

Tone and Intonation in Burmese

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ABSTRACT

This paper offers a first look at tone and intonation in Burmese. Using a speech sample of radio news broadcasts, pitch measurements were made of some 200 syllables. Even taking account of global pitch declination, statistical analysis suggests that tonal categories cannot be determined by the pitch characteristic of canonical pronunciations of the tones, unless the final phrase of each sentence, which has a distinctive low + rise pitch contour, is omitted. Furthermore, it is suggested that the pitch of final syllables of intonational phrases is determined its position in the syntactic structure of the sentence.

1. INTRODUCTION

This paper is a preliminary look at the relationship between tone and intonation in Burmese. It presents data which illustrate some of the effects of intonation on the pitch at which lexical tones in Burmese are realised in running speech. Relatively few studies have been made of intonation in tone languages, where attention is typically drawn to explaining the pitch behaviour of individual tones or tone strings in which tone sandhi effects of some kind are observed. The study of the tone–intonation relationship in Asian tone languages, which differ typologically from African tone languages, has been advanced considerably by recent descriptive studies of three tone languages, namely Thai, Vietnamese and *pütonghuà* Chinese [1]. Tone languages also feature in recent textbook accounts of intonational phonology, though not prominently. One claim made is that ‘in a tone language the intonational means of focussing is likely to be much less used than in a non-tone language.’ Burmese is an interesting case in point since it appears to come close to contradicting this claim outright, even though other tone languages such as Thai and Vietnamese might support it.

This paper argues that intonation in Burmese is organised on three hierarchically-arranged prosodic domains. The largest domain which will be defined here is the *intonational sentence*. This domain delimits one cycle of global pitch declination and ends when pitch is reset at and the next intonational sentence begins. Typically, but not necessarily, an intonational sentence corresponds to a syntactic sentence ending with a verbal or nominal predicate, and is followed by a long pause and inhalation. In the news-reading style which informs this study,

intonational sentences are divided into *intonational phrases*, which are delimited by existing syntactic phrase boundaries and are separated by short pauses, typically of around 500ms. Intonational phrases frequently consist of a single syntactic phrase, but equally may consist of several, and be up to around 3s in duration. Their length appears to be determined by discourse structure and style as much as syntax. Lowest in the hierarchy is the *intonational word*, namely a string of syllables forming a syntactic phrase, within which intonation and syntactic structure, as well as tonal identity, determine the pitch characteristics of each syllable.

This preliminary study seeks to investigate to what extent tonal identity can be recovered from the pitch characteristics of a string of tones in Burmese speech when intonation is overlaid on them.

2. BURMESE TONES

Figure 1 illustrates the pitch characteristics of canonical readings of the four tones in Burmese, taken from data illustrated in [3].

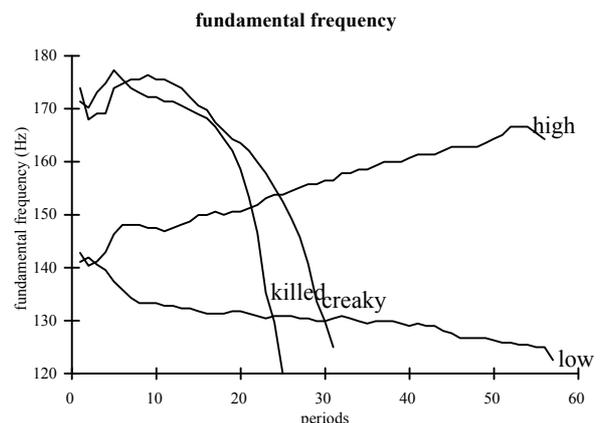


Figure 1. Fundamental frequency in each period of a single utterance of the four tones: /ka: ká: kâ kâ?/ (ကက ကး က ကံ in Burmese).

In context, however, the canonical pitch contours may be further shaped by phonotactic effects, such as the assimilation of final glottal stops in killed tone syllables with the initial consonant of the following word, akin to *raddoppiamento sintattico* in Italian [4], and some unpredictable tone sandhi effects, such as the lowering of high and killed tone preceding creaky tone [5].

Note that the pitch contours of creaky and killed tones are very similar. Pitch is not the only contrastive feature in Burmese tones, as already suggested by the duration differences evident in Figure 1. Other contrastive features include phonation type and intensity [6, 7].

