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GLOTTALIC CONSONANTS IN HAUSA AND SOME OTHER LANGUAGES

Mona Lindau

The Hausa sound system includes one rather diverse class of consonants that is usually referred to as GLOTTALIC. Different places of articulation in this consonant class are associated with different glottal mechanisms. Labial and alveolar glottalic consonants have been described as voiced implosives, /ɓ, ɗ/. These sounds are produced by a rapid downward movement of the glottis. A palatal glottalic consonant is realized as a palatal glide with creaky voice, /'y/. The velar glottalic consonant is a voiceless ejective, /k'/. Ejectives are produced by a rapid upward movement of the glottis. These Hausa sounds were investigated acoustically. In addition, implosives and ejectives in some other languages were studied in order to highlight the language specific properties of glottalic consonants in Hausa.

The data consist of tape recordings of several speakers for each language. Most of the recordings were made on a good reel to reel tape recorder in the field. The glottalic consonants were in intervocalic position between a-type vowels in real words, said in a frame. These consonants were analyzed using a computer system for displaying the waveforms and spectra.

The palatal glide /'y/.

This sound is unusual in Hausa, but it clearly contrasts with a regular palatal glide /y/. Compare for example /'ya'ya/ "children" with /yaya/ "how?".

The acoustic analysis of the /'y/ was done in a qualitative way, inferring the glottal activities from the wave form. Figure 1 shows a typical wave form of a medial /'y/ in /'ya'ya/. One major characteristic is the very low fundamental frequency, about 35 Hz in this particular sound. Another characteristic is the high damping of the sound wave. This usually indicates a large amount of high frequency components in the sound. Emphasis of higher frequencies in the sound spectrum will occur when the glottal wave form of the sound source contains an angle approaching ninety degrees in the closure phase. A square wave contains an infinite number of high frequencies. The closer the closure angle of the glottal wave form approaches a square wave, the more higher frequencies will be emphasized in the sound spectrum. This fairly sharp angle of the closure phase in the glottal wave is a result of the vocal cords coming very rapidly and tightly together when vibrating. In this type of creaky voice in Hausa the vocal cords are vibrating very slowly, with a relatively high closing rate.

Implosives.

The list below states the languages concerned, their linguistic classification, and the number of speakers from whom data was collected. According to Maddieson (1981) about 10 % of the world's languages have implosives, and they are very common in certain geographical areas, like West Africa. All the languages in this list are spoken in Nigeria.

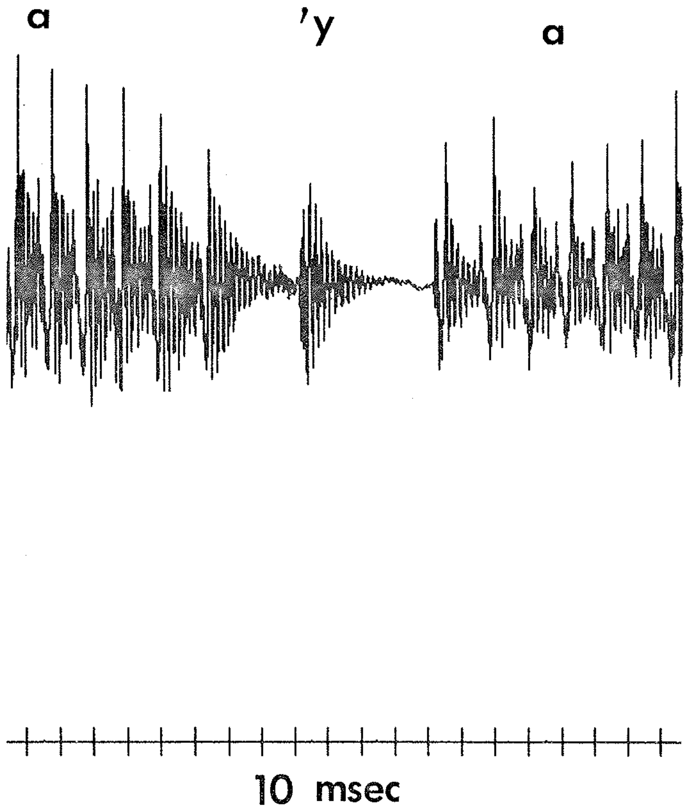

Figure 1. Waveform of the laryngealized palatal glide in Hausa.

	Languages		Number of subjects
AFRO-ASIATIC	Chadic	Hausa	14
NIGER-CONGO	Ịjọ	Kalaḅari	7
		Okrika	4
		Bụmọ	5
	Edoid	Degema	4

Figure 2 shows the waveforms of a regular plosive [b] and an implosive [ɓ] spoken by a speaker of Degema.

