

Notes on *creaky* and *killed* tone in Burmese.¹

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1. Introduction

The four tones of Burmese (*low*, *high*, *creaky*, *killed*) are of special interest to phonologists and phoneticians because they can be explained only with reference to several aspects of the language's phonological structure, both segmental and suprasegmental, including the features of pitch level, pitch contour, phonation type, vowel quality and duration. This study explores the multi-tiered structure of the tones by focusing on two tones, *creaky* and *killed*.

A glance at the survey of some of the published descriptions of Burmese tone in Table 1 suggests that one of their most striking features is the lack any real consensus on major issues such as the pitch characteristics of the *low* and *high* tones, whether or not *killed* can properly be counted as a tone, whether or not breathy phonation is a consistent feature of *high* tone, and so on. Some of the anomalies in the descriptive schemata summarised in Table 1 are discussed below, although the formulation of a comprehensive account of tonal phenomena in Burmese remains far beyond the scope of this paper.

Regarding the number of tones, Allott (1967) writes: "In different descriptions of Burmese one finds the apparently conflicting statements that Burmese has variously 5 tones, 4 tones and 3 tones. In fact none of the authors is in any doubt about how to describe Burmese; they simply do not agree in their use of the word 'tone'." Whichever syllable types one chooses to recognise as tones, the varied descriptions of each tone arise chiefly for two reasons. The first is a complex array of tonal *sandhi* phenomena, which have yet to be fully described. It is clear, however, that Burmese tones cannot be described fully with reference only to the differences between syllables pronounced in any one context. The pronunciation of a tone may be determined in part by the segmental or intonational context, or even by the syntactic features of the syllable by which it is borne and the syntactic structure of the environment in which it is found. In addition to these systematic influences, intonation wreaks further complex changes on the surface phonetic rendering of the tones. Preliminary descriptions (Sprigg 1977, Watkins 2000) of some of these effects have been assembled, but much work remains to be done.

Nonetheless, acknowledging the existence of such effects accounts for the discrepancies between existing descriptions. The various authors, in addition to Watkins (2000) and the present paper, describe syllables either in isolation or in a context which may differ between studies or even within the same study, so it is not surprising that they do not tally in all respects.

¹ Burmese was renamed 'Myanmar' in 1989, though the change of name for the language has not been universally adopted. Many thanks to Kevin Wang and Lwin Ohn Soe for allowing me to record them.

Table 1. Survey of descriptions of Burmese tones.

Author (s)	Verbal description of tone		
	Low (ခေ)	High (ခေး)	Creaky (ခေ)
Armstrong & Pe Maung Tin (1925)	low and level	high falling	medium length, creaky voice, “terminated by a weak closure of the glottis”
Bernot (1963)	low, long, medium intensity	pitch between low and creaky tones, very long, high intensity to begin, falling off at the end	high, short, forceful pronunciation, “et, à la fin, un arrêt brusque de la voix, avec occlusion glottale faible”, i.e. weak glottal stop
Richter (1967)	low onset, slightly falling, long	high onset, falling, long	high onset, slightly falling, short, “schwacher harter Stimmabsatz”, i.e. weak glottal stop
Stewart (1936)	relatively low-pitched, “no fall is permissible”	begins high-pitched, falling evenly, breathy voice	falls jerkily and terminates in a weak closure of the glottis
Bradley (1982)	low level or rising pitch, low intensity, normal phonation, long	fairly high, rising and/or falling pitch, high intensity, sometimes breathy, long	high, slightly falling, very high intensity, creaky phonation, less long
Thein Tun (1982)	moderate	long	short
Yip’s (1995) interpretation of Bradley (1982)	plain (clear) ‘L’	breathy ‘M/HM’	‘HL’
			very short
			[omitted]

2. Comparing *creaky* and *killed* - a summary of phonetic correlates of Burmese tones

Some instrumental data illustrating the more easily measured phonetic correlates of Burmese tones are given below. These data were measured from syllables in a controlled context, namely the frame sentence Table 2, as is customary in experimental studies of phonological contrasts.

Table 2. Frame sentence used for recording

/di:ne:ja:m̩a: _____ pa:jĩ: məkaũ:bú:lá:/
 ဒီနေရာမှာ _____ ပါရင် မကောင်းဘူးလား။
 “Wouldn't it be better if _____ were included here?”

