken in the neighborhood of Lake Eyasi in north-central Tanzania by approximately 800 people. Among its many interesting characteristics is its rich consonant inventory, including clicks, ejective stops and affricates, and lateral fricatives and affricates. Along with Sandawe and Dahalo, it is one of only three languages spoken outside southern Africa to have clicks. In this paper, we will present a description of the basic phonetic characteristics of the language, including results based on instrumental

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articulatory fieldwork and on acoustic analysis of field recordings. The sound system of Hadza has been described previously in several studies, notably Tucker, Bryan, and Woodburn [1977) and de Voogt [1992], but there are discrepancies between the phonetic inventories reported by different researchers. In the notes and analyses resulting from the considerable amount of fieldwork carried out by a number of researchers [Obst 1912, Dempwolff 1916-17, Bleek 1931, 1956, Berger 1943, Tucker, Bryan, and Woodburn 1977, Elderkin 1982, 1983, de Voogt 1992, Wagner forthcoming] there are also differences on such matters as the occurrence of aspiration, the distribution of nasalization and the qualities of the vowels. We hope to clarify these disagreements by providing careful phonetic observations based on a number of speakers, supported by our instrumental analyses. In addition to enhancing our knowledge of this particular language, a description of Hadza is important for the insights it provides into the overall characteristics of typologically rare sounds, such as clicks. More generally, basic phonetic descriptions of any language are relevant for the study of cross-linguistic universals.

A better understanding of the phonetic structure of Hadza may also assist in clarifying its relationships with other languages. Relying on the structure of the phonological inventory and a small number of plausible lexical and morphological similarities, some researchers have classified Hadza among the Khoisan language [Bleek 1931, Greenberg 1966, Ehret 1986], while 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 1997]. A better understanding of the linguistic structure of Hadza can assist in understanding the nature of similarities to other languages, and aid in determining whether they are indicative of historical relationship or not.

This study is based on field observations and transcriptions and instrumental analyses. Field work was carried out in Mangola, Mbulu District, Tanzania, in August 1991 by all three authors. All of the consultants for this study resided in the Mangola area and speak a uniform dialect. Speakers in some areas are considered to be more strongly influenced by Isanzu or Sukuma, both neighboring Bantu languages. The differences between dialects are primarily in the lexicon and not in the sound system, and will not be discussed here. Two male speakers served as primary consultants for the preparation of an extensive word-list designed to illustrate all the salient segmental phonetic phenomena of the language. Subsequently, a group of seven speakers, four women and three men ranging in age from early 20's to early 50's, were tape-recorded saying the more selective list of words which is provided as an Appendix to this paper. The audio recording was made in a somewhat reverberant indoor setting in order to avoid substantial outdoor wind noise, but is generally of very good quality despite these difficulties. All the acoustic analyses reported below were conducted on words in this recording. Articulatory characteristics of clicks and lateral affricates were documented by palatograms and linguograms provided by the two primary

speakers. Palatal casts were also made to assist in interpreting the palatographic and linguographic data. The first author returned to Mangola for further fieldwork from January to June 1992. The analyses reported here are based on the material obtained during the first field trip, supplemented by observations of some additional words noted during the second period of fieldwork.

2. Consonants

An overview of the inventory of distinctive consonants of Hadza is provided by the chart in Table 1. In this table, and in all subsequent citations of Hadza data, the transcription follows the current practice of the IPA.

Table 1. Hadza Consonants

	Bilabial	Labio-dental	Dental	Alveolar	Palato-alveolar / Palatal	Velar	Labialized Velar	Glottal
Plosive	pʰ p b			tʰ t d		kʰ k g	kʰʷ kʷ gʷ	ʔ
Ejective	(p')					k'	k'ʷ	
Cen. Oral Click			k|	k!				
Lat. Oral Click					k‖			
Nasal	m			n	ɲ	ŋ	ŋʷ	
Nas. Cen. Click			ŋ|' ŋ|	ŋ!' ŋ!				
Nas. Lat. Click					ŋ‖' ŋ‖			
Prenas. Plosive	mpʰ mb			ntʰ nd		ŋkʰ ŋg		
Prenas. Affricate				nts ndz	ndʒ			
Cen. Affricate				ts dz	tʃ dʒ			
Lat. Affricate					tɺ̊			
Ejec. Cen. Affr.				ts'	tʃ'			
Ejec. Lat. Affr.					tɺ̊'			
Cen. Fricative		f		s	ʃ			
Lat. Fricative				ɬ				
Cen. Approx.					j		w	ɦ
Lat. Approx.				l				

(Cen. = central, Lat. = lateral, Nas. = nasalized, Prenas. = prenasalized, Ejec. = ejective, Affr. = affricate)

As Table 1 shows, consonants occur at seven places of articulation but the number of place contrasts differs depending on the manner of articulation. There are three contrasting places among plain plosives: bilabial, alveolar, and velar. Nasals and prenasalized stops occur at these three places, and there is in addition a palatal nasal. On the other hand, there are only two places for ejective stops, bilabial and velar, with the bilabial one occurring in only a very few lexical items. One of the two places used for central clicks, the dental, does not occur with other consonant manners, but there is a considerable number of other consonants formed in the same place as the lateral clicks, the palato-alveolar or palatal region. The only labio-dental is a voiceless fricative. Labialization occurs only with velar consonants; a separate column is provided for labialized velars on the chart. For convenience, the labial-velar approximant [w] has also been placed in this column. "Glottal" is also listed as a place of articulation; the glottal stop is shown in Table 1 with the plosives, and [ɦ] is shown as a glottal approximant. Some of the articulations involved will be discussed in more detail later in this paper.

Hadza has a large number of types of stop consonants, differing in onset and release characteristics, laryngeal setting, and airstream mechanism. As we will show in more detail later, plosives (pulmonic stops) occur voiced, voiceless, and aspirated, but there is only a two-way laryngeal contrast among prenasalized plosives and pulmonic central affricates. The only pulmonic lateral affricate is voiceless. Hadza lacks implosives but has a variety of ejective stops, including central and lateral ejective affricates. As we will also discuss in more detail below, there are nine distinct clicks in Hadza, formed by combining three click types with three click accompaniments: voiceless oral, voiced nasal, and voiceless nasal with glottalization. The continuant consonants of Hadza include voiced nasals, voiceless fricatives, and voiced approximants. There are two lateral continuants, one a voiceless fricative, the other a voiced approximant. In intervocalic position, the approximant [l] varies with a flap [ɾ].

Words illustrating all the Hadza consonants are shown in phonemic form in Table 2. The number after the gloss indicates the number of that word in the Appendix, which lists the words in the order in which they appear on the field recording mentioned above. Copies of this recording can be made available to those who are interested in pursuing further research. A few of the words in Table 2 are not among those on the recording, in some cases because they were not observed until the second period of fieldwork.

(In the table, gender and number suffixes of nouns are separated from the root by a hyphen. Verbs are generally cited as roots, with a final hyphen to indicate that a suffix would normally follow, for example the infinitive -ʔV.)

Table 2. Words illustrating the contrastive consonants of Hadza in initial and medial positions.

	word	gloss	# on tape	word	gloss	# on tape
	Bilabial:					
pʰ	pʰandʒu-pʰe	*'sp. plant'*	32	ʔúpʰúkʰʷa	*'leg'*	101
p	patáku'ʃé	*'palm of hand'*	99	łupá-kʰo	*'foam'*	81
b	badá	*'hole'*	44	ŋǁobá-kʰo	*'baobab'*	138
p'	p'áʔùwé-	*'to split'*	-			
m	mákʰo	*'clay pot'*	85	sámakʰa-pʰi	*'three'*	37
mpʰ	mpʰalamaño-kʰo	*'slingshot'*	-	ɦompʰai-kʰo	*'wing'*	-
mb	mbalata-kʰo	*'cockroach'*	-	kǁamba-bi	*'small intestine'*	186
	Labiodental:					
f	fá-	*'to drink'*	11	ts'ifi	*'night'*	46
	Dental:					
kǀ	kǀútʰi-	*'neck'*	177	kǀakǀa	*'large flat rock'*	-
ŋǀ'	ŋǀ'ats'e-	*'to reheat'*	211	táŋǀ'e	*'belt'*	140
ŋǀ	'ŋǀáʧʰá	*'tongue'*	228	kǀikíĩĩ'ŋǀa	*'little finger'*	181
	Alveolar:					
tʰ	tʰasé	*'long'*	123	átʰa'má	*'blood'*	107
t	titʃ'i-	*'black'*	120	patáku'ʃé	*'palm of hand'*	99
d	dalaŋga	*'flour'*	-	badá	*'hole*	44
n	nátʰi	*'donkey'*	-	ʔéna-pʰi	*'grass'*	30
ntʰ	ntʰuli-bi	*'beer'*	-	ʔintʰawe	*'nose'*	-
nd	ndagʷe-ko	*'notch'*	-	ŋ!andá	*'agama lizard'*	97
l[ɾ]	lalá-kʰo	*'gazelle'*	67	baʔalá-kʰo	*'honey'*	91
ts	tsipit'í	*'porcupine'*	65	tsetse-	*'to grow old'*	-
dz	dzá-	*'come!'*	2	tɕ'odzo-	*'to say'*	19
ts'	ts'áke-	*'to steal'*	24	ɦits'á-pʰe	*'fat'*	89
nts	ntsá-kʰo	*'star'*	47	tan(t)se-	*'to crack'*	-
ndz	ndzopʰa	*'bottle'*	-	mindza	*'reedbuck'*	-
s	sámaka-pʰi	*'three'*	37	pápa'sa	*'hip bone'*	109
ł	łanó	*'python'*	95	ŋ!'ak'iłá	*'palate'*	179
k!	'k!ákú-	*'to jump over'*	4	k!o'k!ó-kʰo	*'back of head'*	137
ŋ!'	ŋ!'ojé	*'wax'*	139	ɦaŋ!'á-kʰo	*'rock'*	184
ŋ!	ŋ!ána-	*'sp. mongoose'*	64	ŋ!ikiŋ!i-	*'to push a lot'*	-