In the plosive, the amplitude of the vocal cord vibrations decreases gradually throughout the closure. As the supraglottal pressure increases, airflow through the glottis decreases, and eventually voicing dies out. Implosives, on the other hand, typically have either a gradual increase in the amplitude of the voicing - as in the figure - or, in other cases, a level, fairly large amplitude. This is due to an increase in the size of the vocal tract, as the larynx is lowered, and, also, the tongue body behind the place of articulation is typically lowered. The enlarged vocal tract volume keeps the supraglottal pressure from increasing, and voicing can be maintained at the same amplitude or at an increasing amplitude throughout the closure.

Note, too, that the first part of the implosive sound wave contains a certain amount of higher frequencies.

To describe some of the differences between the implosives in the selected languages, voicing amplitude and closure duration were measured, and characteristics of the waveform were examined. Peak-to-peak amplitude of voicing was measured in the middle and at the end of the closure at points marked by arrows on the figure. A ratio of these two amplitudes was calculated by dividing the final amplitude by the medial one. An implosive with level or increasing amplitude will have a ratio of 1 or more. In a regular plosive this ratio will be much less than 1. This measurement provides an indirect indication of the amount of cavity expansion in a voiced implosive.

Closure duration was also measured between points on the waveform display which, because of sharp changes in amplitude, were taken to be the offset and onset of the surrounding vowels. Thirdly, periodicity of the waveform and spectra at selected points were studied as an indication of phonation type.

Five out of the fourteen Hausa speakers produced implosives with voiceless closures, so these were excluded in the measurements of amplitude ratios and closure duration.

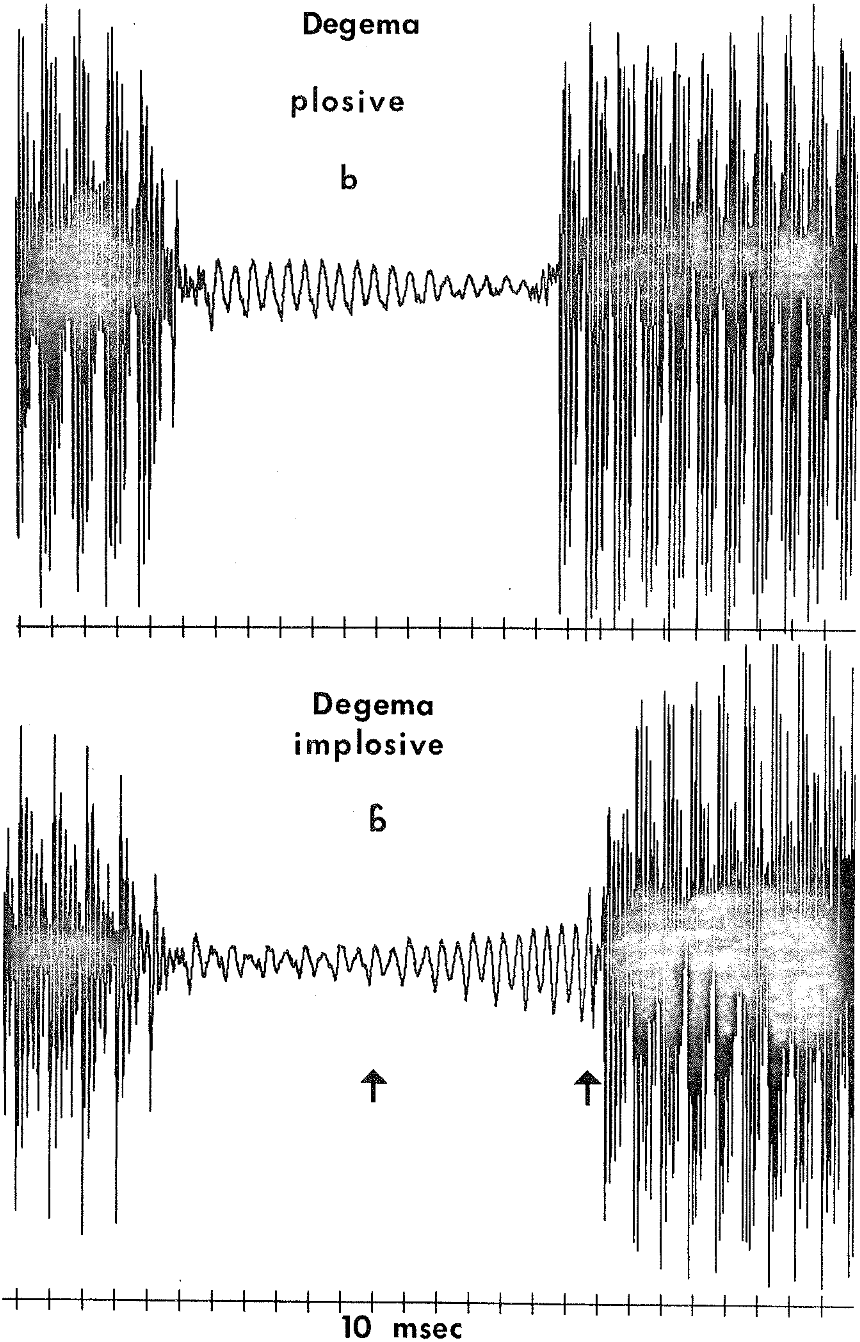

Figure 2. Waveforms of the medial plosive [b] and implosive [ɓ] in Degema.