3. EXPERIMENTAL DESIGN AND METHOD

This study is based on speech from a Burmese radio news broadcast. This genre of speech material was selected because it is stylistically controlled and consistent, making use of intonation for the purposes of focus and clarity, but keeps to a minimum the more extreme intonational tunes associated with the expression of emotions. The text selected is a news summary taken from the end of a longer broadcast. Three news items are summarised in a few sentences each.

Using the Praat program, measurements were made of the pitch at the beginning and end of the voiced portion of all syllables for which pitch was measurable, in addition to the mean pitch during each syllable.

Duration is not measurable here, since measurements were made only of the vocalic portions of syllables for which a fundamental frequency measurement is calculable. In the course of flowing speech, and with no control for initial consonants, any reliable comparison of the duration of vowels, and thus any tonal effect on duration, is impossible within the design of this experiment. Similarly, no reliable acoustic measurement of phonation type is possible from the sound recordings used in this study, since vowel quality is not controlled for. Weakened syllables, sometimes classified as ‘toneless’ were not included in the study, since their pitch is frequently unmeasurable because they involve few (or no) cycles of vocal fold vibration. Linear regression was applied to the pitch trace of each intonational phrase to give an estimate of the rate of global pitch declination, as illustrated in Figures 2 and 3.

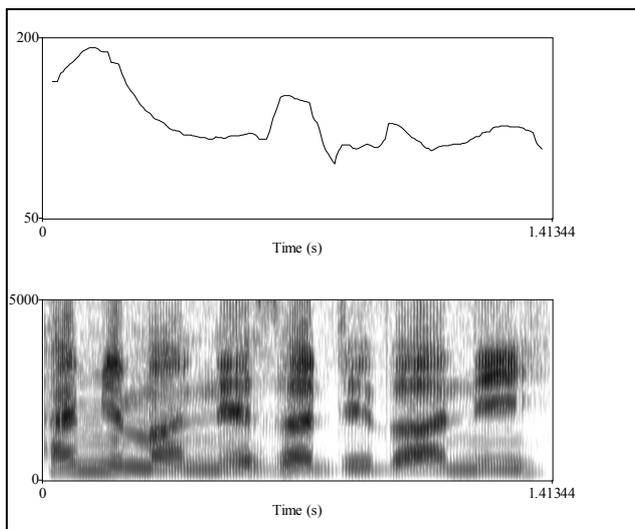


Figure 2: pitch trace and spectrogram of the phrase /thaí.mjāma.nezaʔ.deθa.ʔəni/ ထိုင်းခြံနံ့မာနယ်စပ်ဒေသအနီး: “near the Thai-Myanmar border area”.

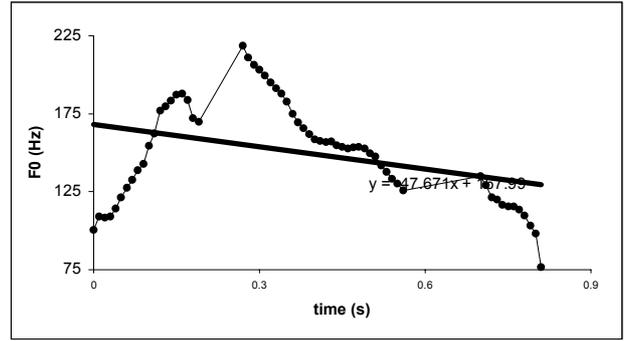
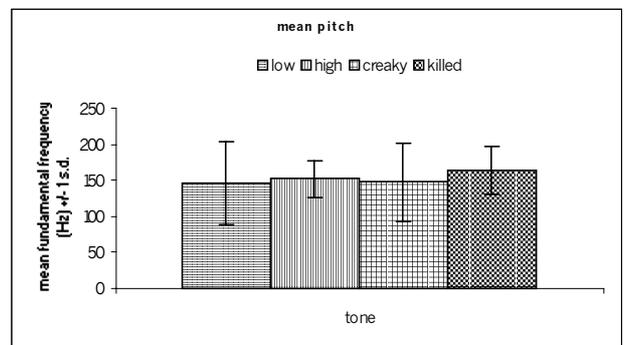


Figure 3: pitch points derived from the sound string in Figure XXX, showing the approximated pitch declination calculated by linear regression.

The measured data were tested within the context of the proposal that without recourse to a model which takes intonation into account, the pitch patterns predicted by tonal identity are not observed in news-read speech in Burmese. In other words, looking at stretches of Burmese speech consisting of several intonational sentences, we cannot use pitch to recover the tonal identity of a given syllable.