Table 3. Burmese syllables recorded for experimental analysis

<i>low</i>		<i>high</i>	
pa: ပါ	ma: မာ	pá: ပါး	má: မား
ta: တာ	na: နာ	tá: တား	ná: နား
ka: ကာ	ɲa: ငါ	ká: ကား	ɲá: ငါး
<i>creaky</i>		<i>killed</i>	
pá ု	má ာ	pá? ုတ်	má? ာတ်
tá ာ	ná ာ	tá? ာတ်	ná? ာတ်
ká ာ	ɲá ာ	ká? ာတ်	ɲá? ာတ်

A single male Burmese speaker from Rangoon (Yangon) was recorded reading twice each of the syllables in Table 3 inserted into the frame sentence. The material was presented in Burmese script in quasi-random order, recorded in the sound-proofed recording studio at the School of Oriental and African Studies in London. The recordings were made on digital audio tape (DAT) using an electret condenser microphone with a Bruel-Kjaer 2069 preamplifier. Simultaneous Fourcin Laryngograph (EGG - see Abberton et al. 1989, Marasek 1997) traces were made using a portable machine manufactured by Laryngograph Ltd. Sound spectrograms were generated using PCLx Analyser software produced by Laryngograph Ltd and the Praat program².

² Available at www.praat.org. Many thanks to the creator of this software, Paul Boersma, for assistance in writing Praat scripts.

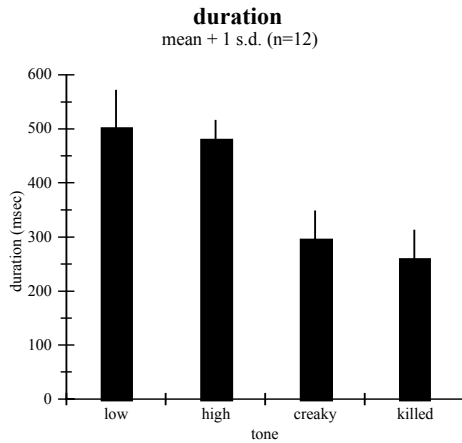


Figure 1. Mean duration of 12 syllables in each of the four tones.

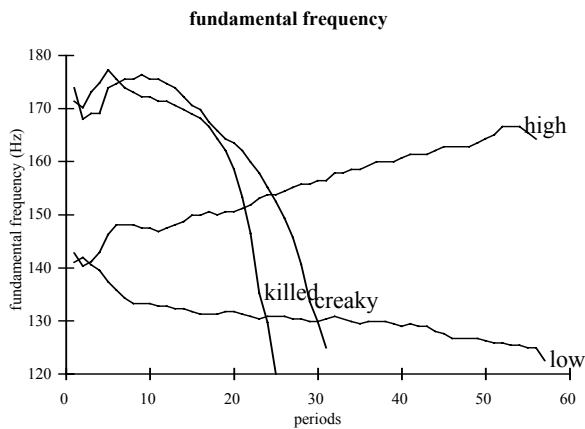


Figure 2. Fundamental frequency in each period of a single utterance of the four tones.

/ka: ká: kǎ kǎ?/ (က ကာ: က ကတ်)

Only one of the researchers whose work is included in Table 1 records *high* as possibly rising in pitch, which is the finding here, illustrated in Figure 2. The pitch contour of *high* was found in Watkins (2000) to be rising before *low* and *high*, but falling before *creaky* and *killed*, and so the rise recorded here is consistent with the context of the frame sentence, in which *high* precedes a *low* tone.

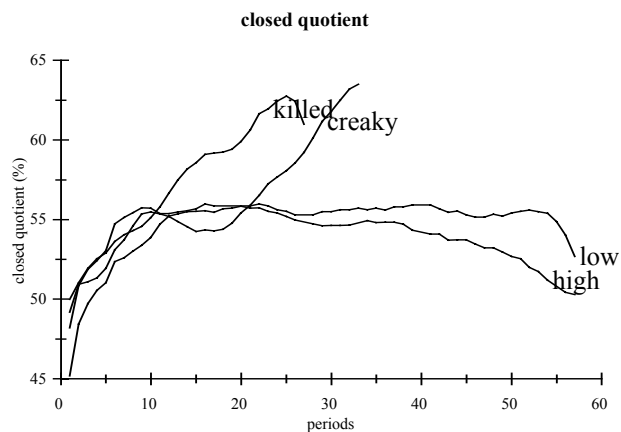


Figure 3. Closed quotient change

Closed quotient in each period of a single utterance of the four syllables /ka: ká: kǎ kǎ?/ (က ကး က ကဝ်)

Figure 3 gives an indication of variation in phonation type, as measured by laryngographically-derived closed quotient, where high closed quotient signals relatively creakier phonation and low closed quotient relatively breathier phonation.