The amplitude ratios and closure durations were averaged for all the speakers of each language. T-tests were used to assess the significance levels of the differences between the languages.

The results are illustrated in figures 3-7. Figure 3 shows histograms of the means of the amplitude ratios for the bilabial and alveolar implosives in each of the five languages. The histograms have been plotted in an order of increasing ratios, that is in an order of increasing amount of cavity expansion. The bars indicate one standard deviation above and below the mean.

For both the labial and the alveolar implosive Hausa has the highest amplitude ratio, indicating that it has the highest degree of implosion.

For the bilabial implosive the amplitude ratios are very significantly different between Hausa, on the one hand, and Degema, Kalaḅari, and Okrika on the other. Okrika is also significantly different from Bụmọ and Degema. For the alveolar implosive this measurement is significantly different only between Hausa on the one hand, and Kalaḅari and Degema on the other.

Figure 4 shows histograms of mean closure durations in the five languages in increasing order. Note that this measurement orders the languages in the same way for both bilabial and alveolar implosives. Hausa has significantly shorter closure durations than the other languages.

The Hausa implosives from the nine speakers are thus produced with both a relatively short closure duration and an amplitude ratio indicating a higher degree of implosion than occurs in the other languages.

However it is not true that a shorter closure always implies a greater degree of cavity expansion. For the languages apart from Hausa there is a tendency towards the opposite relationship between amplitude ratio and closure duration. Particularly for the bilabials, shorter closure durations are associated with lower amplitude ratios. Thus closure duration and degree of cavity expansion are independently variable phonetic parameters of voiced implosives. As to these two parameters Hausa behaves opposite to the Niger-Congo languages.

In addition phonation types were studied. Figure 5 shows a waveform of the bilabial implosive /ɓ/ in Bụmọ. It is typical of the voiced implosives in the four Niger-Congo languages. The first part of the closure displays a considerable amount of high frequency energy. Below the waveform there is a spectrum of the first 50 milliseconds of the closure, centered at the arrow, showing a clear formant structure. The high frequency energy in the waveform is thus an indication of the upper formants. This is probably due to the vocal cords vibrating with a relatively sharp closure while they are being held tightly together in the descending larynx, and this results in cavity resonances. The first part of the closure in these languages is thus typically produced with a form of laryngealization.

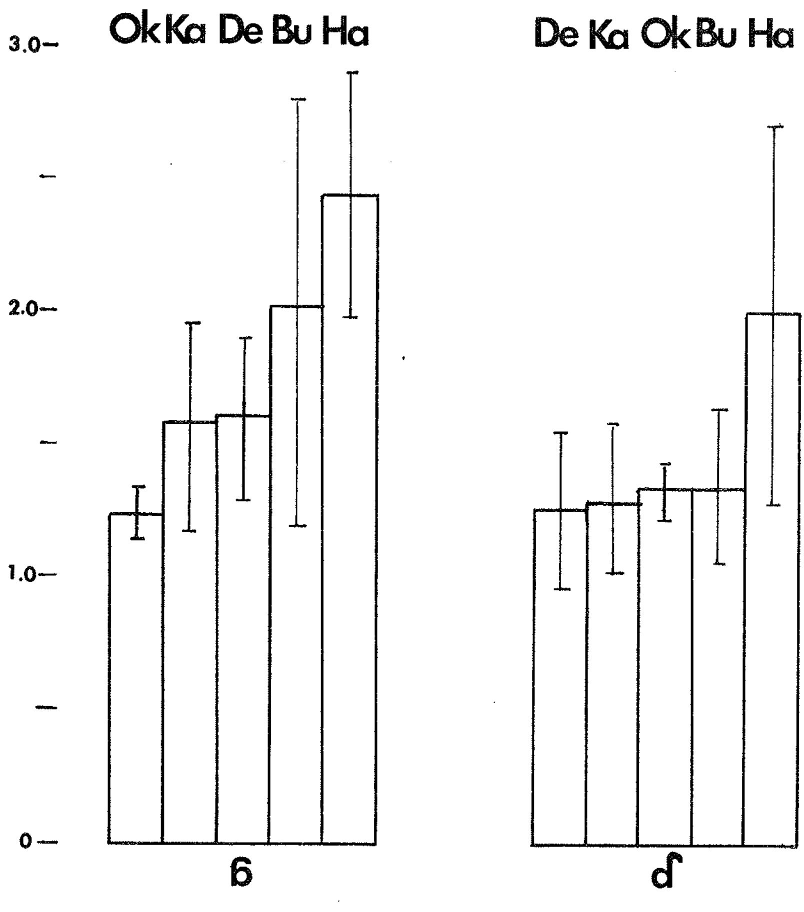

Figure 3. End/middle amplitude ratios of the labial and alveolar implosives in Okrika, Kalaḅari, Ḅụmọ, Degema, and Hausa.