	word	gloss	# on tape	word	gloss	# on tape
	Palatoalveolar/Palatal:					
ɲ	ɲau-wa	*'cat'*	56	moɲóda	*'salt'*	92
tʃ	tʃatʃa	*'bushbaby'*	55	ʔitʃáme	*'one'*	36
dʒ	dʒándʒai	*'leopard'*	167	gubidʒi-	*'to get s.t. ready'*	-
tʃ'	'tʃ'á-k^{h}o	*'guineafowl'*	117	fiatʃ'apitʃ'i-k^{h}o	*'ear'*	-
ndʒ	ndʒa	*'reedbuck'*	-	dʒandʒai	*'leopard'*	167
ʃ	ʃamu-ko	*'Swahili'*	-	andáʃa	*'caracal'*	-
tʂ	tʂákáte	*'rhino'*	183	k^{w}atʂa	*'shoe'*	84
tʂ'	tʂ'áʔa-	*'to sing'*	22	mitʂ'a:	*'bone'*	142
kǁ	kǁa'p^{h}á	*'stump'*	190	kakǁá-	*'to hunt'*	14
ŋǁ'	ŋǁ'ek^{hw}á	*'sp. root'*	188	k^{h}aŋǁ'é-	*'to jump'*	203
ŋǁ	'ŋǁáʔa-	*'to scavenge'*	214	koŋǁafiete	*'man w/ 2 wives'*	-
j	jámu-a	*'land'*	40	ʔijátu-bi	*'snakes'*	96
	Velar:					
k^{h}	k^{h}alimo	*'animal'*	52	mak^{h}o-wa	*'clay pot'*	85
k	káŋga	*'sp. mongoose'*	57	fiaká-	*'to go'*	13
g	gaʃa-bi	*'honey beer'*	-	damoga-k^{h}o	*'beard'*	-
k'	k'apáku-bi	*'jaws'*	114	ts'ik'ó	*'smoke'*	43
ŋk^{h}	ŋk^{h}ólo-'á-k^{h}o	*'heart'*	108	ts'aŋk^{h}a	*'sp. mongoose'*	58
ŋg	ŋgat^{h}á	*'head ornament'*	113	k!oŋga	*'hare'*	158
ŋ	ŋaŋa	*'kind of fruit'*	50	ŋaŋa	*'kind of fruit'*	50
	Labialized Velar:					
k^{hw}	k^{hw}akǁa-	*'to vomit'*	224	uk^{hw}á-k^{h}o	*'arm'*	98
k^{w}	k^{w}aʔí	*'warthog'*	68	ŋǁ'ek^{w}a	*'sp. root'*	188
g^{w}	g^{w}anda-k^{h}o	*'shirt'*	-	fiag^{w}anda	*'adolescent animal'*	-
k'^{w}	k'^{w}aʔu-k^{h}o	*'eggshell'*	-	fiek'^{w}a-be	*'shell, rind'*	-
ŋ^{w}	ŋ^{w}apo-k^{h}o	*'ditch'*	-	—		
w	watʃ'o	*'sp. mongoose'*	63	ʔáwawa	*'bee'*	93
	Glottal:					
ʔ	ʔá'fiú	*'skin'*	104	tʂ'ó'ʔa-k^{h}o	*'a skin'*	103
fi	fiaka	*'to go'*	13	k^{h}áfia	*'to climb'*	8

3. Vowels

Hadza has five contrastive vowel qualities [i, e, a, o, u], as illustrated by the examples in Table 3. The vowels occur nasalized when they precede a voiced or

voiceless nasalized click. The vowels [ĩ, ũ] occur in two recorded lexical items in which their nasality cannot be predicted from the environment. These are also given in Table 3. In both these examples, the nasalized vowel is followed by [fi], but occurrence of [fi] is not generally associated with nasalized vowels. It is possible that these words may once have contained a nasal or a nasalized click.

Table 3. Words illustrating the distinctive vowels of Hadza.

i	ŋǂi-ʔi	*'put poison on female arrow'*	210
e	ŋǂe-ʔe	*'put poison on male arrow'*	209
a	ŋǂáʔa-	*'to scavenge'*	214
o	ŋǂ'o-ʔo	*'wash, bathe'*	226
u	'ŋǂúʔu-	*'to snore'*	220
ĩ	ĩfie-	*'to blow nose'*	-
ũ	safiũfie	*'be quiet!'*	-

The oral vowel qualities are plotted on a standard vowel chart in Figure 1. Note that Hadza vowels in general tend to be auditorily somewhat centralized rather than peripheral.

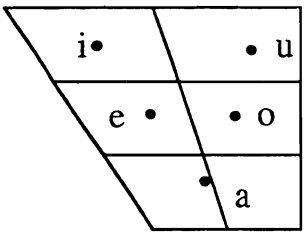


Figure 1. Qualities of Hadza oral vowels.

Length is not underlyingly contrastive in the vowel system, although there are phonetic differences in length which correlate with differences in pitch or accent, and long vowels may occur as the result of the addition of an affix to a word, e.g., /uk^{h}wa-a-k^{h}o/ 'It is an arm' [uk^{h}wa:k^{h}o]. Reduction of intervocalic [fi] can also result in a long vowel, e.g., [k^{h}afia]/[k^{h}a:] 'to climb'. Final vowels frequently become voiceless [i̥, e̥, ḁ, o̥, u̥], particularly when preceded by a glottal stop or any other voiceless stop. In fact, this devoicing can also extend to the penultimate vowels so that as much as the final two syllables of a word in utterance-final position can become whispered.

4. Tone and stress

The roles of tone and stress in Hadza are not entirely clear. Tucker, Bryan, and Woodburn [1977] transcribe both stress and three level tones, high, low and mid (unmarked), although they are careful not to claim that these are all contrastive elements. They mark five tonal classes for the nouns (in the frame: ___*bàhèâ* 'there is ___'): MMM, MML, MHH, HML, HMH. For the verbs they note four tonal classes (using the first person singular future as the elicited form): LH, HL, HH, LL. The mid tone thus appears not to be distinctive.'

Words in this article are transcribed with high tone [´], and stress ['']. These notations are impresssionistic and based principally on repeated listening to the recorded wordlist. Syllables without a tone mark were heard as low, at least on a majority of occasions. In the field, we noted a good deal of variation in the pitch pattern in repetitions of a given word, e.g., [ŋǁ'ekʰwá], [ŋǁ'ékʰwá], [ŋǁ'ēkʰwā] 'species of root' (188). High toned syllables are typically longer and more stressed than low toned syllables. We have found no minimal or near minimal pairs which contrast a mid tone with either a high or a low tone. Most words seem to have one or other of two word-level melodies, LHL and HL, but the interaction of these melodies with additional morphemes attached to the root and with larger prosodic constituents has not been worked out. We believe that these facts, as well as the overall behavior of tone and stress might best be accounted for by analysing Hadza as a pitch-accent language, with prominence shifting from one syllable to another according to the context.

5. Click types

The following more detailed description of the place of articulation of the clicks is based on field observations combined with the questioning of the consultants about their articulations, and instrumental palatographic records. Because only a few studies, such as Doke [1923, 1925], Beach [1938], Traill [1985], and Ladefoged and Traill [1984, 1994], have described clicks with the use of instrumental techniques, these sounds were given particular attention in our fieldwork. Following a tradition going back to Beach, we distinguish between click type and click accompaniment (Beach used the terms 'influx' and 'efflux'). The type of a click is the place of articulation and manner of release of the front closure. The accompaniment of a click is all of its other properties, such as the place of the back closure and its manner of release, the laryngeal actions, and the position of the velum determining if the click is nasalized or not. 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.