Table 4 summarises the differences between *creaky* and *killed* tone reported by some authors. Predictably, in light of the discussion above of the differences between their descriptions, these are not uniform. The overbearing impression given by the illustrations of duration, pitch contour and closed quotient presented above and below is that *creaky* and *killed* are somewhat similar to each other in terms of these phonetic features, while *low* and *high* resemble one another in duration in closed quotient change, but not in pitch change.

Table 4. Reported differences between killed and creaky tone

Author	pitch level	pitch contour	phonation type	duration	vowel quality	intensity	‘weak glottal stop’
Armstrong & Pe Maung Tin (1925)			•	•	•		•
Stewart (1955)							•
Bernot (1963)							•
Bradley (1982)	•	•	•	•	•	•	
Richter (1967)		•		•			•

The degree of similarity between *creaky* and *killed* is further illustrated in Figure 4 and Figure 5, which demonstrate, respectively, that the patterns of pitch and phonation type in similar syllables in *creaky* and *killed* tone are indistinguishable. The second graphic in each of these Figures is an illustration of syllables with initial nasal consonants, in which part of each trace is a measurement of vocal fold vibration during the nasal consonant itself.

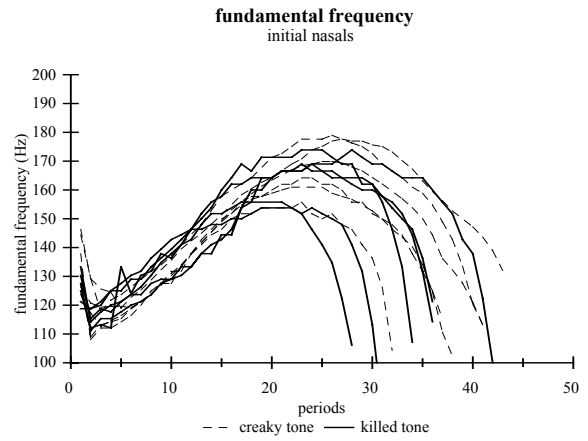
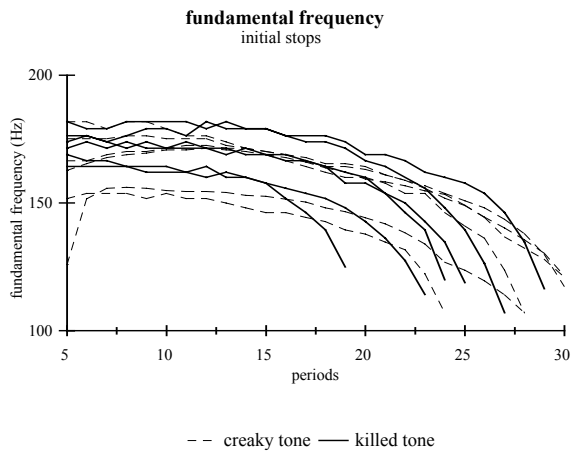


Figure 4.

