

THE BILABIAL TRILLS OF AHAMB (VANUATU): ACOUSTIC AND ARTICULATORY PROPERTIES

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ABSTRACT

Ahamb, an endangered and previously undocumented language of Malekula Island in Vanuatu, has two phonemic bilabial trills - a prenasalised voiced /^mB/ (with a complementary voiceless allophone word-finally) and a plain voiceless /β/. This paper adds to our knowledge about these rare sounds by describing their acoustic and articulatory properties, including measurements of the nasal and/or oral closure duration and the frequency of vibration. Such data for bilabial trills in other languages are rare, especially for /β/. The analysis is based on audio recordings of citation forms for 11 speakers and examples extracted from connected speech.

The results suggest that prenasalisation, rather than voicing is the primary cue for contrast between /^mB/ and /β/. Besides, in some realisations of Ahamb bilabial trills, trilling appears to fail. Evidence from slow motion video recordings of Ahamb speakers suggests that in some such examples the lips may still oscillate without producing complete closure.

Keywords: bilabial trill, prenasalisation, Malekula, Ahamb

1. INTRODUCTION

Bilabial trills are typologically rare [11]. Most languages with bilabial trills are geographically clustered in a handful of “hotspots” including Central Africa, Papua New Guinea and Malekula Island in Vanuatu [9]. Bilabial trills have two main portions: a *bilabial closure* followed by a *period in trilling*. They can be plain (voiced or voiceless) or may be prenasalised. For the prenasalised trill the bilabial closure period normally involves a relatively long *nasal closure* (lips closed, nasal airflow present) followed by a shorter *oral closure* (absence of both nasal and oral airflow). Plain trills feature a long oral closure. Both trill categories normally involve a *period in trilling* with 2-3 *trill periods* (oscillations of the lips). When the lips are oscillating in a trill, they do not always make full contact, especially in the second or subsequent oscillations [11]. Sometimes trilling seems to fail to occur where it is expected [6, 11, 18], which is a feature of trills in general [10].

Of the 32 languages of Malekula, at least a dozen are known to have a prenasalised voiced bilabial trill [^mB], either phonemic or as a variant of /^mb/ [1, 5, 7, 8, 9, 11, 15]. A non-contrastive plain voiceless [β] as a variant of /p/ has been documented in two of these languages [1, 5].

Ahamb (ISO639-3: ahb) is an endangered language with around 950 speakers, most of whom live on a small island of the same name off the southern coast of Malekula. The two previous publications about Ahamb were wordlists [4, 17], neither of which identified bilabial trills in the language. Current work on Ahamb, as part of a wider language documentation project, shows that both [^mB] and [β] are phonemic in this language, as illustrated by the contrastive set /^mbus/ ‘to squeeze’, /βus/ ‘coconut milk’, /^mbus/ ‘plain’, /pus/ ‘to ask’ [19]. Both trills occur in the syllable onset before /u, y, ə/, with /^mB/ also possible before /i/; /^mB/ can also occur word-finally, where it is devoiced: /xa^mB/ [xa^mβ] ‘fire’. Besides the bilabial trills, the phoneme inventory of Ahamb also includes: /^mb, p, ⁿd, t, ^ŋg, k, ⁿd̥r, r, m, n, ŋ, v, s, x, tʃ, l, j, w/, and the vowels /i, e, y, ø, a, o, u, ə/.

This paper adds to our knowledge about these rare sounds for which data is scarce, especially for /β/, whose phonetic properties have received little attention in investigations of other languages [1, 5, 12, 13, 14]. More specifically, it aims to establish the acoustic and articulatory characteristics of /^mB, β/ in Ahamb, including measurements of the duration of the nasal and oral closures and the frequency rate of trilling. Variants of bilabial trills where trilling appears to fail to occur are also discussed in this context. The characteristics that distinguish the two types of trills are identified.

2. DATA AND METHODOLOGY

2.1. Speech material, recording procedures and participants

The analysis presented in this paper is based on controlled wordlist data and connected speech collected in 2017 and 2018 by the author.

For the controlled wordlist data, 11 speakers (six women aged 18-43 and five men aged 23-53) were recorded producing target words from the wordlist in

citation form. When it seemed unnatural for a target word to appear on its own, it was included in a short carrier phrase. During the recordings, the author almost exclusively used prompts in Bislama and the speaker produced each form three times. The second repetition was used for analysis. The wordlist data come from a list of around 250 Ahamb words including words containing /ɸ, ^mB/, which were randomly dispersed in the list.

