

Chapter 1

Velar Tap in Dàgáàrè

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Bodomo (1997) describes intervocalic velar [g] in Dàgáàrè as fricative [ɣ]. With 42 tokens of intervocalic [g] from a native speaker of Dàgáàrè, we investigated the acoustic and articulatory features of the Dàgáàrè intervocalic velar [g] using ultrasound images, waveforms, spectrograms, and palatogram. The results of the study suggest that Dàgáàrè intervocalic [g] is not a fricative but a velar with strong tap-like features, a previously unattested sound in natural language (Ladefoged 1990). Following from this, we conclude that Dàgáàrè intervocalic velar [g] is not a fricative but a tap.

1 Introduction

Dàgáàrè is a Gur language of the Niger-Congo family, part of a language group known as the Mabia languages. It is spoken by about 1.5 million people in north-western Ghana and some parts of Burkina Faso (Kennedy 1966, Bodomo 1997).

Dàgáàrè is described as having twenty-five consonants and two underlying glides (Bodomo 1997). The vowel inventory contains nine vowels, with tongue root contrasts for high and mid vowels, but a single low vowel [a]. In Bodomo's (1997) description of the consonant inventory, the voiced velar stop [g] is said to alternate with [ɣ] intervocalically. The data included with this description is the single word (/pógó/ 'woman') where [g] occurs between RTR vowels. According to our auditory impression, including that of the second author who is a native speaker, intervocalic <g> is not a velar fricative.

This paper describes an acoustic and articulatory study of Dàgáàrè <g> in Central Dàgáàrè, spoken in Nadowli-Kaleo district in Ghana. Waveforms, spectrograms, duration, ultrasound images, and static palatograms of intervocalic <g>



are studied. The acoustic and articulatory results show that intervocalic <g> has the complex waveform, amplitude variation, formant structure, tongue movement, and closure typical of a tap, rather than a velar fricative.

2 Methodology

The data come from a native speaker of Dàgáàrè and were collected at ISRL Lab, University of British Columbia, in a room using Sennheiser MKH 8060 shotgun microphone at the sampling rate of 44kHz/16bit.

An Aloka Pro-Sound SSD 5000 ultrasound machine with an Aloka UST-9119-3.5 convex transducer (pulse frequency 3.5MHz, field of view 120°) collected a moving image of tongue movement. The ultrasound probe was positioned manually against the mylohyoid muscle and was kept stable with a mechanical arm. The stimuli for ultrasound and acoustic studies contain 42 tokens with intervocalic [g]. Each token was repeated twice.

To determine the place of articulation of the closure, a palatogram was recorded. The tongue was painted with charcoal mixed in olive oil before the participant produced four tokens with intervocalic <g>. After articulating each of the tokens, an image of the soft-palate was captured.

3 Results

All instances of intervocalic <g> were segmented manually in Praat (Boersma 2002) and a script was used to extract duration values. The waveform and spectrogram were manually extracted.

The waveform of Dàgáàrè <g> has a decrease in amplitude compared to surrounding vowels, but it is complex as can be seen in Figure 1. This is similar to the expected properties of a tap, but distinct from both voiced velar stops and resonants; from a voiced stop, we would expect a simple waveform for voicing, while with a resonant, we would not expect an amplitude decrease.

In the spectrogram of Dàgáàrè <g>, we regularly see formant structure throughout the consonant. This is typical of resonants and possible for taps but is not consistent with a stop. For a [g], we would expect a gap in the spectrogram with a voicing bar at the bottom; but this is not what we see for Dàgáàrè <g>. With a fricative, we would expect random noise, which is again not what we see. the spectrogram also shows that <g> does not feature spectral energy like the other non-sibilant fricative [v] in the spectrogram or a dorsal fricative (see Jesus & Shadle 2005).