We consider that Hadza has three click types, dental, lateral and alveolar, but some earlier descriptions reported a larger number of types. Bleek [1956 (but based on fieldwork conducted in the early 1930's)] transcribed a fourth click type

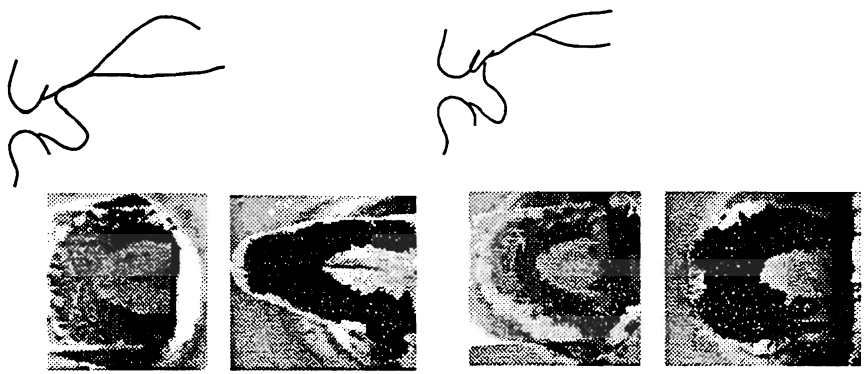
with the symbol [ǂ]. In Nama and other Southern African Khoisan languages the click transcribed with this symbol has a more forward point of release and usually greater affrication than [!] [Ladefoged and Maddieson 1966]. Greenberg [1966] followed Bleek in reporting four click types in Hadza. All the words which Bleek transcribed with the [ǂ] click have been been transcribed by us or Sands [1992 ms] with other sounds, such as [!], [ǁ], and [k']. 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, transcribed [!!]. The two words they give as examples of a 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; however it was acceptable to precede the greeting with a labio-manual click — a kiss on one's own hand. We will consider later the occurrence of a flapped version of the [!] click.

In order to study the production of the three click types, palatograms and linguograms were made for two adult male speakers of Hadza, using techniques described by Ladefoged [1993]. A small number of words containing a single click and no other oral consonants were selected for study. Separate repetitions were used to study the contact area on the upper surface of the mouth and the part of the tongue making the contact. Each speaker uttered a given word twice before the contact area was recorded on videotape, using a mirror to view the contact on the roof of the mouth, and having the speaker stick out the tongue to see the lingual contact area. Palatograms and linguograms of the ejective lateral affricate were also made, as this sound has a striking acoustic similarity to the lateral type of click. The video images were later digitized using a Macintosh computer equipped with a video capture card. For each speaker, a dental impression was made, showing the shape of the roof of the mouth. This was used to create a sagittal view of the fixed structures of the speaker's vocal tract.

The dental clicks [ǀ] can be described as having a laminal coronal closure, extending from the upper teeth to the alveolar ridge. This can be seen in Figure 2, which shows palatograms and linguograms of the front articulation in a dental click, as produced by the two speakers. The palatograms on the left of each pair of pictures show the front contact as observed in the mirror. The linguograms on the right of each pair show the projected tongue viewed directly. The areas covered by the black marking medium indicate where the articulators made contact during the articulation in each case. A sagittal view of the maximum area of the front contact for each speaker, inferred from the information in the palatograms and linguograms, 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 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. The extension of the closure along the sides of the mouth, however, can be seen. This lateral closure, along with the front and back closures, is necessary to create a suction chamber and hence generate the inflow of air characteristic of a click release.



Speaker 1 Speaker 2

Figure 2. Palatograms and linguograms of a dental click in the word [ŋǀaha] 'forget', as spoken by two male Hadza speakers. The sagittal view of each articulation was inferred from the patterns of contact on the tongue and palate, and the known contour of the palate.

The inability to see the back closure in the palatograms of the dental click in Figure 2 (and those of the alveolopalatal and lateral clicks in Figures 3 and 4, which we will be discussing later) indicates that this contact must be quite far back on the roof of the mouth and/or quite short in the sagittal plane. This is similar to the production observed in Dahalo dental clicks [Maddieson, Spajić, Sands, and Ladefoged 1993] but differs from the 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. Sagittal diagrams of !Xóõ clicks [Traill 1985, Ladefoged and Traill 1984, 1994], based on x-ray cinema-tography, also show that at the onset of the formation of the click there is usually a smaller enclosed air space than our palatographic records indicate for Hadza. It is uncertain if this difference is due to the fact that the speakers differ in their oral morphology, or is attributable to a different target position for the back closure. The two Hadza speakers studied have a somewhat higher palatal vault than the !Xóõ speakers, and a less sharply curved arrangement of the teeth so that the distance between the left and right

molars is greater. These differences might make a more forward closure harder to achieve. The shape of the roof of the mouth is not given for the Zulu speakers studied by Doke, but their dentition seems to be more like that of the Hadza speakers than that of the !Xóõ speakers studied by Trail [1985]. If this is so, it may be the case that the more retracted back contact is a controlled property of Hadza clicks, that is, a component of their target.

Palatograms, linguograms, and inferred sagittal sections of the front articulation of the [!] click type are shown in Figure 3. We describe this click type as alveolar since the front closure of these clicks tends to be made at a less anterior place of articulation than the [|] type; it might even be labeled 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.

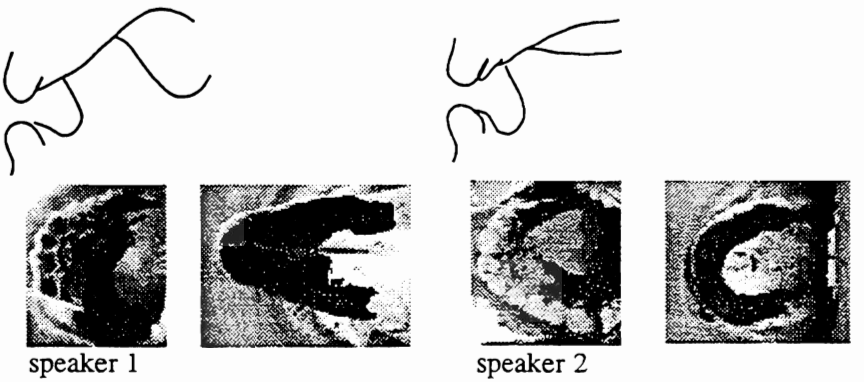


Figure 3. Palatograms, linguograms, and inferred sagittal view of the alveolar click in the word [ŋ!eʔe] 'to cut', as spoken by two male Hadza speakers.

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 seen is thus not consistent with 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 extent of the contact area for the front click closure is somewhat longer in the sagittal dimension for speaker 1 than for speaker 2. This is consistent with the idea that speaker 1 articulated the click with a rather forceful release. The contact would have extended to the post-alveolar region initially, but later only covered the alveolar region as the cavity behind the closure was enlarged to lower the intraoral pressure. This is similar to the reduction in contact area before release seen in Traill's cineradiographic data on one speaker's production of [!] in !Xóõ (Traill 1985: 110].

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 languages such as !Xóõ and !Xǔ, which is typically very loud and salient [Traill 1994, Snyman 1978]. Waveforms illustrating strong and weak productions of this click are shown in Figure 4. In the high-amplitude production of this click, 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 here.

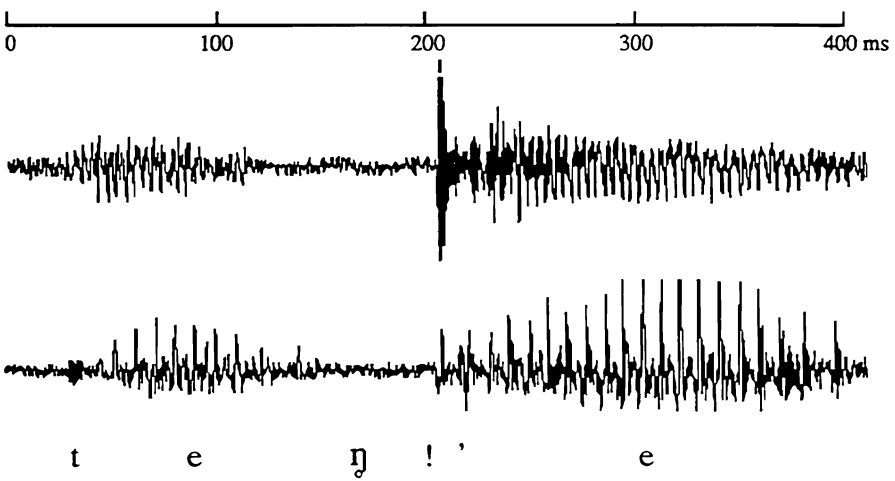


Figure 4. Waveforms of the word [teŋ!'e] 'to carry on shoulders' as produced by two different speakers. The upper exemplar (from a female speaker) shows a high-amplitude burst for the release of this click; the lower examplar (from a male speaker) shows a low-amplitude burst.

A notable unconditioned allophonic variant of the [!] click was observed at times from most of the 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 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 is "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 we have observed this kind of production of [!] to be quite frequent in Sandawe [Wright, Maddieson, Sands, and Ladefoged 1995]. A suggested phonetic notation for this variant is [¡].