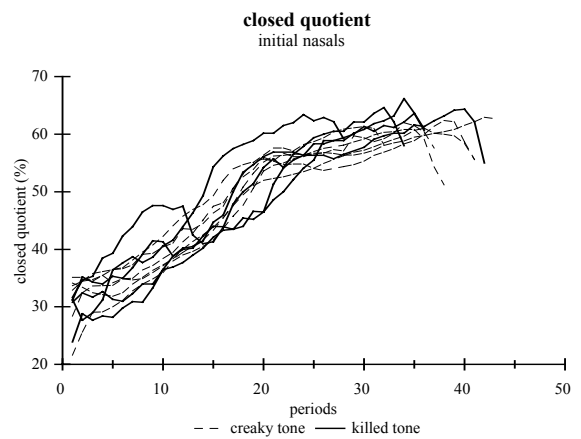
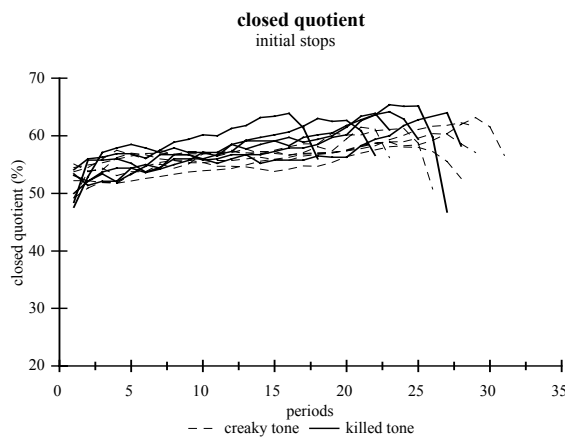


Figure 5.

3. Differences between *creaky* and *killed*

Despite their apparent similarities in terms of duration, pitch and phonation type, in practice *creaky* and *killed* are not easily confused.

3.1 Gemination of consonants following *killed* tone

The final glottal stop of a *killed* tone syllable assimilates to the initial consonant of a syllable which follows it, when the two syllables are adjacent in connected speech. The glottal stop assumes both the place and manner of articulation of the following consonant, resulting in the effective gemination of that consonant, as in the examples in Table 5.

Table 5. Assimilatory effects of Burmese *killed* tone

ʔə.máɪʔ <i>rubbish</i> အမှိုက်	+	poʊ: <i>bucket</i> ပုံး	>	ʔə.máɪ[p:]oʊ: <i>rubbish bin</i> အမှိုက်ပုံး
léʔ <i>hand</i> လက်	+	s ^h aʊ: <i>carry along</i> ဆောင်	>	lé[s ^h :]aʊ: <i>gift</i> လက်ဆောင်

téʔ <i>ascend</i> တက်	+	jaúʔ <i>arrive</i> ရောက်	>	té[j:]aúʔ <i>attend</i> တက်ရောက်
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This effect has been likened to the *raddoppiamento sintattico* effect of final stressed vowels in Italian, which similarly does takes place only across selected syntactic junctures, as in the examples in Table 6 below.

Table 6. Raddoppiamento sintattico gemination in Italian. Examples from Inkelas and Zec (1995:536)

città <i>cities</i>	+	vecchie <i>old</i>	>	città [v:]ecchie <i>old cities</i>
parlò <i>he spoke</i>	+	bene <i>well</i>	>	parlò [b:]ene <i>he spoke well</i>

3.2 Vowel quality

There is a distributional constraint on the set of vowels which are found in creaky and killed tone words. Non-nasalised creaky tone syllables may contain any of the non-nasalised vowels found with low and high tones, while the set of vowels which may occur in killed tone syllables is restricted to the syllables spelt with a final stop or final nasal consonant letter, which were closed syllables in Proto Lolo-Burmese (Thurgood 1981:3). The two vowel sets of non-nasal, open syllable vowels (Table 7) and nasal open syllable vowels or vowels in syllables closed with a glottal stop (Table 8), given in IPA transcription with example Burmese words.

Table 7. Orthographically open syllables

vowel quality	low tone			high tone			creaky tone		
	IPA	English	Burmese	IPA	English	Burmese	IPA	English	Burmese
/i/	mi:	(name)	မိ:	mi:	fire	မိ	mí	mother	
/e/	me:	May	မေ:	me:	ask	မေ့	mé	forget	
/ɛ/	mɛ:	mother	မဲ	mé:	vote	မဲ့	mé̃	without	
/a/	ma:	hard	မာ:	má:	towering	မ	má	female	
/ɔ/	mɔ:	look up	မော့	mɔ:	tired	မော့	mɔ̃	tilt up	
/o/	mo:	heaped	မိုး	mó:	sky	မိုး	mó̃	because	
/u/	mu:	nature	မူး	mú:	drunk	မူး	mú̃	respect	

Table 8. Orthographically closed syllables (killed tone or nasal vowel)