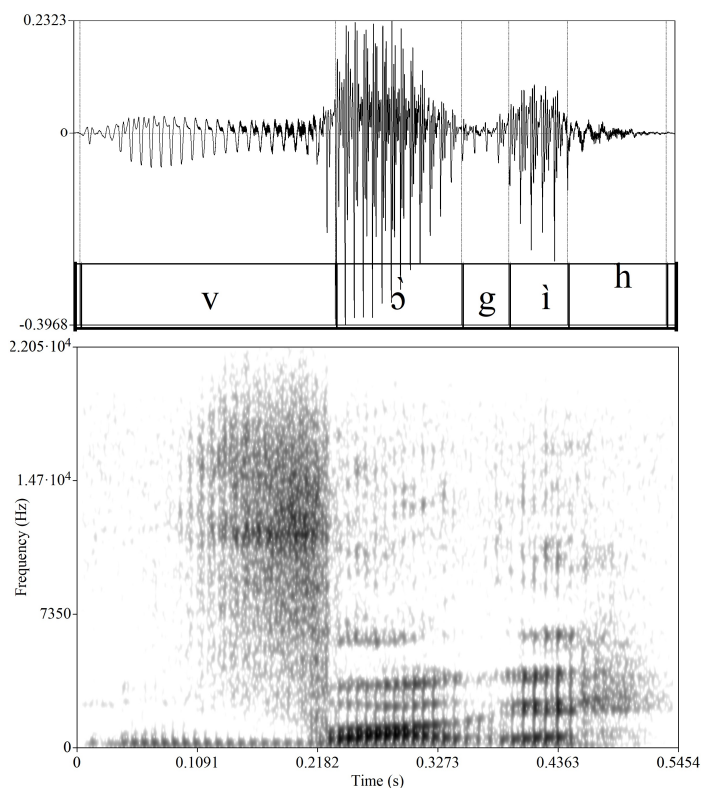


Figure 1: Waveform (top) and spectrogram (bottom) of Dàgáàrè <g>

In terms of duration (including both closure duration and release duration), the average duration of the collected <g> tokens was 0.055 seconds. This is substantially shorter than English [g], as a comparison, which has a duration of around 0.081 seconds (Byrd 1993: closure duration 54ms, release duration 27ms). It is also longer than an alveolar tap, which tends to have a duration between 0.028 and 0.041 seconds. The durations for the Dàgáàrè velar can be seen compared to English [g] and [r] in Figure 2.

On the ultrasound, the tongue movement between the vowel position and the consonant was substantial; the tongue back raised towards the palate/velum. This degree of movement is consistent with either a stop or a tap, because the tongue moves far from the vowel position to make closure. A resonant would have less movement, due to the lack of closure. The ultrasound images can be seen in Figure 3. A fricative would have less movement than a stop or tap, but more than a resonant; these images are potentially consistent with a fricative.

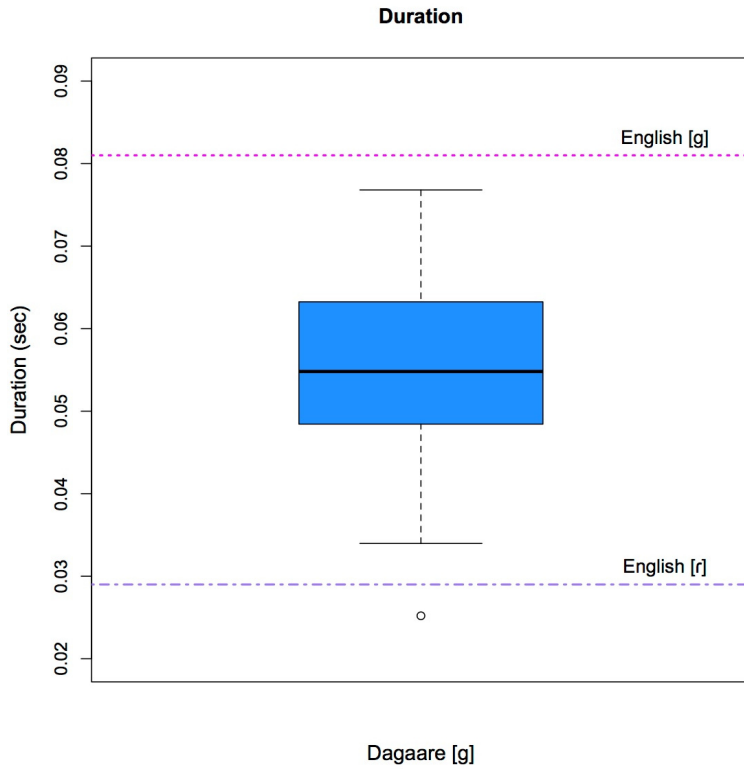


Figure 2: Dàgáàrè <g> relative to English [g] and [r]

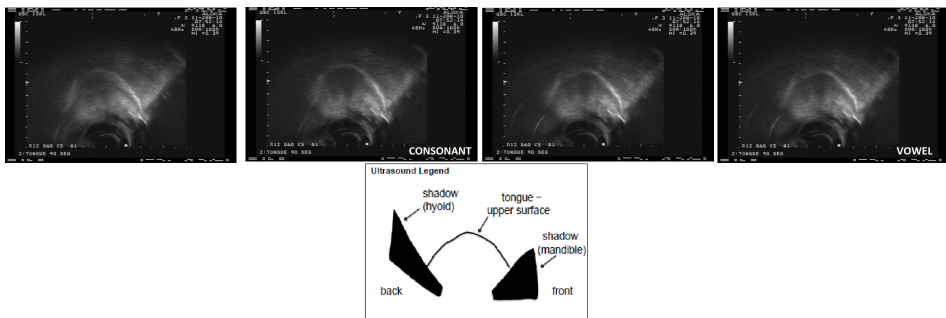


Figure 3: Intervocalic <g> in Dàgáàrè

In the palatography shown in Figure 4 (page 6), the pattern of charcoal left on the palate after production of <g> showed evidence of closure in the palatal/velar region. Closure is typically seen for stops and taps, but not for resonants or fricatives.