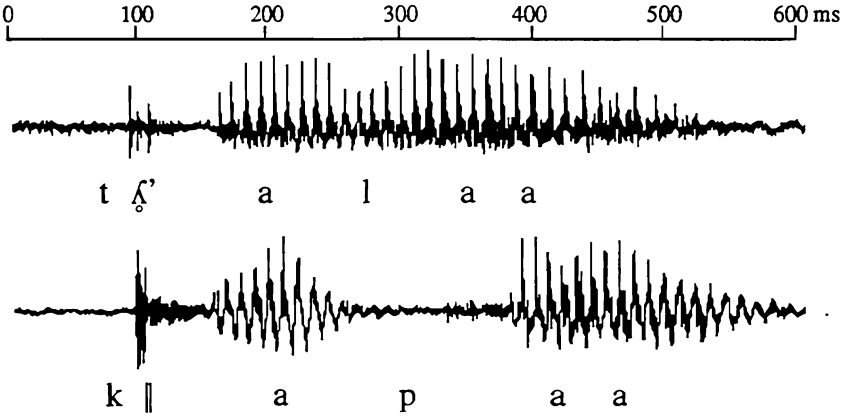
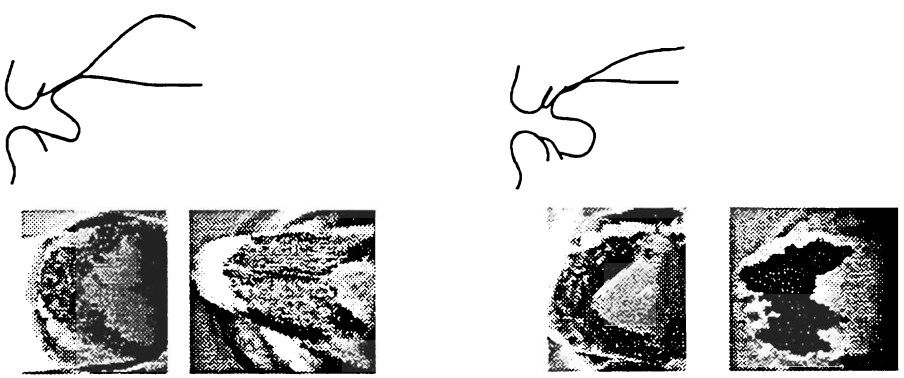


Figure 5. Waveforms ilustrating a lateral ejective affricate in the word [tʃ'ala-a] 'dove' and a lateral click in the word [k‖apa-a] 'stump', spoken by one of the female speakers recorded.

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

acoustic and and articulatory respects, these two sounds are quite comparable. Figure 5 shows waveforms of words containing [k‖] and [t͡ʃ'] 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 [c͡ʎ'], or even as [kʟ']. Based on the articulatory data we classify these sounds as palato-alveolar (or laminal alveolar) in place. Figure 6 shows the palatograms and linguograms of the lateral click for the two speakers, and Figure 7 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.



speaker 1 speaker 2

Figure 6. Palatograms, linguograms, and inferred sagittal view of a lateral click in the word [ŋ‖a?a] 'to scavenge' as spoken by two male Hadza speakers.

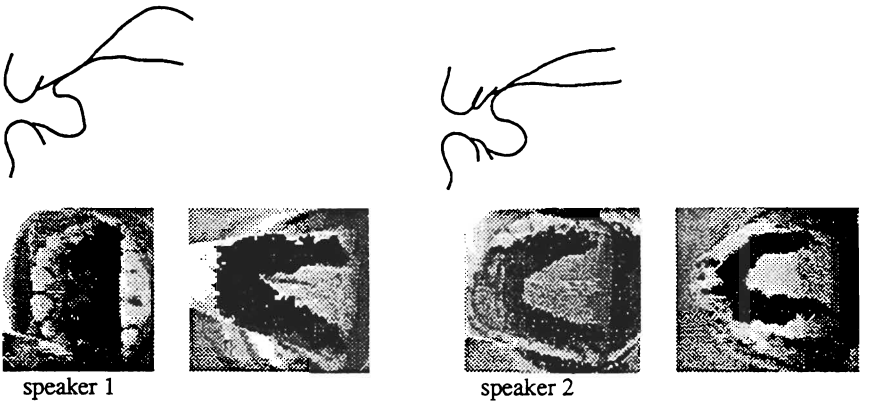


Figure 7. Palatograms, linguograms, and inferred sagittal view of a lateral ejective affricate in the word 'bone' [mitɬ̰'a] as spoken by two male Hadza speakers. The position of the tongue is shown by a dashed line for speaker 1 as the mouth was not open sufficiently and the extent of contact cannot be seen.

6. Click accompaniment

The range of accompaniments to the clicks in Hadza is more limited than that which occurs in many of the Khoisan languages of Southern Africa and even in some of the Bantu languages of the same area [Ladefoged and Traill 1994, Ladefoged and Maddieson 1996]. There are no plain (i.e., non-nasalized) voiced clicks, and aspiration plays no role in distinguishing between clicks. In Hadza, each of the three types of clicks, [|, ‖, !], can have three different accompaniments. The first possibility can be regarded as an accompanying voiceless velar stop [k], giving [k|, k‖, k!]. A waveform of a word in Hadza containing an intervocalic dental click with this accompaniment is shown in Figure 8. The same accompaniment is also illustrated in Figure 5. We will discuss the degree of aspiration in these clicks in a later section.

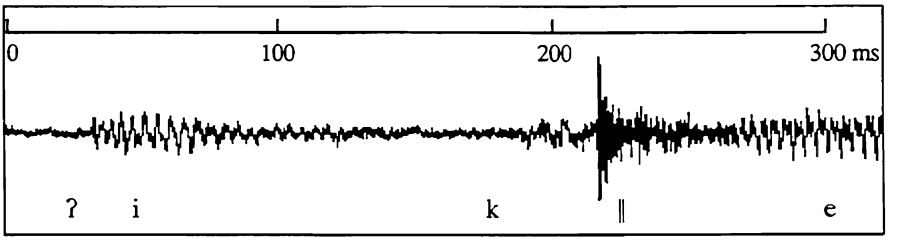


Figure 8. Waveform of voiceless click in intervocalic position in the word [ʔik‖e-ʔe] 'to close'.

The other two accompaniments involve nasalization of the click. The second possibility is an accompanying voiced velar nasal [ŋ|, ŋǁ, ŋ!]. Voicing continues throughout the production of clicks with this accompaniment, as shown in the waveform of a dental click in Figure 9. Some anticipatory nasalization of a preceding vowel occurs before clicks with this accompaniment.

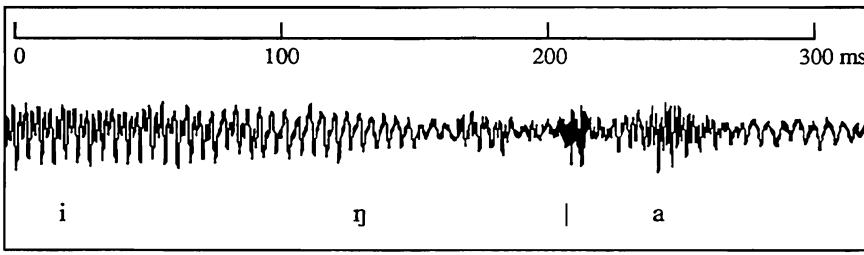


Figure 9. Waveform of voiced nasal click in intervocalic position in [kǀikiliŋǀa] 'little finger'.

The third accompaniment is more complex; it is both nasalized and glottalized. This voiceless nasal accompaniment is transcribed (ŋ̥', ŋ̥ǁ', ŋ̥!'), 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. 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' [ɦãŋ̥!'á-ak^{h}o]. Similar anticipation of nasalization is 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 10 clearly shows that the closure for this click is voiceless. 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 their similar effects on neighboring vowels, the voiced and voiceless nasalized click accompaniments can be difficult to distinguish in intervocalic position on first hearing. But as Figures 9 and 10 show, the laryngeal contrast between them is not neutralized in this position.

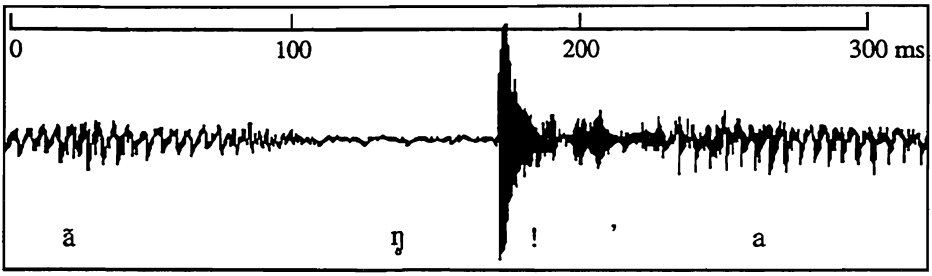


Figure 10. Waveform of voiceless nasalized click in intervocalic position in [haŋ̃!'a-ko] 'rock'.

Other researchers have distinguished different sets of accompaniments. Bleek [1958] notes among the click accompaniments velar frication, ejection, and voicing, writing [‖kx, ‖k'', g‖], 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] note "pausal" (i.e., only utterance-initial) clicks which have a glottalized accompaniment and go on to report 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 intervocalic, 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.

7. Voice Onset Time

There is some disagreement in the literature as to the nature of the contrastive laryngeal states that accompany the consonants of Hadza. As with all contrasts in the language, there are few minimal pairs to serve as a guide. The distinctions, if any, between aspiration and voicelessness have been particularly difficult for researchers to untangle. Tucker, Bryan, and Woodburn [1977] transcribe an aspirated/unaspirated constrast for both the pulmonic affricates and the clicks, and de Voogt [1992] transcribes this contrast for the pulmonic affricates, but feels it may be due to allophonic variation. In fact, simple pulmonic stops, clicks, and affricates all appear to pattern differently with respect to phonation type.