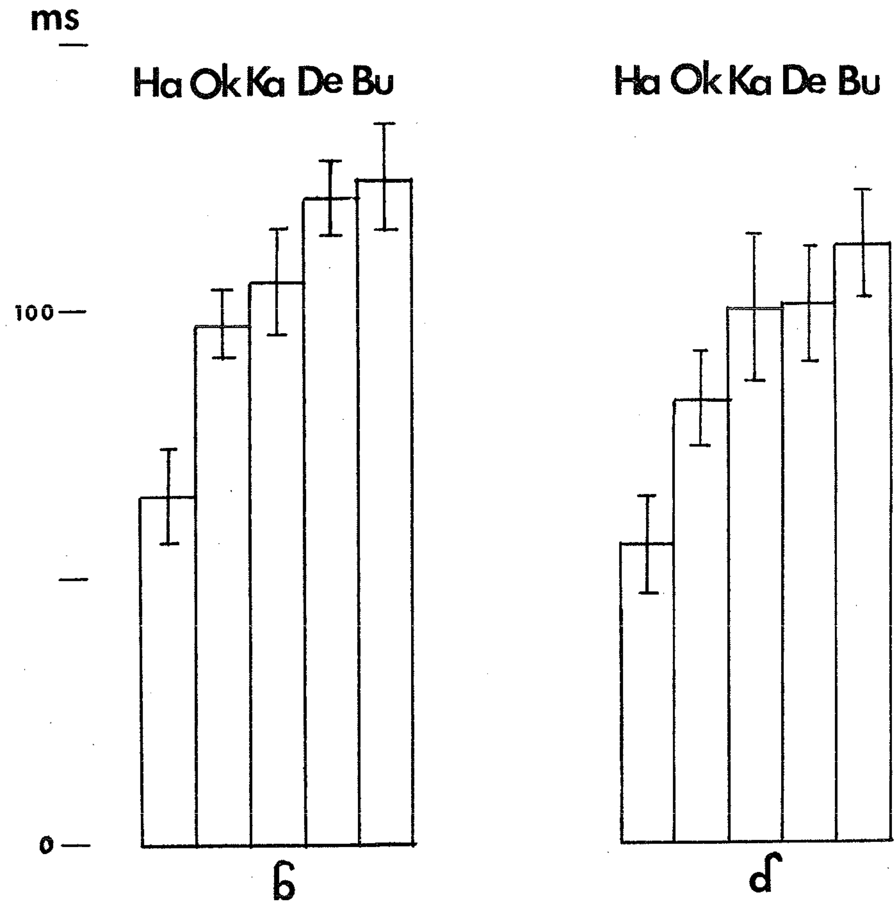

Figure 4. Mean closure durations of the labial and alveolar implosives in Hausa, Okrika, Kalaḅari, Degema, and Bụmọ.