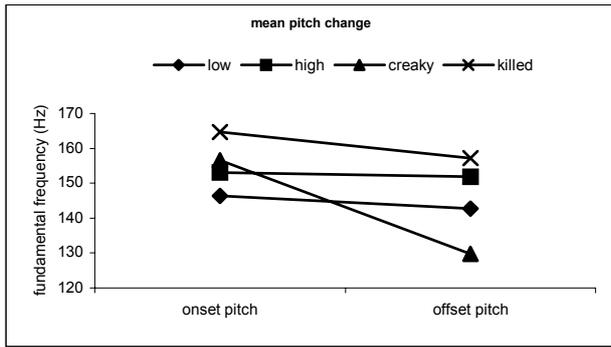
An ANOVA test shows that tone is not a factor which significantly affects measured mean pitch of syllables throughout the news-reading material: (n=246, 3 d.f., F=1.356, p=0.257). Figure 4 shows the mean pitch measurements ± 1 st.dev. for all tokens of each tone.



tone	mean F0 (Hz)	N	std.dev.
low	146.0441319	n=91	58.54
high	151.6823621	n=58	25.80
creaky	147.5510357	n=56	53.95
killed	163.303	n=42	33.61

Figure 4: mean fundamental frequency of four tones.

However, we must at this stage comment on these calculations. We predict from our knowledge of the pitch patterns in canonical readings of Burmese tones that third tone should be ‘high’ rather than the somewhat ‘low’ mean pitch observed here. A look at the mean pitch change within syllables, instead of the mean pitch, for each of the four tonal categories, suggests that creaky tone maintains a falling pitch contour generally while killed tone does not, as illustrated in Figure 5



tone		onset	offset
low	Mean	146.4339	142.7540
	N	89	89
	s.d.	44.80701	56.00610
high	Mean	153.0045	151.9115
	N	58	58
	s.d.	56.35451	31.08891
creaky	Mean	156.5840	129.6989
	N	54	55
	s.d.	62.03736	37.91869
killed	Mean	164.6337	157.2394
	N	42	42
	s.d.	38.32063	34.76243

Figure 5: mean fundamental frequency change by tonal category.

An alternative proposal, then, is that tones are predictable within each individual intonational phrase, using a crude model where pitch declination is predicted by linear regression from the pitch contour observed. By calculating pitch relative to the globally declining pitch within a phrase, modelled by linear regression, we can improve considerably the likelihood of correctly identifying the tonal identity of a syllable based on its mean pitch. An ANOVA test (n=240, 3 d.f., F=2.615, p=0.52) finds that tone cannot quite be shown to have a statistically significant effect on the mean fundamental frequency of a syllable, even with using this linear model of pitch declination within each intonational phrase. However, we find that tonal identity has a more ordered effect on fundamental frequency if we exclude from the pitch declination model:

- (a) phrase-final grammatical particles and forms, since we suspect their pitch to be determined by syntactical phrase hierarchy rather than phrase internal tunes and / or
- (b) the last intonational phrase (typically a verb phrase) in each intonational sentence, since this is associated with a distinctly different intonational tune which involves a dip to the lowest pitch observed in the intonational followed by a sharp rise, as illustrated in Figure 6.

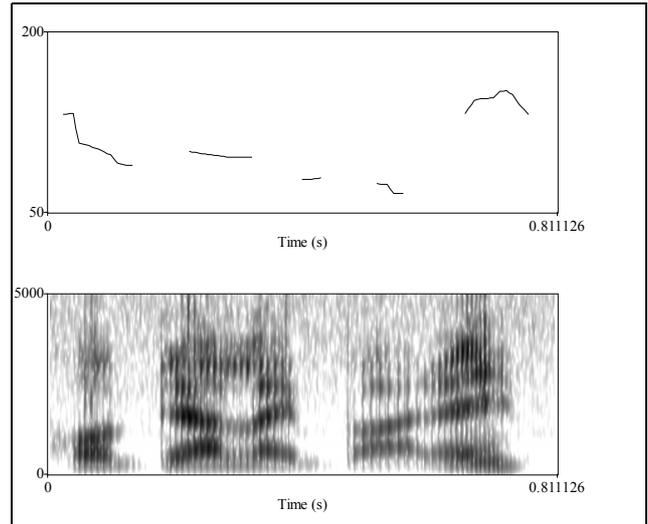


Figure 6: pitch track and spectrogram illustrating typical phrase-final intonation in the phrase "...reported" /p^hɔ.pjə.laɪ.ɔ.pa.de/ ဖော်ပြလိုက်ပါတယ်။

4. RESULTS and DISCUSSION

The following table gives a summary of the results of the ANOVA tests which were carried out on to test the effect of tonal identity on the mean fundamental frequency of the syllables in the speech sample. Statistically significant results are in bold.