In order to investigate these differences, measurements of Voice Onset Time (VOT) were taken in a range of clicks, and pulmonic and ejective stops and affricates. Each of these words were said twice by each of the 7 speakers on the recording, providing usually 14 measureable tokens of any individual word. Some lexical roots have additional repetitions on the tape. These additional repetitions were made at a different place on the word list and are averaged separately. Measurements were made by examining simultaneous displays of spectrograms and waveforms on a Kay Elemetrics Computer Speech Lab, with speech digitized at 10 kHz. The duration measured was from the beginning of the release burst of the consonant to the onset of voicing of the following vowel.

Simple plosives made at bilabial, alveolar, and velar places occur both phonetically voiced and with voiceless closure. We are persuaded that there are two series of voiceless stops, which are transcribed as aspirated [p^h, t^h, k^h] and unaspirated [p, t, k], although both stop series are phonetically aspirated to some degree, that is, they have some delay between the stop release and the onset of voicing for a following vowel. Measurements of VOT for voiceless pulmonic velar stops in 22 separate lexical items were taken. The means and standard deviations of the VOTs for pulmonic velars by word is shown in Figure 11, arranged in order from shortest to longest. The first 14 words from the left clearly group together, separate from the 9 rightmost words. The mean VOT in the word [ŋk^holo-wa-k^ho], the only prenasalized velar stop in the set, falls in neither group. For the other words, the overall mean VOT's are 45.2 ms (standard deviation 13.6) for 114 tokens of /k^h/, and 23.6 ms (s.d. 7.9) for 142 tokens of /k/. This is a much smaller difference than is usually observed between voiceless aspirated and unaspirated plosives, which probably accounts for the uncertainties surrounding the phonological pertinence of this difference.

There does not seem to be a two-way contrast in aspiration for the prenasalized stops. The degree of aspiration for voiceless prenasalized stops does not correspond to that of either the less aspirated or the more highly aspirated stops, but falls in between. We have chosen to represent them as aspirated. Similar results to those for the velars were found in measurements of bilabial and alveolar stops, although smaller data sets were examined.

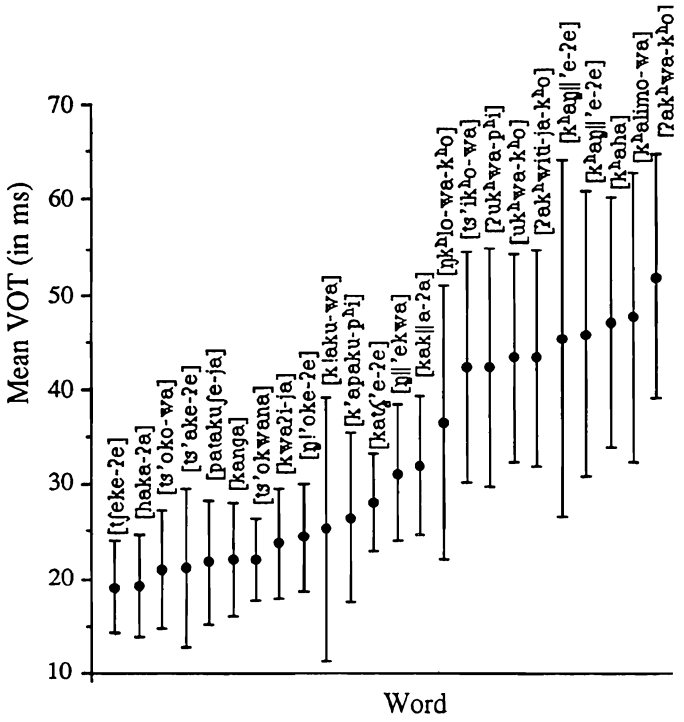


Figure 11. Plot of the mean VOT of a velar stop [k^h, k] in 22 separate lexical roots. VOT was measured for 7 speakers, producing each item twice. Each mean represents no fewer than 9, and no more than 14, separate tokens.

The set of velar stops includes an ejective, /k'/, as well as the voiced, voiceless aspirated and unaspirated stops /g/, /k^h/, and /k/. The occurrence of ejective stops is marginal at the bilabial place, and is not found at the alveolar place. The VOT measurements for pulmonic velars shown in Figure 11 were compared with measurements of ejective velars in 5 lexical items. An overall mean of VOT of 50.0 ms (s.d. 14.9) was found in 78 tokens of /k'/. In an analysis of variance with speaker and phonation type as independent variables, VOT was found to be significantly different for /k'/ and /k/ ($p<.0001$). The mean VOT for the ejectives is slightly longer than for the aspirated stops, but this difference was not significant.

In contrast with the pulmonic consonants, we have not observed a distinction between aspirated and unaspirated affricates and clicks. The lack of a systematic contrast between aspirated and unaspirated voiceless clicks can be seen in Figure 12, a plot of mean VOTs for words containing voiceless oral [k!] clicks. These tend to show some aspiration, but of a variable extent. The variation between the means of the three repetition sets of the word [k!e?e] 'to cut' (10, 196, 216) can be seen to be quite large.

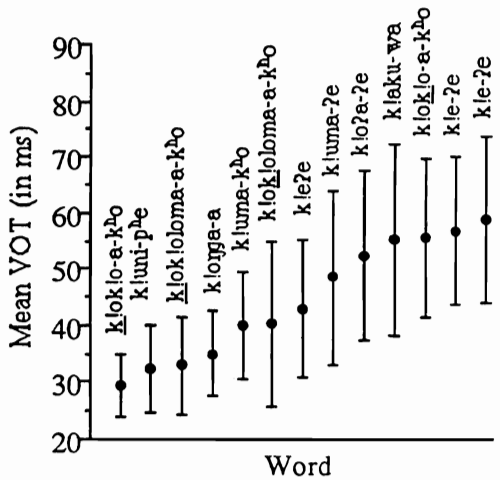


Figure 12. Means and Standard Deviations of VOT of voiceless alveolar clicks for 7 Hadza speakers. Separate means are given for each click in words with more than one click; the relevant click is underlined.

There is, however, a small but significant difference in mean VOT between the voiceless oral clicks and voiceless nasalized clicks with glottalization. The voiceless nasalized clicks tend to have longer VOTs. The mean VOT is 45.9 ms (s.d. 16.7) for 182 tokens of /k!/, and 51.0 ms (s.d. 18.6) for 220 tokens of /ŋ!'/. These values are very similar to those found for /kʰ/ and /k'/, respectively. In an analysis of variance with speaker, syllable position, and accompaniment type as independent variables, this difference was found to be significant (p=.0042). Recall that these two click accompaniments are also distinguished by the presence or absence of nasalization on any immediately preceding or following vowel and by the glottalization feature, so that this small VOT difference is unlikely to be itself an important cue to perceiving the contrast. Differences in VOT between pulmonic and ejective affricates were also found, with the ejective affricates having longer VOTs. These differences tended to be somewhat greater than the difference between these clicks.

Tucker, Bryan, and Woodburn [1977] note that an initial consonant has a very short VOT in a word where the first and second syllables are otherwise the same. During the course of our fieldwork, we noted that this generalization holds for plosives, affricates and clicks. That is, these consonants have a shorter VOT if they are the initial consonant in the first of two identical syllables than if they occur in a non-identical sequence. The mean VOT for initial [k!] clicks in words where the first two syllables are identical was found to be significantly different ($p<.0001$) from the VOT of the second [k!] click in these words in a paired, two-tailed T-test. The words used in this comparison are among those shown in Figure 12. As can be seen in this figure, the mean VOTs for the initial clicks in [k!ok!oloma] 'epiglottis' (129) and [k!ok!o-ak^{h}o] 'back of head' (137) are shorter than the VOT's for the second clicks in these words. Similar comparisons for /p/ and /p^h/ showed the same effect.

The other systematic variation in VOT of clicks that we observed occurs when the following syllable contains a nasal. In the data set shown in Figure 12, four words have an initial click with a nasal in the following syllable: [k!uni-p^{h}e] (144), [k!uma-k^{h}o] (145), [k^{h}uma-ʔe] (20) and [k!oŋga-a] (158). In an analysis of variance with speaker as an independent variable, these clicks had significantly lower VOTs ($p<.0001$) than the other clicks (excluding the initial clicks in [k!ok!oloma] (129) and [k!ok!o-ak^{h}o] (137)) in this data set. Given that both absence of nasalization of the following vowel and a shorter VOT are cues to the voiceless oral click accompaniment as contrasted with the voiceless nasalized accompaniment, we might expect some trade-off between these cues to be possible. Where a vowel becomes partly nasalized due to a following nasal consonant, it might be more difficult for the listener to determine whether a preceding click is oral or nasal based on the cue of the nasalization of a following vowel alone. The reason why voiceless oral clicks have shorter VOTs when a nasal follows might therefore be that this enhances the VOT cue to their identity in the context where the cues from vowel nasalization are more ambiguous.