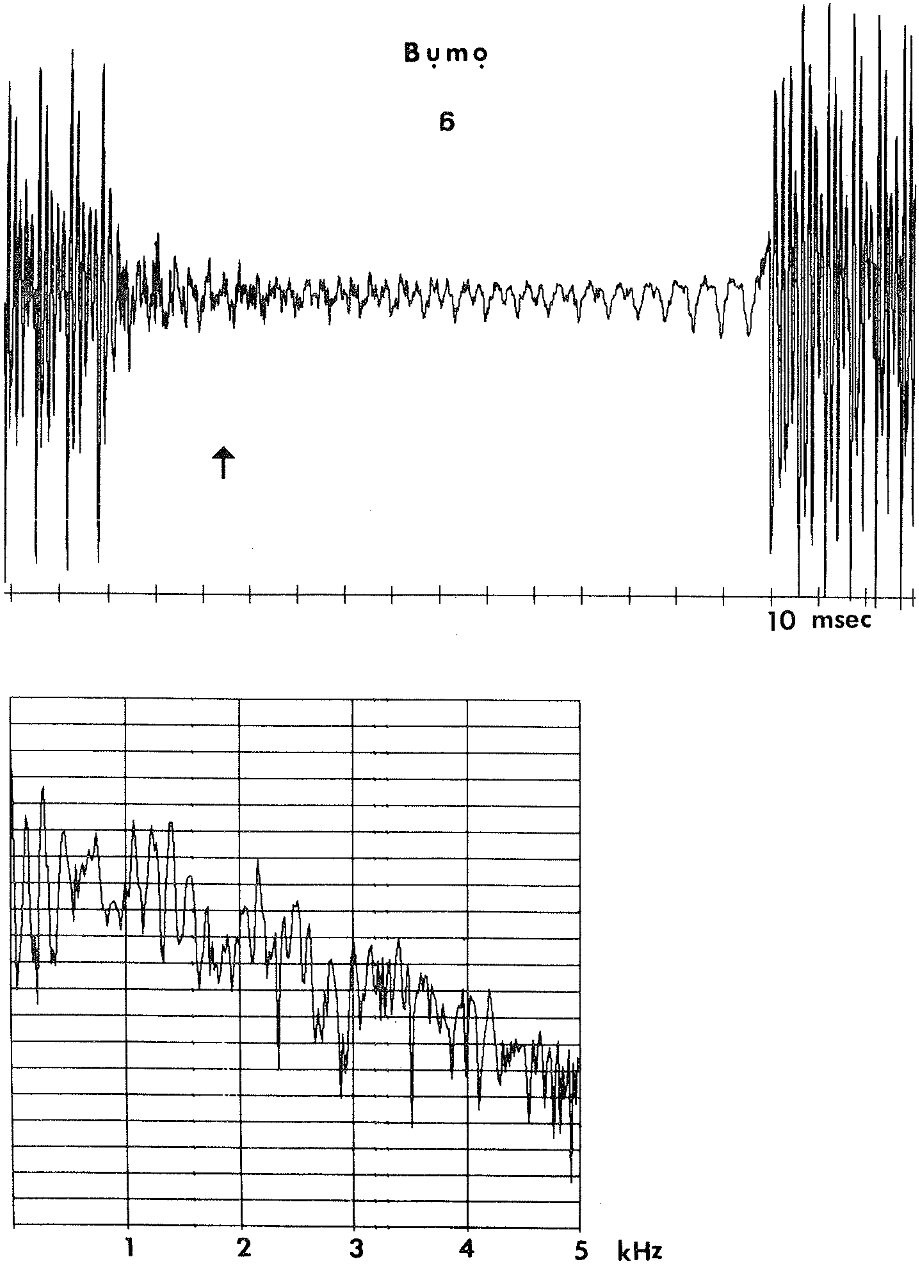

Figure 5. Waveform and spectrum of the labial implosive in Bụmọ.

Again, Hausa implosives differ considerably from the Niger-Congo languages in the waveform pattern during the closure (cf. Ladefoged 1964). There is also considerable individual variation in Hausa. Five out of the fourteen speakers produce a voiceless beginning of the closure, presumably from a glottal closure as the larynx descends. One speaker has an implosive just like those in the Niger-Congo languages. The eight remaining speakers produce an implosive as seen in figure 6. Hausa implosives display highly aperiodic vocal cord vibrations during the closure. The spectrum shows no clear formant structure but there is a peak around 3500 Hz. This peak cannot be due to cavity resonance from sharp closures in the vocal cord vibrations. If it were, the lower formants would be apparent as well as one at this high frequency. The peak is possibly instead due to noise from INcomplete closures in the vocal cord vibrations, and possibly also to noise generated by perturbations of the vocal tract walls as the larynx descends. The incomplete closures would also explain why the Hausa implosives last a shorter time, as there will be leakage of air through the descending glottis.The Hausa implosives are thus produced with aperiodic, inefficiently closing vocal cord vibrations. This is usually also labelled "laryngealization". Apparently, what we label laryngealization may involve several different mechanisms.

The voiced plosive [b] in Hausa is illustrated in figure 7. Typically it has periodic voicing vibrations with decreasing amplitude during the closure phase, so the voicelessness or aperiodicity in Hausa implosives may serve to keep them apart from the voiced plosives.

Thus, Hausa implosives are characterized by a type of creaky phonation, implosion, and relatively short duration. The Hausa implosives differ considerably from those in the Niger-Congo languages. This supports the reconstruction of implosives in Proto-Chadic (Newman and Ma 1966).In case they had been borrowed from neighbouring Niger-Congo languages, one would have expected closer agreement in their phonetic properties to Niger-Congo type implosives.

Summarizing the data on implosives, it is apparent that there are several independent phonetic parameters distinguishing segments that have been called implosives in different languages. Some languages use one combination of values of these parameters and others another combination. It is also evident that there is considerable speaker to speaker variation between implosives in languages, and that languages may differ in the way that they maintain distinction between implosives and the corresponding voiced plosives.

Ejectives.

Ejectives are more common in the languages of the world than implosives, about 18% of the world's languages have ejectives. These stops are produced with a closed glottis moving rapidly upwards, followed by glottal and oral releases. My data on ejectives consist of velar ejectives from twelve Hausa speakers and nine speakers of Navaho, an Athabascan language spoken in the Southwestern United States. These data were also analysed from displays of the waveform.