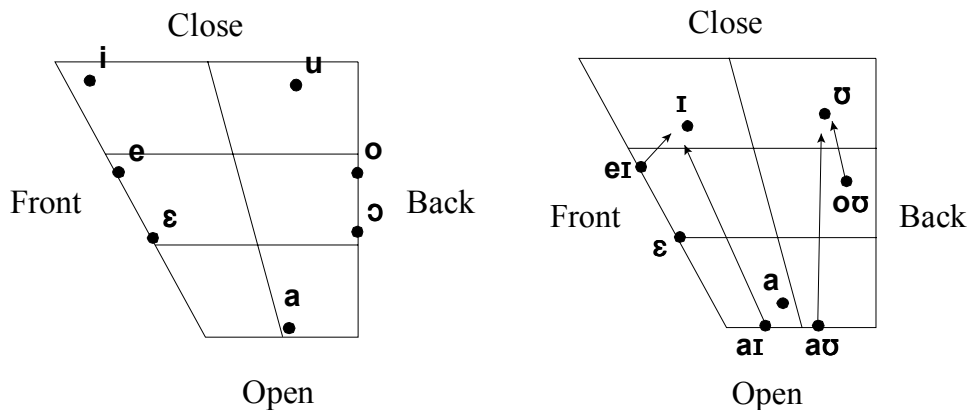
vowel	nasal vowel									killed tone		
	low tone			high tone			creaky tone					
/ɪ/	မင်	mĩ:	fond of	မင်း	mĩ:	king	မိ	mĩ	(particle)	မြစ်	mjɪʔ	river
/eɪ/	မိန်	meĩ:	season	မိန်း	meĩ:	girl	မိန်	meĩ	say	မိတ်	meĩʔ	friend
/ɛ/										မက်	méʔ	dream
/aɪ/	မိုင်	maĩ:	mile	မိုင်	maĩ:	mine	ပိုင်	paĩ	pint	မိုက်	maĩʔ	stupid
/a/	မံ	mã:	plaster	မန်း	mã:	recite	နန်း	nã	jiggle	မတ်	mãʔ	March
/aʊ/	မောင့်	maũ:	younger brother	မောင့်	maũ:	drive	စောင့်	saũ	wait	မောက်	maũʔ	haughty
/ou/	မုန်	moũ:	storm	မုန်း	moũ:	hate	မုန်း	moũ	flour	မုတ်	moũʔ	pearl
/u/	မွန်	mũ:	Mon	မွမ်း	mũ:	decorate	တွန့်	tũ	wrinkle	မွတ်	mũʔ	smooth

The asymmetrical distribution of vowels in orthographically open and closed syllables in Burmese means that in practise there are few instances where *creaky* and *killed* could occur on vowels with the same vowel quality: /a/ and /ɛ/ are the only two vowels which occur in all four tones in syllables with non-nasal vowels, while only /a/ occurs in all four tones, both nasal and non-nasal. Table 9 summarises the array of vowels found in each syllable type; Armstrong & Pe Maung Tin's (1925) description of the relative qualities of these vowels in terms of the proprioceptive vowel quadrilateral is reproduced in Figure 6.

Table 9. Distribution of vowels in orthographically open and closed syllables

vowels occurring in orthographically open syllables (non-nasal vowels on low, high and creaky tones)			vowels occurring in orthographically closed syllables (nasal vowels on low, high and creaky tones; killed tones)		
/i/		/u/	/ɪ/		/ʊ/
/e/		/o/	/eɪ/		/oʊ/
/ɛ/		/ɔ/	/ɛ/*		
	/a/		/aɪ/	/a/	/aʊ/

* killed tone only; there is no nasal vowel /ɛ/



in orthographically open syllables

in orthographically closed syllables

Figure 6 Burmese vowels as described by Armstrong & Pe Maung Tin (1925).