These data were recorded in two sessions for each speaker. Firstly, all words were recorded at 16-bit/48kHz using a Shure WH20 headset microphone with a ZOOM H4N audio recorder or a ZOOM Q8 video recorder. Of the 250 words, 28 were used for the present analysis including 12 forms with syllable-initial /^mB/ (e.g. /^mbut^mbutat/ ‘entangled’, /^mbynsi/ ‘to look’, /nma^mbən/ ‘chest’, /su^mbin/ ‘meeting’), 6 forms with word-final /^mB/, and ten forms with /ɸ/ (e.g. /ɸur/ ‘to trade’, /ɸys/ ‘to blossom’). A total of 209 occurrences of /^mB/ (143 of ^mBV and 66 of -^mBØ) and 110 occurrences of /ɸ/ were analysed. These recordings were used for calculating bilabial closure duration and the frequency rate of trilling. Simultaneously with these audio recordings, the speakers’ faces were recorded using a GoPro Hero 3 video camera at 120fps (2017) or a GoPro Hero 6 at 240fps (2018). The video data were used in the analysis of lip movement and contact.

Secondly, in separate sessions, the same speakers were recorded producing words from a subset of the main wordlist for the purpose of analysing nasal duration. The recordings were made using earbud headphones as microphones, as described by Stewart and Kohlberger [16]. This accessible method involves one earbud placed in front of one nostril and the other next to the mouth to produce a stereo recording that captures the relative intensity of sound exiting the nasal and oral cavities in different channels. Using this method, nasal duration can be more easily and precisely measured as the nasality cut-off point is clearly seen in waveforms and spectrograms, even if the recordings are otherwise of relatively poor quality. These recordings were made according to the guidelines provided by Stewart and Kohlberger [16] using a ZOOM H4N recorder at 16-bit/48kHz. Earbud recordings were used to calculate the nasal portion as a percentage of the total period of bilabial closure for /^mB/. This analysis is based on 107 occurrences of /^mB/ and 37 occurrences of /ɸ/.

All speakers for the wordlist data were born and spent most of their lives on Ahamb Island and reside there at present. In this paper the speakers will be referred to with the letter F (female) or M (male), followed by the speaker’s age.

For the connected speech corpus, over 20 hours of recorded natural speech were transcribed and

translated. Over 50 speakers aged 18-87 were recorded. Recordings included narratives, procedural texts, dialogues and targeted elicitation. Sound was captured primarily using an Audio Technica BP4025 cardioid microphone or, occasionally the Shure WH20 headset microphone or the ZOOM H4N and ZOOM Q8 inbuilt microphones. Most connected speech recordings therefore captured more background noise than the wordlist recordings. A total of 100 tokens with /^mB/ and 40 tokens with /ɸ/ were extracted. Of them 22 realisations of /^mB/ and 6 of /ɸ/ were considered “successful” and analysed.

2.2. Data processing and analysis

Waveforms and spectrograms were inspected in Praat [3]. The durations of bilabial closure and period in trilling were measured and the number of visible trill periods were counted. Following Maddieson [11], one trill period is defined as the period between a release of the bilabial closure and the end of a following (at least partial) bilabial contact. On a waveform and spectrogram this is manifested in a rise in amplitude and airflow (release) followed by a drop in amplitude and airflow (contact). Most often, the first trill period is more pronounced and any subsequent trill periods are weaker. When a trill was expected but no trill period was observed on the spectrogram and waveform, the trill was classified as “failed” (hereinafter referred to as a *failed trill* as opposed to a *successful trill*). Examples from the wordlist data where the above pattern was not present or had only one weak trilling period, were identified in the video recordings and the movement of the lips was observed at slow motion.

The earbud recordings were used to measure the duration of the nasal and oral closure during the period of lip closure. Absence of intensity in the oral channel of the recording indicates bilabial closure. Nasality is observed as the presence of waveform in the nasal channel.

3. RESULTS

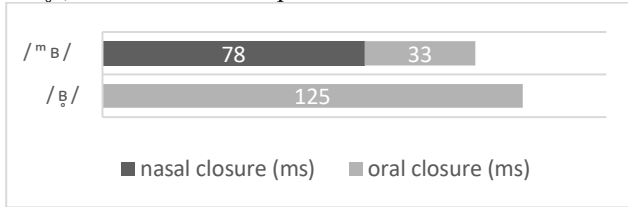
3.1. Bilabial closure

The mean duration of bilabial closure for the wordlist data was 111 ms (s.d. = 27) for /^mB/ and 125 ms (s.d. = 40) for /ɸ/. The mean percentage of the nasal closure as part of the bilabial closure for /^mB/ is 70% (s.d. = 11), calculated from the earbud recordings, see Figure 1.