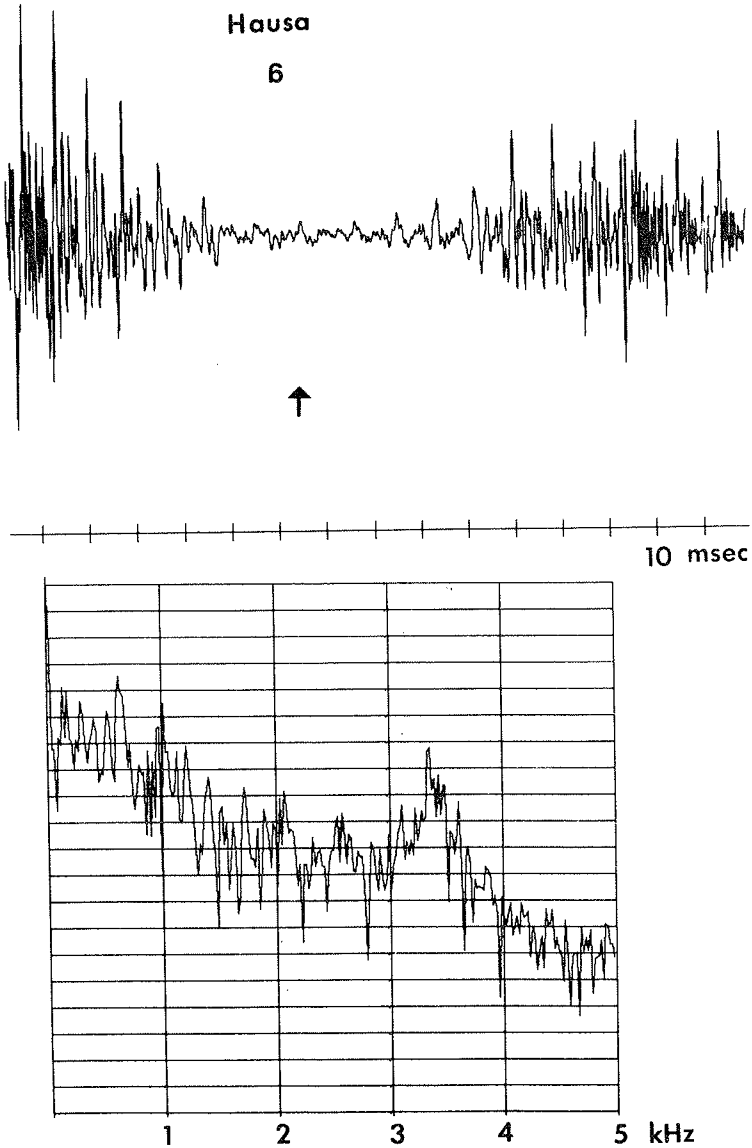

Figure 6. Waveform and spectrum of the labial implosive in Hausa.

