Contrastive Lateral Clicks and Variation in Click Types

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Abstract

We report on a new click type found in Mangetti Dune !Xung (M.D. !Xung) - a forward released denti-alveolar lateral click, transcribed [ ||| ]. We present acoustic data showing that ||| is distinct from the "typical" lateral (post-) alveolar ||, and the central (post-) alveolar !, a conclusion supported by synchronic and diachronic analyses of Northern Khoisan [8, 12].

We use Adaptive Dispersion [6] to account for acoustic differences seen between || in !Xung and Ju|'hoansi, a related language without the ||| click.

The ! click is distinct from both || and ||| lateral clicks in rise time till peak intensity [4, 5], burst duration and peak burst frequency, while || and || differ primarily in terms of rise time and peak intensity.

1. Introduction

The International Phonetic Association currently recognizes 5 contrastive click types in the languages of the world, though clicks are only a regular feature of Southern African, and East African languages. The five recognized click types are given in the chart in (1) along with their phonetic labels [3].

![Click Types Chart]

(1) Currently Recognized Click types

<table>
<thead>
<tr>
<th>Bilabial</th>
<th>Dental</th>
<th>Palatal</th>
<th>Alveolar</th>
<th>Lateral Alveolar</th>
</tr>
</thead>
<tbody>
<tr>
<td>O</td>
<td>!</td>
<td>!</td>
<td>!</td>
<td>!</td>
</tr>
</tbody>
</table>

All of these click types except for the bilabial click are present in both Northern Khoisan languages discussed in this paper. The existence of an additional contrastive click type in the Northern Khoisan language M.D. !Xung has also been noted [8, 12]. The click type is described as a forward released lateral click, and it is transcribed with the symbol [ ||| ]. The data in (2) give an illustrative minimal triple showing the contrast between the [!], [ || ] and [ ||| ] click types in M.D. !Xung. In Ju|'hoansi there is only a two-way contrast between the [ ! ] and [ || ] click types.

(2) Minimal Pairs between [!], [ || ] and [ ||| ] click types in Mangetti Dune !Xung

| Ju|'hoansi | !Xung | English Gloss |
|-------|-------|----------|
| ηηηηη | ηηηηη | ‘Tylosema’ |
| ηηηηη | ηηηηη | ‘eland’ |
| ηηηηη | ηηηηη | ‘inside’ |

The acoustic attributes of this new click type will be discussed in this paper, and the contrast between this click type and the most similar other click types in the same language, the central alveolar and the lateral alveolar click types, will be motivated.

The acoustic attributes of the central alveolar and lateral alveolar click types in Mangetti Dune !Xung and Ju|'hoansi are similar to the attributes of these click types in Xhosa [10], in the Southern Khoisan languages [4, 5, 15] and in central Khoisan languages [2]. This new click type is important to phonetics and phonology, in that it motivates a new contrastive sound which phonological theories will need to account for.

The recognition of this click type also aids in the historical reconstruction of Northern Khoisan click types, where correspondences are found between the alveolar and the lateral alveolar click type in different languages. [8, 12]

2. Method

We collected cognate sets of words which had been transcribed by previous researchers [13] as having a lateral alveolar click in Mangetti Dune !Xung and a central alveolar click in Ju|'hoansi. Through its auditory properties and visual cues atesting to different articulations, as well as native speaker intuition, we determined that the lateral clicks in these words were different from the lateral clicks in the words that correspond to lateral clicks in Ju|'hoansi.