8. Vowel Quality

The quality of the five vowels in Hadza was examined by making measurements of the formant frequencies of each of these vowels in a similar environment. The first five words in Table 3 were used for this purpose. These words were chosen to measure because they represented the nearest to a full minimal set available for the vowels, despite the fact that they contain nasalized clicks which could affect the formant estimates. For each of the seven speakers, there were two utterances of each word, and two identical vowels in each word. Formant frequencies were measured in the midpoint of each voiced vowel, i.e., the final vowels were not measured if devoiced. Figures 13 and 14 plot the first formant against the difference between the first and second formants for each token for the four female and three male speakers, respectively. In these figures, the axes of the diagram

are scaled according to the Bark scale but labeled in Hz. The origin of both axes is in the upper right corner, so that the vowels are arranged in the same orientation as in the traditional vowel plot used in Figure 1. The use of the formant difference for the horizontal axis also assists in presenting the vowels in a familar-looking spatial arrangement. The mean position for each vowel is shown by a large dot and the ellipses enclose all data points for a given vowel that are within two standard deviations of the first two principal components of the distribution of that vowel. The third formant is not plotted or discussed due to the large number of tokens in which it could not be reliably estimated.

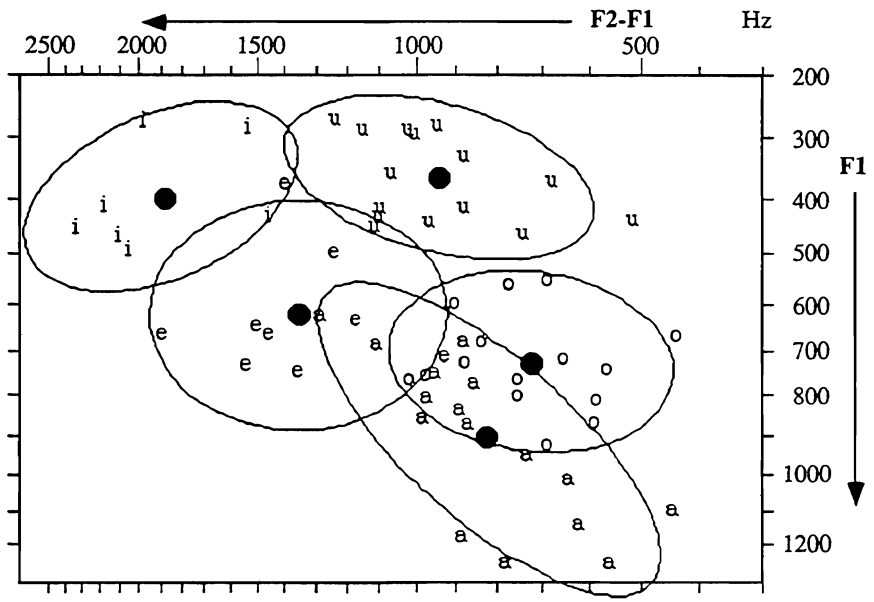


Figure 13. Frequencies of F1 and F2-F1 of the vowels [i, e, a, o, u] for four female speakers of Hadza.

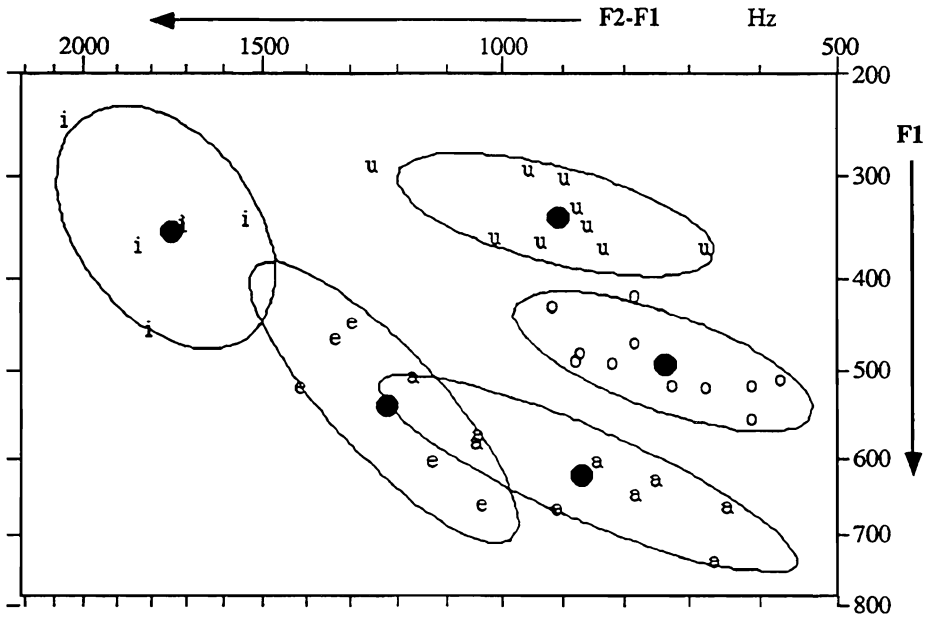


Figure 14. Frequencies of F1 and F2-F1 of the vowels [i, e, a, o, u] for three male speakers of Hadza.

The mean vowel positions are well separated in both Figures 13 and 14, but the individual points show considerable scatter. This scatter is surely due in part to speaker differences in vocal tract size and shape, but it is also our impression that Hadza vowels are free to vary quite widely within given ranges of quality. It is likely that the scatter of points in these figures also represents some of this optional variability. Given the large number of distinct consonants and the rarity of monosyllabic forms, lexical contrast rarely depends solely on vowel quality in Hadza; this may encourage toleration of vowel variation. One notable feature of the vowels is the relatively high mean second formant of the high back vowel [u], reflected in the location of the mean position for this vowel to the left of that for [o] in the figures. This property would correspond to a perceptual fronting of this vowel relative to Cardinal Vowel 8, and might result either from a more fronted tongue position or a less rounded lip position, or some combination of both.

8. Concluding comments

This paper has clarified some of the phonetic contrasts that underlie the phonological system of Hadza. In particular, it has presented a clear picture of the system of click types and accompaniments, showing that it includes some features that are unusual even when considered in relation to the much larger set of clicks

found in some of the Southern African Khoisan languages. Some documentation of the similarities between lateral clicks and the lateral ejective affricate has been provided. Such similarities suggest one possible avenue by which a language could gain or lose clicks in its inventory. The presence of an aspiration contrast in the plosives has been supported, and a number of other details of the consonant and vowel systems have been noted in greater detail than in the previous literature.

There are three languages spoken in East Africa whose phonetic inventories include clicks. One of them, Sandawe, is spoken by several thousand people who form a strong community with schools and local government bodies in which they form the largest group. Another, Dahalo [Maddieson, Spajić, Sands, and Ladefoged 1993], is clearly a language in retreat, spoken by only a few hundred people scattered among other larger communities. The situation of Hadza is harder to describe. It appears to have been spoken by a small group for a very long time. Children today are learning the language, despite a high frequency of contact with other languages. As linguists, we are glad that this language continues to show this vitality.

APPENDIX

The following appendix contains the word list recorded by four women and three men in August, 1991. Words are cited as roots, with the endings placed in a separate column. The different speakers varied in whether they gave a form with or without an ending and often gave different endings. Variant transcriptions we noted are given in the final column.

(tape 1)

#	root	gloss	recorded endings	observed variants
1	boˈtʃó-	'to come'	-ʔo	bɤtʃo-ʔo, bətʃo-ʔo, bʊtʃo-ʔo
2	dzá-	'to come'	-ʔa	dz̥a-ʔa
3	kʰaˈŋ‖'é-	'to jump', 'to spring up' (= 203)	-ʔe	
4	ˈk!áku-	'to jump over	-wa	
5	ˈtʃi-	'to run'		
6	teˈŋ!'é-	'to carry on shoulders'	-ʔe	teˈŋ̊!'ẽ-
7	ˈpótɻ̊'o-we-	'to break'	-ʔe	ˈpútɻ̊'o-ˌwé-
8	kʰáfia-	'to climb'	-ʔa	káfia-ʔa̰, káa-ʔ
9	ŋ̊‖'utʰi-je-	'to cook'	-ʔe	ŋ̊‖'ʊti-je-ʔe
10	ˈk!a-	'to cut' (= 196 & 216)	-ʔe	ˈk!é-
11	fá-	'to drink'	-ʔa	
12	séme-	'to eat'	-ʔe	séme-ʔ
13	haká-	'to go'	-ʔa	
14	k‖aˈk‖á-	'to hunt' (= 202)	-ʔa	kak‖a-ʔa
15	tʃé-	'to take'	-ʔe	
16	ts'afia-	'to know'	-ʔe	ts'áfie-
17	tʰa-ija	'to leave off', 'to stop doing sth.'	-ʔe	tʰa-je-
18	tʃeké-	'to put'	-ʔe	
19	tɻ̊'odzo-	'to say'	-ʔo	
20	k!uma-	'to wrinkle'	-ʔe	
21	k!oʔá-	'to scratch'	-ʔa	
22	tɻ̊'áʔa-	'to sing'	-ʔa	
23	tsija-	'to sneeze'	-ʔa	