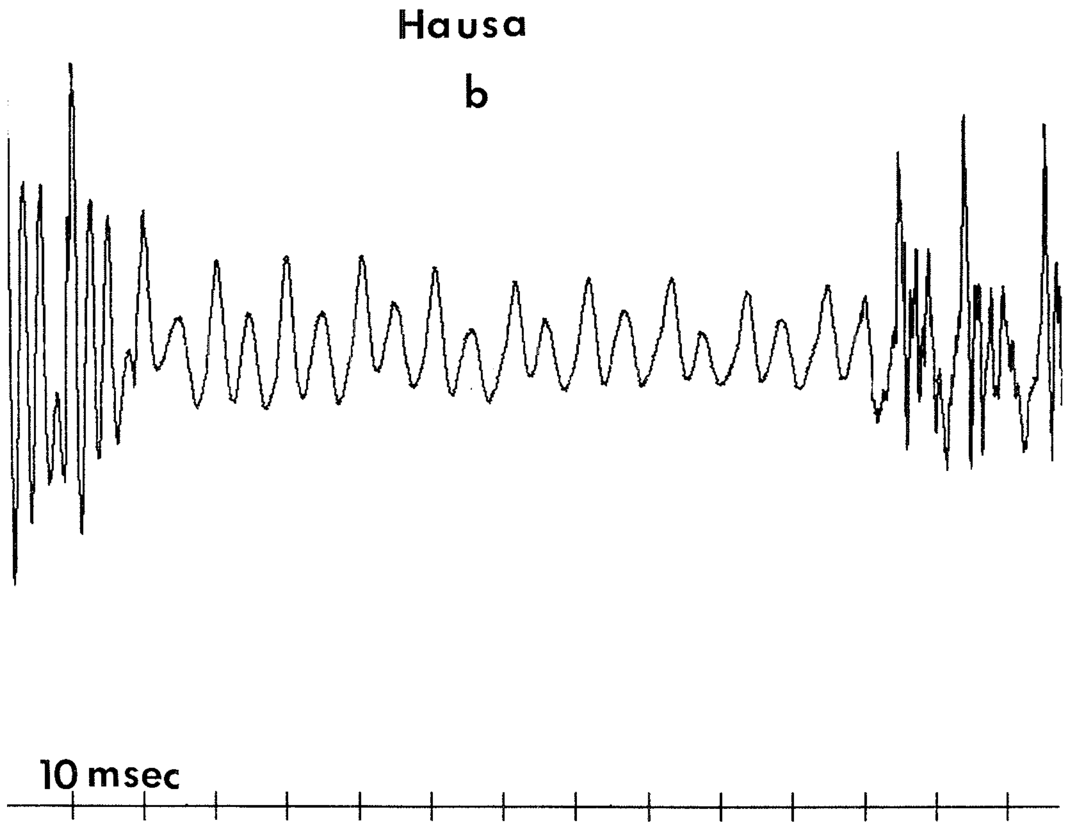

Figure 7. Waveform of the voiced plosive [b] in Hausa.

For each ejective, the total duration - that is, the sum of the closure duration and the VOT - was measured and a ratio of the closure duration to the VOT was calculated. A qualitative examination of the waveform was made to reach conclusions about phonation type.

The results show that here too variation between speakers was prominent in Hausa. Four out of the twelve Hausa speakers realise the ejective /k'/-phoneme, not as an ejective but as an unaspirated [k] or as a voiced [g]. All nine Navaho speakers have a true ejective [k'].

Figure 8 shows histograms of the means of the total duration and the closure duration/VOT ratio. Standard deviations are shown by the bars. For both these measures, the differences between Hausa and Navaho are highly significant. The ejective in Navaho has more than twice the total duration of the one in Hausa. This difference is not due to a slower speaking rate in Navaho. The rate of speaking in both languages was measured as number of syllables per second, and the difference was non-significant (both 4.3 - 4.5 syllables per second).

As the difference in the ratio indicates, these languages also differ in relative durations of the different parts of the ejectives. The closure duration in Hausa is about twice that of the VOT part, while the closure duration in Navaho is only 1.5 times as long as the VOT.

In addition, the vowel onset differs considerably in the two languages. This is illustrated in figure 9. In Navaho the glottal release coincides with the vowel onset, so the vowel starts with a sharp, large amplitude.

In Hausa, the glottal release occurs together with the oral release, and the vowel begins gradually, with aperiodic vibrations. This aperiodicity of the vowel onset after the ejective could be an important cue for differentiating voiceless plosives and ejectives in Hausa, since the Hausa velar plosive is followed by periodic onset of the vowel.

In conclusion, this study shows that both implosives and ejectives can vary in a number of ways. Some of this variation is reliably associated with the particular language concerned. From this it follows that contrasts between similar pairs of segments, such as implosives and voiced plosives, may be maintained by different values of particular phonetic parameters in different languages. These facts suggest that the phonetic component of the grammars of languages must be much more specific and detailed than is provided for in most current theories.

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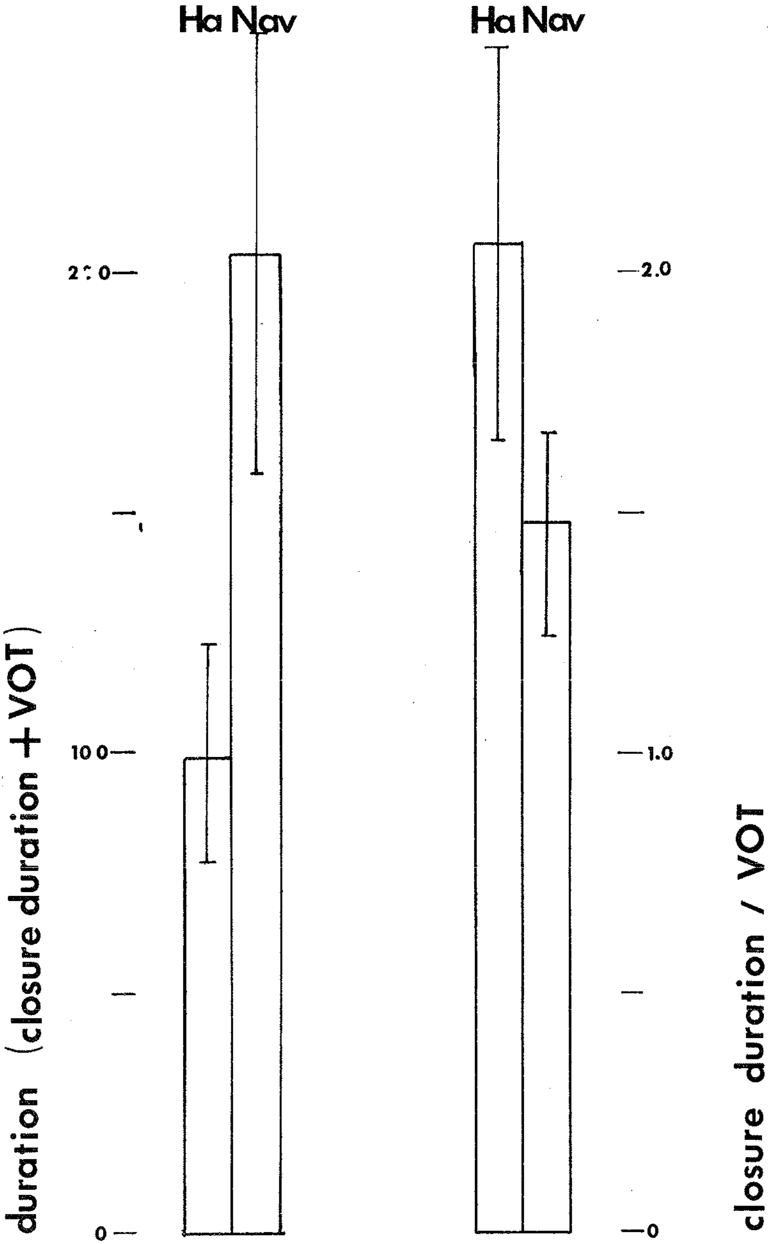