Table 10 Minimal *creaky* / *killed* pairs

	/a/	/ɛ/
<i>creaky</i>	/mjá/ မြဲ 'emerald'	/sɪʔmɛ́/ စစ်မဲ့ 'non-military'
<i>killed</i>	/mjáʔ/ မြတ် 'noble'	/sɪʔmɛ́ʔ/ စစ်မက် 'military'

There are only two vowels which can occur in both creaky and killed tones: /ε/ and /a/, as in the minimal *creaky/killed* pairs in Table 10. Experimental investigation suggests, however, that while most accounts of Burmese phonetics equate creaky tone /ε/ and /a/ with killed tone /ε/ and /a/, there are in fact consistent differences in vowel quality. Figure 7 and Figure 8 are F1-F2 plots illustrating the vowel quality at the mid-point of the *creaky* and *killed* tone vowels /ε/ and /a/

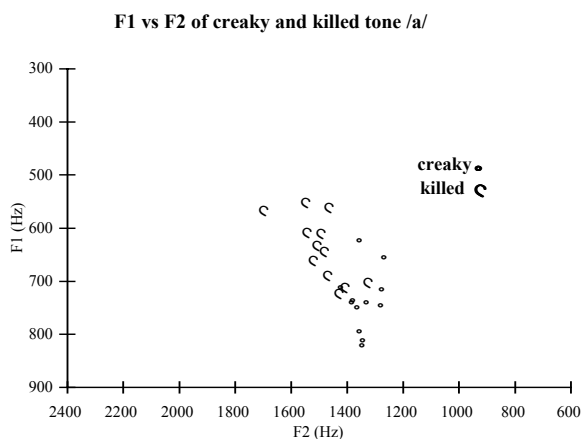


Figure 7. Vowel quality in *creaky* and *killed* tone /a/.

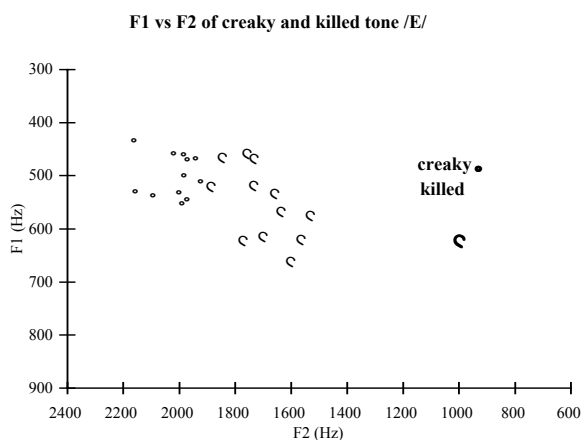


Figure 8. Vowel quality in *creaky* and *killed* tone /ε/.

Figure 7 shows that *creaky* /a/ is more open and back than *killed* /a/, while Figure 8 suggests that *creaky* /ε/ is closer and more fronted than *killed* /ε/. This variation in /a/ is consistent with the vowel qualities described by Armstrong & Pe Maung Tin (1925) illustrated in Figure 6, though not that of /ε/. It is possible that the variation in /ε/ may be an artefact of coarticulation anticipating the initial /p/ of the syllable /pa:/ (ɔ̃), which follows it in the frame sentence (see Table 2). The difference, especially in F2, is also visible in the spectrogram in Figure 10. A larger sample of measurements will be necessary to establish the finer detail of allophonic vowel quality variation in

Burmese. Whatever the source of the effect, these differences in vowel quality represent another factor distinguishing *creaky* tone from *killed*.

3.3 The weak glottal stop

What, then, of the much-vaunted ‘weak glottal stop’? The difference between the ‘weak glottal stop’ which ends *creaky* tone vowels and the final glottal stop of *killed* tone syllables is all that remains to distinguish these two tones if segmental assimilation of the final glottal stop of *killed* does not take place, and if no vowel quality difference is perceptible. This difference adds to the complex of phonetic features which set the Burmese tones apart.

Figure 10 shows a speech pressure waveform and Figure 10 a broadband spectrogram of a creaky and a killed tone syllable, allowing comparison of a ‘weak’ and a ‘full’ glottal stop. The full glottal stop illustrated here is characterised by a sharper fall in amplitude and a change from periodic vocal fold vibration during the vowel to cessation of vibration within two or three periods of swift and smooth deceleration. The ‘weak’ glottal stop, on the other hand, consists of more gradual, staggered fall in amplitude and a more prolonged transition from periodic vocal fold vibration to cessation of vibration, entailing some aperiodic periods of phonation. This difference is clearly audible to trained ears, although these events each last only a few milliseconds.