Model:	A	B	C	D
Mean F0	F(3,246) =1.356; p=0.257	F(3,228) = 4.946 p = 0.02	F(3,217) = 0.835 p=0.476	F(3,202) = 4.454 p=0.05
Mean F0 relative to regression-predicted pitch declination.	F(3,240) = 2.615; p=0.052	F(3,226) = 7.899 p<0.0005	(3,211) F=1.687; p=0.171	(3,200) F=6.041 p=0.001

- A: all syllables included
- B: omitting all syllables occurring in final phrase of intonational sentence
- C: omitting final syllables of each intonational phrase
- D: omitting both B and C.

We observe that it is by excluding the final phrase in each intonation sentence that the tonal identity of syllables becomes recoverable from their fundamental frequency. This paper does not examine the intonational tunes of to be observed within intonational phrases and their effect on the realisation of tones, but the results support the proposal that intonation is hierarchically organised in Burmese. At the intonational sentence level, we find a low+rise tune characteristic of the final intonational phrase in the sentence. Another tier of the hierarchy which emerges in this study is at the intonational phrase level, where the following example suggests that the pitch of phrase final syllables seem to be determined by phrase-level syntax. One intonational sentence reads as follows:

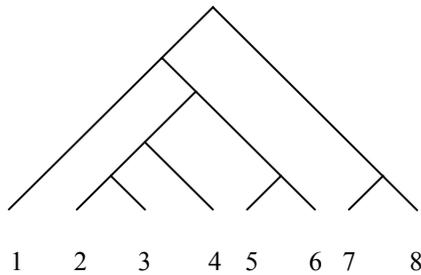
“A manager has sacked for Burmese workers at a garment factory called DD near Mae Sot in the Thai-Burma border area without giving any reason, according to the Mizzima News Agency.”

The Burmese text, broken down into intonational phrases, is:

ထိုင်းမြန်မာနယ်စပ်ဒေသအနီး / မယ်ဆောက်မြို့ရှိ /
ဒီဒီအမည်ရှိအထည်စက်ရုံက / မြန်မာသား အလုပ်သမား
လေးယောက်တို့ကို / အလုပ်ရုံမှာနေကျက /
တစ်စုံတစ်ရာအပြစ် မဖော်ပြဘဲနဲ့ အလုပ်ထုတ်လိုက်တဲ့
အကြောင်း / မဇ္ဈိမသတင်းဌာနက / ဖော်ပြလိုက်ပါတယ်။

This sentence parses as follows, with a tree structure as below.

phrase #	meaning	type	tone of final syll.
1	at the border	adverb	high
2	in Maesot	place	creaky
3	from a factory	origin	creaky
4	four workers	object	low
5	the manager	subject	creaky
6	sacked	subord. verb	high
7	news agency	subject	creaky
8	reported	main verb	low



The pitch trace of the final syllables of each of these phrases is shown in Figure 7, but it is suggested that this sequence represents a phrase-level intonational tune overlaid on the sentence such that the pitch of these syllables is determined not by their tonal identity, but by the syntactic role of the phrases in which they occur.

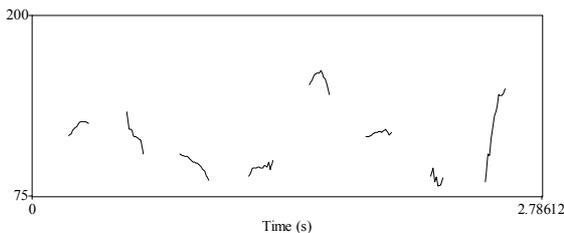


Figure 7: fundamental frequency trace of final syllables in each intonational phrase of a single intonational structure.

We can try to map the pitches of the last syllable in each phrase to the higher phrase structure in the intonational sentence. Phrases 7 and 8 have the distinctive final verb phrase low + rise contour mentioned above. Otherwise, we see that the pitch pattern mirrors the phrase structure in the tree above. In phrases 2 and 5, higher pitch appears to signal the beginning of two complex constituents, the fronted object noun phrase and the subject-verb complex.

This study raises far more questions than it answers. It remains to be replicated for much more speech data, including speech in styles other than the controlled news broadcast used here.

ACKNOWLEDGMENTS

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