In summary, although the Dàgáàrè <g> has a longer duration than an alveolar tap, its production is most consistent with the behaviour of a tap, in terms of waveform, spectrogram, ultrasound, and palatography. In particular, it is not consistent with a stop or a resonant in a number of ways. These results are summarized in Table 1 (page 6).

4 Discussion and conclusion

The results show that intervocalic [g] in Dàgáàrè has a complex waveform, amplitude decrease, formant structure, a short duration, significant tongue movement, and closure. These features are strong tap-like features and suggest that Dàgáàrè intervocalic velar [g] is not a velar fricative but a tap. Such a segment type has previously been unattested and predicted, moreover, to be impossible (Ladefoged 1990). Given cross-linguistic evidence that velar softening mostly results in palatalization (Halle 2005) and the charcoal stain on the participant's velum and hard palate in the palatograms, we note however that the intervocalic velar in Dàgáàrè could be a palatal tap, a sound which is also unattested but predicted to be possible.

Given that this study was based on data from a single native speaker of Dàgáàrè, future work should focus on a larger population sample of Dàgáàrè speakers. Dàgáàrè intervocalic velar [g] should also be compared with velar [g] in clusters and related segments in related languages, e.g. lenited velars in Dagbani (Hudu 2010). This is a logical direction considering the argument in Elugbe 1978 that the lenis consonants in Edoid languages are taps.

Generally, this study has shown that Dàgáàrè intervocalic [g] is not a fricative, but a velar tap or a palatal tap which are both previously unattested sounds. Based on these findings, Dàgáàrè velar [g] requires further investigation.

Examples of words with voiced velar [g] in Dàgáàrè

- | | | |
|------------------------------|-----------------------------|-------------------------------|
| (1) <i>dàgà</i> 'box/coffin' | (4) <i>bègè</i> 'imbercile' | (7) <i>bógó</i> 'shoulder' |
| (2) <i>yàgá</i> 'cheeks' | (5) <i>pégí</i> 'shell' | (8) <i>dàgì</i> 'give birth' |
| (3) <i>wégè</i> 'log' | (6) <i>pógó</i> 'woman' | (9) <i>pàgì</i> 'close/cover' |



Figure 4: Palatogram showing closure

Table 1: Result summary

Properties	Dàgáárè results	Expected of			
		[g] ^a	tap ^b	resonant	fricative
Waveform	complex waveform, amplitude decrease	simple waveform (voicing)	more complex waveform, amplitude decrease	no amplitude decrease	random pattern in the waveform
Spectrogram	formant structure	gap with voicing bar	formant structure possible	formant structure	random noise
Duration	0.055 sec	~0.081 sec	~0.028–0.041 sec	<n/a>	<n/a>
Ultrasound	lots of tongue movement	lots of mvt.	lots of mvt.	less mvt.	intermed. mvt.
Palatography	closure	closure	closure	no closure	no closure

^a(Byrd 1993)

^b(Ting 2007)

- | | | |
|---|--|---|
| (10) <i>tìgì</i> ‘treat/heal’ | (15) <i>wógì</i> ‘tall’ | (21) <i>fùgì</i> ‘scare
away/threaten’ |
| (11) <i>sígì</i> ‘hut’ | (16) <i>bògì</i> ‘hole’ | (22) <i>pùgì</i> ‘praise’ |
| (12) <i>d̀v̀g̀v̀</i> ‘a kind of
dance’ | (17) <i>lígì</i> ‘to get dark’ | (23) <i>dìgì</i> ‘chase’ |
| (13) <i>v̀g̀g̀</i> ‘remove/take
off’ | (18) <i>tògì</i> ‘remove from
fire’ | (24) <i>sígì</i> ‘come down’ |
| (14) <i>tígé</i> ‘festivals’ | (19) <i>kógó</i> ‘chair’ | (25) <i>mùgì</i> ‘suck’ |
| | (20) <i>kógò</i> ‘mahogany’ | (26) <i>vígì</i> ‘owl’ |

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