24	ts'áke-	'to steal'	-ʔe	
25	ŋǃeko	'to stir'	-ʔe	ŋǃéke-
26	ŋ̊!'uʔ-ija-	'to swell'	-ʔa	
27	tʃ̊éɦena	'below, bottom'		tʃ̊é:na
28	ŋ̊‖'o-	'to wash' (= 226)	-ʔo	
29	ga'gá-	'grasshopper'	-a	ga:'gá-a
30	ʔéna-	'grass'	-pʰi	
31	ɦáts'apʰi-	'leaves'	-pʰi	
32	pʰándʒu-	'sp. plant'	-pʰe	
33	pʰisé-	'thorn'	-ja	
34	ts'ití-	'tree'	-ja	
35	bone-	'four'	-pʰe	bonɛ-pʰe, bole-pʰe
36	ʔitʃáme-	'one'	-ja	
37	sámaka-	'three'	-pʰi	
38	píje-	'two'	-pʰe	pʰíjɛ-pʰe
39	ɦék'wa-	'bark, shell, rind, crust'	-pʰe	
40	jámuʔá-	'country, land'	-a	
41	tʃ̊'alá-	'dust'	-a-kʰo	
42	ts'okó-	'fire'	-wa	
43	ts'ik'ó-	'smoke' (= 86)	-wa	
44	badá-	'hole'	-a	
45	'sétʰa-	'moon'	-a	se:tʰa:
46	ts'ifi-	'night'	-ja	
47	ntsa-	'star'	-a-kʰo	tsa-kʰo
48	iʃó-	'sun'	-wa-kʰo	
49	atʱi-	'water'	-pʰi	
50	ŋaŋa	'sp. fruit'		
51	maná-	'meat'	-a-kʰo	
52	kʰalimo-	'animal'		kʰalimo, -wa̰
53	ɦáts'e-	'hunger'	-ja	
54	nak'oma-	'buffalo'	-a	
55	tʃatʃa-	'lesser bushbaby'	-a	
56	ɲáu-	'cat'	-wa-kʰo	
57	káŋga-	'sp. mongoose'	-a	ka:ŋga:

58	ts'aŋkʰá-	'banded mongoose'	-a	
59	ts'ɔkwana-	'giraffe'	-a	
60	ts'iŋgaʔú	'oryx, sable or roan antelope'	-wa	
61	ˌʔúndaʔúnda-	'hedgehog'		
62	wéts'ái-	'hippo'	-ja-kʰo	
63	watʃ'o-	'sp. mongoose'	-wa	
64	ŋ!ána-	'kudu'	-a	
65	tsipiti-	'porcupine'	-ja	
66	jóndo-	'rat'	-wa	
67	lalá-	'gazelle'	-a	la:la:kʰo
68	kwaʔĭ-	'warthog'	-ja	
69	mbugida-	'wild dog'	-a	
70	dóŋgo-	'zebra'	-wa-kʰo	
71	ʔolá-	'child'	-a	
72	báwa-	'father'		bawə
73	ɬemé-	'man'	-ja	ɬɛme-ja
74	ʔákʰwití-	'woman'	-ja-kʰo	
75	ɦióts'o-	'ashes'	-wa-kʰo	
76	loʔo-	'horn'	-pʰe	
77	mbo'góʃi-	'bag'	-ja-kʰo	bogoʃi-, bʊgʊʃi-
78	ndzópá-	'bottle'	-a	nzópá-
79	kʰóʔó-	'bow'	-wa	
80	'kʰómati-	'eland'	-ja	
81	ɬupʰá-	'foam'	-a-kʰo	
82	k‖ek‖etʃe-	'woman's loincloth'	-ja	ŋ‖'eŋ‖'etʃe
83	lógo-	'shield'	-wa	
84	kwatʃ̬a-	'shoe'	-a-kʰo	kwatʃ̬'a-
85	mákʰo-	'clay pot'	-wa	
86	ts'íˈk'o-	'smoke' (= 43)	-wa	
87	utʰumé-	'spear'	-ja	
88	ɦiek'wá-	'shell, bark, rind' (= 39)	-a-kʰo	
89	ɦiits'á-	'fat, oil'	-pʰe	
90	semé-	'food'	-ja	seme-
91	baʔalá-	'honey'	-ko	baʔalá-ko
92	moŋóda-	'salt'	-a	moŋo:da:

93	ʔawawa	'bee'	-a	
94	tʃ'áɦi-	'maggot'	-p^{h}i	
95	ɬanó-	'python'	-wa	
96	ʔijátu-	'snake'	-p^{h}i	
97	ŋ̊!'anda-	'agama lizard'	-a	
98	ʔu'k^{h}wa-	'arm'	-ko	
	ʔu'k^{h}wa-	'hand'	-p^{h}i	
99	patákuʃé-	'palm of hand', 'sole of foot'	-ja	
100	guliŋgu'rí-	'kneecap'	-ja-k^{h}o	guluŋguri-
101	ʔúp^{h}úk^{h}wa-	'leg'	-a	
102	ɦáts'áts'e-	'lower leg bones'	-ja	
103	tɕ̊'ó?a-	'cloth tied around shoulder'	-a-k^{h}o	
104	ʔá'ɦú-	'skin'	-wa	
105	ts'á'ɦó-	'tail'	-wa	
106	ɦomp^{h}ái-	'wing'	-ja-k^{h}o	
107	ʔát^{h}a'má-	'blood'	-a	
108	ŋkólo-	'heart'	-wa-k^{h}o	
109	pápasa-	'innominate bone'	-a	
110	ho'tʃ'ó-	'lung'	-p^{h}e	
111	ʔatʃú-	'sinew'	-p^{h}i	
112	ʔak^{h}wá-	'eye'	-a-k^{h}o	
113	ŋk^{h}at^{h}a-	'strand of beads worn on head'	-a	ŋkat^{h}a
114	k'apáku-	'mandible'	-p^{h}i	
115	ʔáwaniká-	'mouth'	-a	
116	ʔáɦá-	'tooth'	-p^{h}e	
117	'tʃ'á-	'guineafowl'	-a-k^{h}o -p^{h}e	
118	wáʔiná-ma	'all'	-ma	
119	pákapaʔá-	'big'	-a	
120	títʃ'i-	'black'	-jé-ja	
121	ts'útʃi-	'wind'	-p^{h}i	
122	ŋǁa'tɕ̊'á-	'to be cold'	-ne-ja	
123	t^{h}asé-	'tall, long'	-ja	
124	petɕ̊'ái-	'white'	-ja	
125	k'alaɦái	'sp. fruit'		

(Tape 2)

126	ts'ukú-	'firewood'	-p^hi	
127	ʔi'k‖á-	'to close'	-ʔe	ʔi'k‖é-
128	hi'ŋ̥!'é-	'to come out of', 'to exude', 'to give out'	-ʔe	
129	k!ok!óloma-	'epiglottis'	-a, -a-k^ho	
130	ŋ̥‖'ekéjo-	'ankle'	-wa	
131	huŋ̥‖'ú-	'anthill'	-wa	
132	k‖ána-	'arrow, female'	-a-k^ho	
133	k‖ána-	'arrow, male'	-a	
134	'k‖ák^{h}á-	'arrowstand'	-p^hi	
135	néʔe-	'baboon'	-ja-k^ho	
136	ŋ̥!aleʔa-	'red flesh which sticks out of the anus, or red area on a baboon		
137	k!ok!ó-	'back of head'	-a-k^ho	
138	ŋ‖obá-	'baobab'	-a-k^ho	
139	ŋ̥!ojé-	'beeswax'	-ja	
140	taŋ̥|'e-	'belt, rope'	-ja	
141	ˌŋ‖áwé'tʃ'e-ne	'blue, green'		
142	mitʂ̥'á-	'bone'	-a	
143	tʂ̥'áɦa-	'bushpig'	-a	
144	k!úni-	'calf muscle'	-p^he	
145	k!uma-	'club'	-a-k^ho	
146	ŋgets'ea-	'forehead'	-p^he	
147	k‖átʃ'o-	'fontanelle' (same root as 'frog' 156)	-wa-k^ho	
148	k‖áʔano-	'dog'	-wa	
149	tʂ̥'ápo-	'dove', 'gull'	-wa-k^ho	
150	tʂ̥'á'lá-	'dust'	-a-k^ho	
151	ŋ̥!'oko	'to pierce'	-ʔ	ŋ̥!'uki-
152	ŋ̥|'úkú'maje-	'elbow'	-ja-k^ho	
153	ŋ̥‖'in'tʃino-	'fang'	-p^hi	ŋ̥‖'indʒino-
154	ŋ̥|'amá-	'fish'	-a	
155	k|a'k|á-	'flat rock'	-a	
156	k‖átʃ'o-	'frog' (same root as 'fontanelle' 147)		
157	'ɦátʂ̥'é-	'hair'	-p^he	
158	k!óŋ̥'ga-	'hare'	-a	