Interspeaker variation was substantial. The mean closure duration for /^mB/ varied between 95 ms and 160 ms with the nasal closure percentage varying between 58% and 83%. The mean closure duration for /ɸ/ varied from 101 ms to 161 ms. Bilabial closure

duration for both /^mB/ and /β/ was consistent for each speaker, so for example if a speaker had long bilabial closure for /^mB/, it would be relatively long for /β/ too.

Figure 1. Mean duration of the bilabial closure for /^mB/, β/, and nasal and oral portions for /^mB/.



The significant nasal portion for /^mB/ and the significant oral closure for /β/ suggest that prenasalisation rather than voicing is the primary contrast between Ahamb's bilabial trill phonemes, which reflects a similar distinction between plosives.

3.2. Trilling

Realisations with one to four trill periods were observed during spectrogram and waveform analysis. Most commonly two trill periods were observed.

Figure 2: Waveform and spectrogram for [ᵐB], [β] and [ᵐβ] demonstrating clear trill periods and their acoustic realisation. In this example of [β], the trill overlaps with the following vowel and a clear vowel segment is missing. See [19] for the audio data.

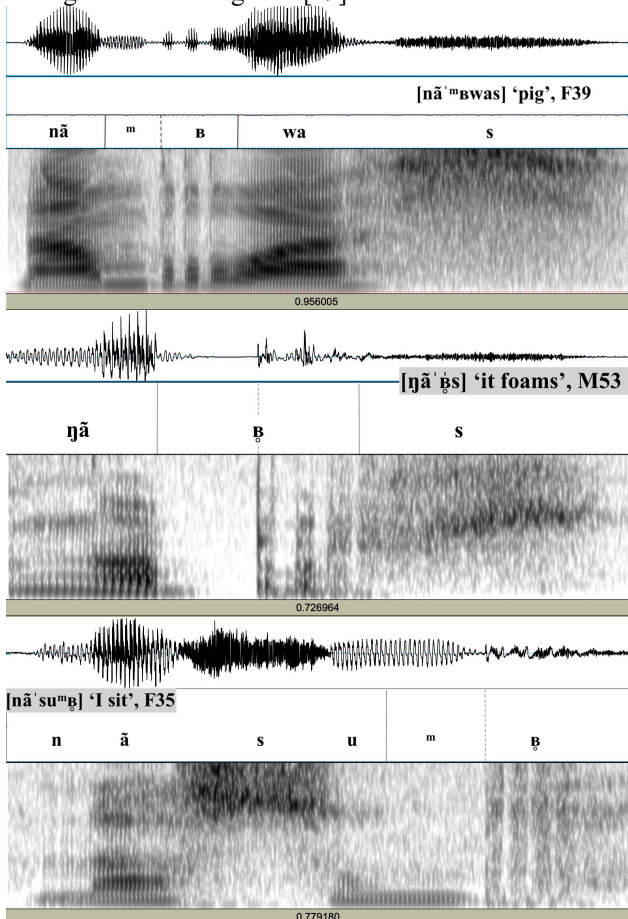


Figure 2 shows examples of three clear trill periods for [ᵐB] and [β] and four for [ᵐβ]. When the period in trilling is substantial, it often overlaps with the following vowel (when it is a monophthong).

3.3. Successful and failed trills

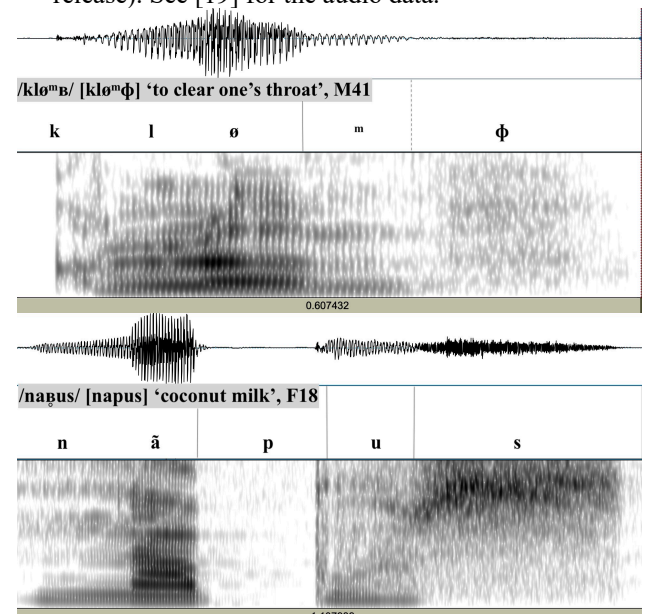
The success rate of trilling was relatively low, as can be seen in Table 1.