In order to investigate the acoustic differences between the two lateral clicks in M. D. !Xung, we recorded 20 cognate sets that both contained central alveolar clicks, 10 cognate sets that both contained lateral alveolar clicks, and 12 cognate sets that...
contained alveolar clicks in Ju|hoansi and the new forward released lateral click type in M. D. !Xung. We recorded these word sets at 22050 Hz, capturing digitally on a Toshiba Laptop computer using PCQuirer speech analysis software developed by Scicon, and using a Shure SM10A head-worn microphone. The words were recorded by a single female M.D. !Xung speaker, as well as a single female Ju|hoansi speaker. Spectra were computed using a 20 msec. Hamming window centered over the beginning of the burst for each token, using the X-Waves Xspectrum utility. The acoustic properties of an additional male speaker, and two additional female speakers’ productions of ! and || click types in Ju|hoansi were also used to attempt to gain a picture of the range of acoustic variation of lateral clicks in Ju|hoansi, in order to determine whether the differences found between the lateral alveolar and the central alveolar click types in the two languages are language differences rather than individual speaker differences [9]. A total of 73 central alveolar click types and a total of 60 lateral alveolar click types were used to investigate acoustic properties of these click types by these three speakers. All clicks were word initial.

Several measures are reported on in this paper. Measures of peak frequency were taken from the 20 msec. spectral slice described above. Mean values for each speaker are reported here. Burst duration (the time from the beginning of the burst until the voice onset of the following vowel) was also measured for each click type, and mean values are reported. Mean rise time to peak amplitude [4] is also reported for each click type.

3. Results

In (2) below, we show waveforms of one token each of the three click types in M. D. !Xung along with one token each of the two click types in Ju|hoansi.

3.1 Waveforms of |||áäng 'tylosema' (top) and ||áäng 'eland' (bottom) in Mangetti Dune !Xung

(a) Waveforms of g|ụụ 'belly' (top) and g|ụụ 'water' (bottom) in Mangetti Dune !Xung

The clicks don’t differ much in their peak burst frequencies, as shown by the averaged spectra in Figure 1. However, the [ || ] click type has slightly higher peak frequency than the [ ||| ] click type. The average peak frequency of the central alveolar click for the M.D. !Xung speaker SR is 1033 Hz. with a standard deviation of 295 Hz., while the peak frequency for her lateral alveolar click type [ || ] is 2255 Hz. with a standard deviation of 255 Hz., and the peak frequency of the forward-released lateral click type is 2137 Hz. with a standard deviation of 155 Hz. The peak burst frequencies for [!] and [ || ] were significantly different in a t-test with t=12.1 at the level of p<.01, as was the difference between [ ! ] and [ |||| ], t=19.4 at the level of p<.01. However, there was not a significant difference on this measure between the two lateral click types.

Figure 1: Averaged spectra of all three click types under investigation: (1) central alveolar [ ! ]; (2) lateral alveolar [ || ]; and (3) forward released lateral clicks [ ||| ] produced by the Mangetti Dune !Xung speaker.

The two lateral clicks are quite different in other respects. The mean burst durations are given in (4), which show that the [ || ] click has the longest burst duration, followed by [ ||| ], and [ ! ] has the shortest burst duration. Standard Deviations are given in parentheses.

4. Averaged Burst Durations (msec.)

| Speaker & Language | || | ||| |
|-------------------|---|---|
| DX (Ju)          | 11.21 (3.3) | 22.8 (8) |
| DK (Ju)          | 13.06 (5.7) | 24.6 (7) |
| KK (Ju)          | 13.32 (5.7) | 28.7 (12) |
| NC (Ju)          | 11.2 (4.9) | 27.4 (9) |
| SR (!Xung)       | 14.82 (5.7) | 19.1 (4) |

The difference in burst duration between [ ! ] and [ || ] is significant as shown by an ANOVA for M. D. !Xung at the level of p<.01, and the difference between [ || ] and [ ||| ] was
also significant at the level of p<.05, but there was no significant difference between the burst durations of ['!'] and ['||'] in M.D. !Xung. For the Ju hoansi data, the difference in burst duration between ['||'] and ['!'] was significant as shown by an ANOVA at the level of p<.01, with a significant interaction between speaker and click type, and speaker. The difference between the burst durations of ['!'] and ['||'] were also highly significant at the level of p<.01, with no significant effect of language, but a significant interaction between language and click type.