Figure 8. Means of the total duration and the ratio closure duration/VOT in Hausa and Navaho.

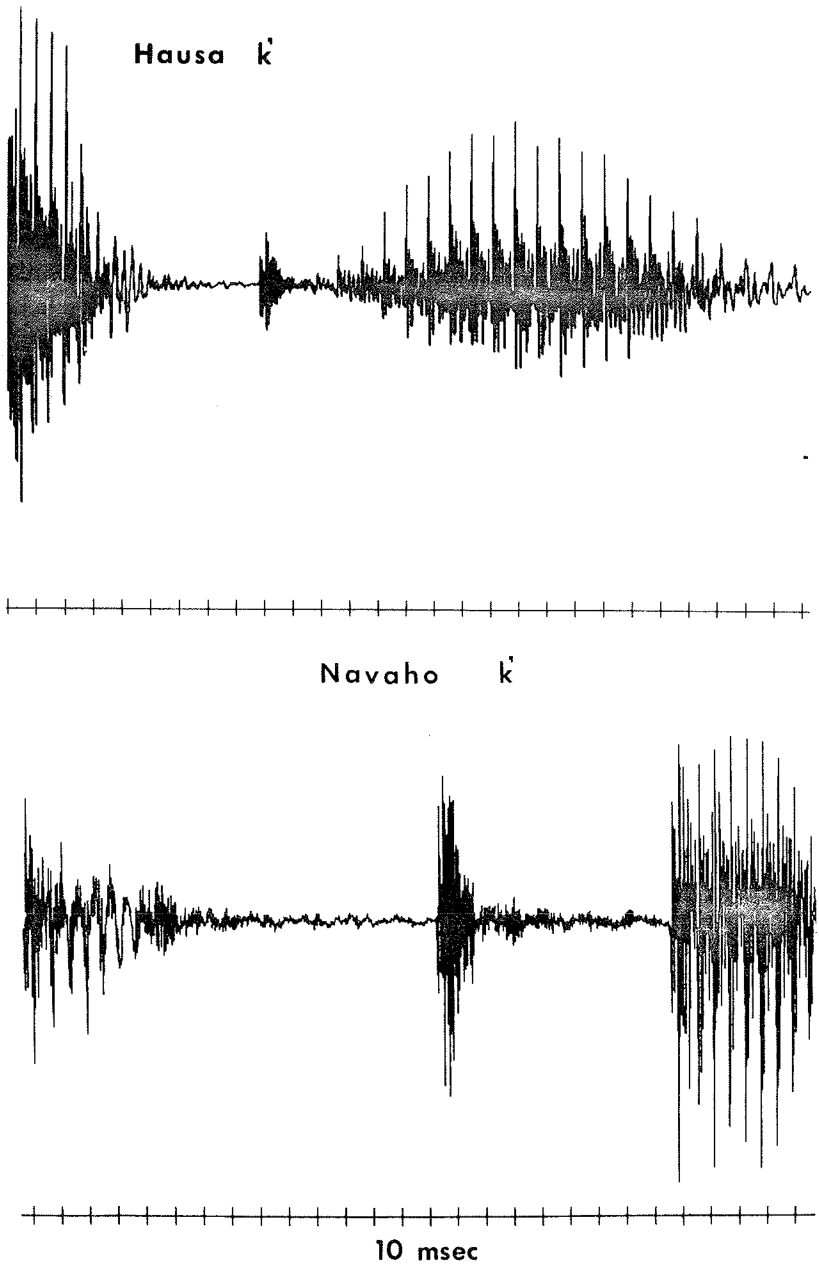

Figure 9. Waveforms of the velar ejectives in Hausa and Navaho.