Table 1: Instances of successful trilling for /^mB, β/.

Trill type	Successful trills
Wordlist data:	
^m BV (n=143)	85 (59%)
- ^m B∅ (n=66)	26 (39%)
β (n=110)	48 (44%)
Connected speech data:	
^m BV (n=78)	20 (26%)
- ^m B∅ (n=22)	1 (4.5%)
β (n=40)	6 (15%)

Interspeaker variation for the wordlist data was considerable. One speaker did not produce any successful trills and 3 speakers produced only one or two successful trills (of the ^mBV type). On the other extreme, for one speaker all trills were successful and four speakers produced no more than seven failed trills. Success rates were lower in connected speech, which can be attributed to the higher speech rate and other effects of connected speech. This variation suggests that the trills have low functional load, which is also supported by the fact that there are few minimal pairs contrasting trills and plosives.

Figure 3: Waveform and spectrogram for failed variants of /^mB/ (fricated release) and /β/ (plosive release). See [19] for the audio data.



Failed variants of bilabial trills in other languages have been described as “one-tap trills” [6] or “stops with fricated release” [18]. In this analysis any forms without the amplitude and airflow pattern described in Section 2.2, were considered failed variants. They can be divided into two general types according to the observed closure release: (a) fricative-like release - a weak release followed by a period of turbulent airflow, and (b) plosive release – a very short sudden release, almost immediately followed by the vowel (or silence word-finally). Figure 3 above shows a /^mB/ with fricated release word-finally and a /B/ with plosive release.

3.4. Frequency rate of trilling

Table 2 lists the mean frequency rates measured in this study. The connected speech data were not broken down by type of trill, because too few successful tokens with /B/ and word-final /^mB/ were identified in the sample.

Table 2: Mean frequency rate of trilling for successful bilabial trills in wordlist data and connected speech.

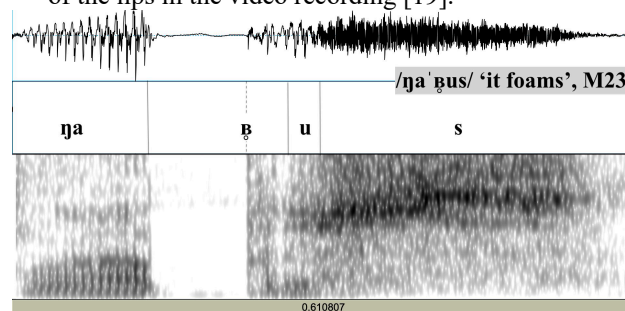
Trill type	Mean frequency rate of trilling (Hz)
Wordlist data:	
^m BV	28.3 (s.d. = 3.8)
- ^m B∅	24.9 (s.d. = 3.3)
B	29.5 (s.d. = 5.7)
Connected speech data:	
All trill types	28.1 (s.d. = 6.4)

The results show no considerable difference between /^mB/ and /B/. A slower trilling rate was observed for /^mB/ word-finally.

3.5. Lip movement

Observations of the slow motion video recordings of Ahamb bilabial trills showed that at least in some cases weak oscillations were visible even when they were not clearly detectable on the waveform and spectrogram, both in failed and successful trills (e.g. one trill period is heard but two oscillations of the lips are seen), cf. Figure 4 and the corresponding video [19]. Only one trill period could be identified on the spectrogram but at least two clear oscillations of the lips can be observed in the video. The video also demonstrates that the lips are looser and less rounded for the trill than for a plosive in the same environment.

Figure 4: Waveform and spectrogram showing one clear trill period, compared to two clear oscillations of the lips in the video recording [19].



4. DISCUSSION AND CONCLUSIONS

This investigation provides a phonetic study of two rare sounds using newly collected data from an endangered language. The analysis finds that the observed frequency rate of trilling was similar to what has been reported for bilabial trills in other languages [10, 11]. The measurements of nasal and oral closure confirmed that prenasalisation (rather than voicing) is likely the main strategy to contrast between the different bilabial trills, mirroring a similar distinction for plosives.

The relatively high rates of failed trilling with substantial interspeaker variation may be an indication that the status of these sounds is unstable. There is evidence that bilabial trills are falling out of use in other Malekula languages [2, 9]. Therefore, future work on bilabial trills in other Malekula languages and on variation is suggested.

Video data showed that trilling can sometimes be too weak to produce a significant acoustic cue. A perception study could shed more light on this issue.

Language documentation approaches can clearly benefit from close examinations of speech sounds. Given that Vanuatu’s bilabial trills have been subject to limited phonetic exploration, hopefully this study can help in laying the groundwork for future investigations into these rare sounds.

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