Rise time to peak intensity has also proven to be a useful measure of contrastive click types in !Xôô [4,5]. This measure also shows a robust difference for the three M.D. !Xung click types investigated here. The mean rise times until peak intensity in M. D. !Xung are given in (5) for all three click types under study, as well as for the two click types produced by four Ju hoansi speakers. Standard deviations are given in parentheses. The Ju hoansi rise times are similar to the !Xung ones:

|             | !   | ||  | ||  | Speaker |
|-------------|-----|-----|-----|---------|
|             | 1.3 | 8.8 |  (5)| DX      |
|             | 1.9 | 10.74|  (4.6)| DK      |
|             | 1.6 | 9.69|  (6.7)| KK      |
|             | 1.4 | 9.54|  (7.3)| NC      |
|             | 1.4 | 12.1|  (9)| 4       |
|             |     |     |     | SR      |
|             |     |     |     | (!Xung) |

The graph in Figure 2 illustrates the differences in rise time to peak intensity in M.D. !Xung:

**Figure 2**: Rise Time Until Peak Intensity for all Three Alveolar Click types in Mangetti Dune !Xung

The M. D. !Xung ['||'] click type has a much faster rise time to peak intensity than the ['||'] click type does, and the ['||'] click type is slower than ['!] click type. A t-test showed a significant difference between the alveolar and forward released lateral clicks, as well as between the alveolar and lateral post-alveolar clicks ['||'] at the level of p<.01 (t=10.8 and t=8.0 ), as well as a significant difference at the level of p<.05 (t=2.548) between the two lateral click types in M.D. !Xung. There was no significant difference for any of the two like click types when grouped by language.

**4. Discussion**

The results show that there are two types of contrastive lateral clicks in M. D. !Xung. The newly introduced forward released denti-alveolar lateral click type has a longer burst duration than the further back released lateral alveolar click type, and a longer rise time until peak intensity, though the peak frequency is about the same as the further back lateral alveolar click type found in Ju hoansi and M. D. !Xung. We have shown in previous work [8, 12] that this additional click type also aids in the historical reconstruction of clicks in Proto Northern Khoisan. The synchronic status of the ['||'] click type motivates plausible acoustically and articulatorily based changes in click type within the various Northern Khosian languages.

Little work has focused on phonetic differences among click types in the different languages where they occur. There are indications that there is quite a bit of variability among click types cross-linguistically, particularly with regards to lateral clicks. Researchers have noted that the lateral click type in Hadza has a much more laminal articulation [11] than is typically found in Khoisan languages, [2, 4, 5, 14, 15]. Beach also shows palatograms indicating more laminal articulations in Xhosa and Khoekhoegowab [1]. Khoekhoegowab lateral clicks also pattern phonologically with dental and palatal clicks in allowing contrasting following front and back vowels, and not with the alveolar click type which co-occurs only with back vowels, as it does in other Khosian languages. [7, 14]

The burst durations reported in this study for M.D. !Xung show that the lateral click is significantly shorter in this language than it is in the related language Ju hoansi. Rise time until peak intensity is also slightly longer for the lateral alveolar ['||'] click type in M.D. !Xung than it is for any of the four Ju hoansi speakers, though there was no significant difference by language. While we cannot completely rule out the possibility of the burst durations being an individual speaker difference, the lack of difference in the temporal domain of the articulation of the ['!] click in the two languages, and the lack of variation in the duration of ['||'] bursts within the four Ju hoansi speakers studied here, indicates that this is a linguistic difference. It is likely that the difference in burst duration of ['||'] between the two languages is due to Adaptive Dispersion [6], where smaller contrastive sets are more spread out over the acoustic space than larger contrastive sets on a given dimension. Since there is no contrastive information in the burst spectrum, the temporal cues are particularly important, and should be maximally distinct in order to be perceptible to the listener.
Clicks are often thought of as unusual speech sounds, but we have added to the growing literature on clicks [2, 3, 4, 5, 10, 11, 14, 15] showing that they can be characterized acoustically using similar measures used in describing pulmonic consonants. While it is marked among the languages of the world to have two contrastive lateral sounds, many Australian languages have this property. The two contrastive lateral clicks in M.D. !Xung can be distinguished by rise time, a measure which is often used to show the difference between pulmonic plosives and affricates.

5. References