159	tɕ́óma-	'head'	-a-k^{h}o	
160	ʔets'á-, ŋǀ'ets'á-	'house'	-a-k^{h}o	
161	ŋ!'uŋguwe-	'hundred'		
162	tɕ́áʃo-	'tree hyrax'	-wa	
163	'ŋ!'úkun,dʒu-	'kidney'	-wa	
164	ŋ!'ama-	'klipspringer'	-a-k^{h}o	
165	ʔitɕ́á-	'knife'	-a-k^{h}o	ʔitɕ́'a-
166	ŋ!'elé-	'hartebeest'	-a-k^{h}o	
167	dʒándʒai	'leopard'		
168	ŋ!é-	'leopard'	-ja	
169	ŋǁ'e-	'liver'	-ja-k^{h}o	
170	ŋǀ'á'máts'i-	'louse'	-ja-k^{h}o	
171	kǁáʔa'kǁaʔa-	'middle'		
172	huŋǁ'u'k'ó-	'molar tooth'	-wa-k^{h}o	haŋǁ'u'k'ó- huŋǁ'o'k'ó-
173	kǁuwi-	'mosquito'	-ja-k^{h}o	
174	ŋǁ'utɕ́'e-	'mountain, hill'	-ja	[ŋǁ'ũtɕ́'e-]
175	toŋ!'oko-	'mud'	-wa-k^{h}o	toŋ!'ok'o-
176	ŋ!'uʃu-	'navel'	-wa-k^{h}o	
177	kǀúti-	'neck'	-ja	
178	ŋ!o'mo-	'half'	-ja	ŋ!umo-ja, ŋ!ʊmo-ja
179	ŋ!'akiłá-	'palate'	-a	ŋ!'ak'iłá-
180	'tɕ́'óŋk^{h}o-	'tawny eagle'	-wa	
181	kǀikiliŋǀa-	'pinky finger'	-a	kǀikiŋǀa-
182	kǁa,tak'á'nó	'rainbow'		
183	tɕ́ákáte-	'rhino'	-ja	tɕ́'akate
184	fiaŋ!'á-	'rock'	-a-k^{h}o	
185	ŋǀ'its'é-	'short'	-ja	ŋǀ'ɪts'e-
186	kǁamba-	'small intestine'	-p^{h}i	ŋǁ'amba-p^{h}i kǁampa-p^{h}i
187	ŋǀáláka-	'snail'	-a	
188	ŋǁ'ekwá-	'sp. root'	-a	
189	pú'kǀ'é-	'spleen'	-ja	
190	kǁa'pá-	'stump'	-a	ŋǁ'apa-

191	k‖áts'i-	'sweat'	-ja	
192	ŋ̥‖'u'k'wá-	'larynx'	-a-k^{h}o	
193	ŋ̥|'ets'é-	'tick'	-ja	
194	ŋ̥|'óso-	'to be full'	-ʔo	
195	ka'tʃ'é-	'to bite'	-ʔ	
196	k!a-	'to cut' (=10, 216)	-ʔe	'k!é-
197	taŋ̥‖'i-	'to die'	-ʔi̥	
198	ŋ!óʔo-	'to enter'	-ʔ	
199	'ŋ|áɦa-	'to forget'	-ʔ	
200	'ŋ‖áʔe-	'to hear'	-ʔ	
201	ŋ̥‖'aka-	'to hit with an arrow', ('to shoot at, to hit')	-ʔ	ŋ̥‖'ake-
202	ka'k‖á-	'to hunt' (=14)	-ʔḁ	
203	k^{h}a'ŋ̥‖'é-	'to jump', 'to spring up' (=3)	-ʔe	
204	'k‖ó-we-	'to kill'	-ʔ	
205	ts'uʔa-	'to remove s.t.'	-ʔe̥	ts'u-we-
206	ŋ|e'ɦé-	'to whistle' (=227)	-ʔe	
207	'ŋ!í-je-	'to push'	-ʔ	
208	ŋ̥|'uts'u-we-	'to push'		
209	ŋ‖e-	'to put poison on a (male) arrow'	ŋ‖e-ʔe	
210	ŋ‖e-	'to put poison on a (female) arrow'	ŋ‖i-ʔi	
211	ŋ̥|'ats'a-	'to reheat'	ŋ̥|'ats'e-ʔe	
212	'máŋ̥!'i-	'to circle around'	-ʔi	
213	k‖aŋgála-	'to pass legs under, to be lying down'	-ɦi	
214	'ŋ‖áʔa-	'to scavenge'	-ʔ	
215	k|i-jé-	'to see'	-ʔ	
216	'k!a-	'to cut' (=10,196)	-ʔe	'k!é-
217	'ŋ̥!'óko-	'to slap'	-ʔe	'ŋ̥!'óke-
218	ʔase-	'to sleep'	-ʔe	
219	'k‖úpi-	'to sleep'		
220	'ŋ‖úʔu-	'to snore'	-ʔ	
221	ŋ̥|'a'k'wé-	'to swallow'	-ʔ	
222	utʃ'ú-we-	'to uproot (roots)'	-ʔ	
223	'ŋ̥!'ó-we-	'to uproot'	-ʔ	
224	'k^{h}wák‖a-	'to vomit'	-ʔa	
225	'ŋ̊íts'i-	'to wait for', 'wait!'	-ʔi	

226	ŋǁ'o-	'to wash', 'to bathe' (=28)	-ʔo
227	ŋ|e'fié-	'to whistle' (=206)	
228	'ŋ|áta-	'tongue'	-a
229	ŋǁímó-	'van der Decken's hornbill'	-a-k^{h}o
230	ŋ!'oŋgojó-	'area of body encompassing the buttocks, hips, pelvis, and tail'	-k^{h}o
231	ŋ|'á'mé-	'white hair'	-ja-k^{h}o
232	'tʗ'ómásá	'pipe'	-a

REFERENCES

Beach, D. M. 1938. *The Phonetics of the Hottentot Language*. Cambridge: W. Heffer & Sons.

Berger, P. 1943. "Überlieferungen der Kindiga." *Afrika* 2: 97-122.

Bleek, D. 1931. "The Hadzapi or Watindega of Tanganyika territory." *Africa* 4: 273-286.

Bleek, D. 1956. *A Bushman Dictionary*. New Haven: American Oriental Society.

Dempwolff, Otto. 1916-17. "Beiträge zur Kenntnis der Sprachen in deutsch-Ostafrika. 12. Wörter der Hatzasprache." *Zeitschrift für Kolonialsprachen* 7: 319-325.

Doke, C. M. 1923. "Notes on a problem in the mechanism of the Zulu clicks." *Bantu Studies* 2(1): 43-45.

Doke, C. M. 1925. "The phonetics of ʗũ Bushman." *Bantu Studies* 2(3): 129-165.

Doke, C. M. 1927. *The Phonetics of the Zulu Language*. Johannesburg: Witwatersrand University Press.

Ehret, Christopher. 1986. "Proposals on Khoisan reconstruction." *Sprache und Geschichte in Afrika* 7(2): 105-130.

Elderkin, E. D. 1982. "On the classification of Hadza." *Sprache und Geschichte in Afrika* 4: 67-82.

Elderkin, E. D. 1983. "Tanzanian and Ugandan isolates." In M. Bechhaus-Gerst and R. Voßen (eds.), *International Symposium on Languages and History of the Nilotic Peoples*, volume 2, pp. 499-521, Kölner Beiträge zur Afrikanistik.

Elderkin, E. D. 1992. "Predictable nasality before East African clicks." *Afrikanistische Arbeitspapiere* 29: 111-129.

Greenberg, Joseph H. 1966. *The Languages of Africa.* Bloomington: Indiana University Press.

Ladefoged, Peter and Ian Maddieson. 1986. *The Sounds of the World's Languages.* Oxford: Blackwells.

Ladefoged, Peter and A. Traill. 1984. "Linguistic phonetic descriptions of clicks." *Language* 60: 1-20.

Ladefoged, Peter and A. Traill. 1994. "Clicks and their accompaniments." *Journal of Phonetics* 21: 33-64.

Maddieson, Ian, Siniša Spajić, Bonny Sands, and Peter Ladefoged. 1993. "Phonetic Structures of Dahalo." *Afrikanistische Arbeitspapiere* 36: 5-53.

Obst, E. 1912. "Von Mkalama ins Land der Wakindiga." *Mitteilungen der Geographischen Gesellschaft* 27: 1-45.

Sands, Bonny. To appear, 1997. *Eastern and Southern African Khoisan: Evaluating Claims of Distant Linguistic Relationships* (Quellen zur Khoisan-Forschung 12). Hamburg: Rüdiger Koppe.

Sands, Bonny. 1992. Unpublished field notes. ms, UCLA.

Snyman, J. W. 1978. "The clicks of Zhul'hõasi." Paper presented at the Second African Languages Congress of UNISA (University of South Africa, Pretoria).

Traill, A. 1985. *Phonetic and Phonological Studies of !Xóõ Bushman.* (Quellen zur Khoisan-Forschung, 1.) Hamburg: Helmut Buske Verlag.

Traill, A. 1994. "The perception of clicks in !Xóõ." *Journal of African Languages and Linguistics*. 15: 161-174.

Tucker, A. N., Margaret Bryan, and J. Woodburn, 1977. "The East African click languages: a phonetic comparison." In W. J. G. Möhlig (ed.), *Zur Sprachgeschichte und Ethnohistorie in Afrika: Neue Beiträge Afrikani-stischer Forschungen,* pp. 300-322. Berlin: Dietrich Reimer.

de Voogt, A. J. 1992. "Some Phonetic Aspects of Hatsa and Sandawe Clicks." Master's thesis: Leiden University, Leiden.

Wagner, J. 1992. Unpublished fieldwork.

Woodburn, J. 1962. "The future of the Tindiga." *Tanganyika Notes and Records*. 59: 268-273.

Wright, Richard, Ian Maddieson, Bonny Sands, and Peter Ladefoged. 1995. "A phonetic study of Sandawe clicks." *UCLA Working Papers in Phonetics* 91: 1-24.

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