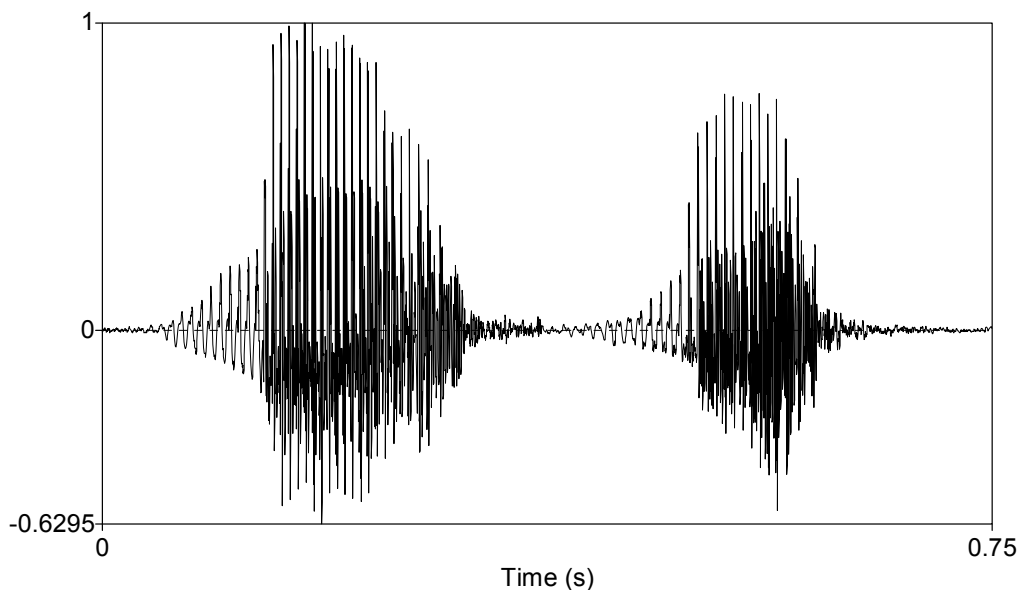


Figure 9. Speech pressure waveform of the syllables /mɛ́/မဲ and /mɛ́ʔ/မင်.

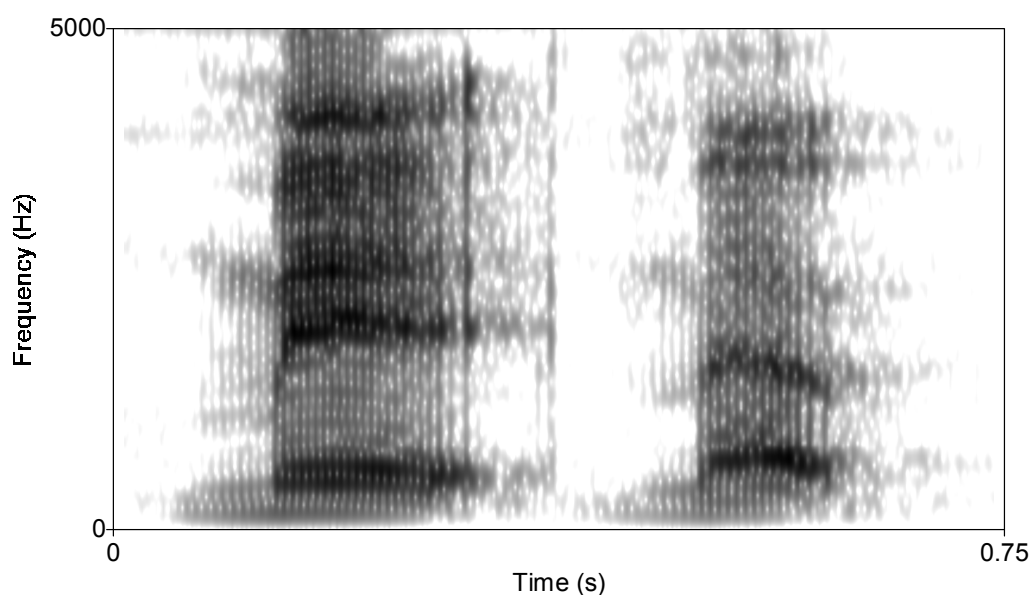


Figure 10. Broadband spectrogram of the syllables /mɛ̃/ and /mɛ̃ʔ/ မင်္ဂ.

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