Burmese Tone?

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I. INTRODUCTION

This paper is an investigation of the lexical properties of Burmese tone. It characterizes Burmese tone as resulting from an interaction between laryngeal and proper tonal features. The first, [±CONSTRICTEDGLOTTIS] (+CG]) is phonetically realized as a distinction between creaky and breathy phonation (Matisoff 1968; 1973; La Raw Maran 1971; Halle & Stevens 1971)[1], while the feature [±HIGH] is phonetically realized as high vs. low tone. These features are not claimed to be independent of one another; on the contrary, their interaction is subject to distinctiveness constraints (Flemming 2006) which both restrict certain combinations of features while favoring others. There is an additional correlation to be noted between vowel length as a phonetic realization of phonation and its correlation with the single contour tone in Burmese, which is only licensed in a long vowel, as predicted by Zhang (2002). Thus, the putatively simple system of Burmese tones results from a complex interaction of features and phonetically motivated constraints.

The paper proceeds as follows: In section 2 I present the basics of Burmese tone and present details of their phonetic realization and syntactic distribution that lead to my proposal. Section 3 is the proposal for the lexical properties of Burmese tone, and couches that proposal in terms of constraints on distinctiveness and contours. Section 4 presents data from tone sandhi in Burmese that is crucial for my claim that one of the Burmese suprasegmentals is a contour tone, an original proposal.

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[*] This paper is based on research done while enrolled in the Field Methods class at Harvard University in the Spring of 2007. Special thanks and all the best luck to Winmar Way, Harvard class of 2007, who patiently said a lot of things into a microphone that didn't make any sense.

[1] These features are often used to distinguish glottal stops and [h]. They also play that role in Burmese, and the creaky voice is historically derivative from a final glottal stop (Bradley 1982).

The analysis follows in the spirit of Sprigg (1964), who similarly considers the phonation contrast and tonal contrast as separate along the same lines presented here. This analysis is thus set against two other conceptions of Burmese tone. The first possibile proposal is a purely tonal analysis, which has been suggested by Yip (2000) but has never been proposed in any formal detail. I show this to be untenable in light of sandhi phenomena. The second possible conceptualization of Burmese tone is as a three-way phonation distinction (Bradley 1982), contrasting breathy vs. modal vs. creaky voice. I also point out a number of difficulties for this analysis in the conclusion.[2]

2. Burmese Laryngeal Contrasts

Traditional descriptions of Burmese distinguish anywhere from three (Bernot 1963) to five (McDavid 1945) tones, though the ambiguity is really the result of different analyses rather than disputes in descriptive content. The five vocalic contrasts in Burmese are listed below, with their stress and distributional properties, as well as duration and pitch (both from a single word pronounced in isolation):

[2] Throughout this paper I will somewhat hypocritically refer to the different phonemic categories of Burmese suprasegmentals by the traditional moniker 'tone.' I do so in spite of the basic premise of the paper being that tone proper is only part of the story for Burmese. Thus, when I refer to the 'creaky tone', there is an implicit irony which I would rather leave unchallenged. Needless to say, 'tone' is justifyable in the sense in is generally used in the literature to refer to phonemic distinctions which transcend purely segmental specifications.

(1) Burmese tone and stress contrasts

		Position	Environment	Duration	Pitch
a.	Creaky Tone[3]	Final	CV(VN)	Short, ~150 ms	Sharp fall
b.	Checked Tone	Final	CV(V)ʔ	Short, ~100 ms	Sharp fall
c.	High Tone	Final	CV(VN)	Long, ~300 ms	Late fall, less steep
d.	Low Tone	Final	CV(VN)	Long, ~270 ms	Early fall, less steep
e.	Reduced Vowel	Penult	CV	Very Short, ~40 ms	Variant

Little more needs to be said about the reduced vowel, which is always schwa, except for that it remains an open question whether or not it might be epenthetic in Burmese. Green (1995), whose analysis of Burmese syllable structure I will assume, analyzes the vowel as reduced and toneless based on the fact that it can be derived based on compounding:

(2) a. tʃáN + po > tʃəbó[4] 'floor' + 'insect' > 'bug'

b. ŋá + ʔṵ > ŋəʔṵ 'fish' + 'egg' > 'fishspawn'

c. θwá + jè > θəjè 'tooth' + 'juice' > 'saliva'

[3] There is no consensus in the literature on the names of the tones; 'killed' is a common alternative name for 'checked', in particular, while 'breathy' or 'heavy' are common alternants for high. I follow Green (1995) and Wheatley (1987) in the names I choose here. They seem accurate, descriptive and anticipate my analysis.

[4] Burmese tones are marked with three diacritics: an accute accent for the high tone, a grave accent marks the low tone, while creaky tone is marked with the IPA symbol: a subscribted tilde.

Note that vowel reduction corresponds with the loss of nasalization (2a) and the loss of initial clusters (2c), as well as the loss of tone. Green analyzes the reduction as resulting from the syllable not being footed due to a preference in Burmese for syllabic feet.

Putting (1e) aside, then, we focus on the first four tones in (1). Note that the way that I have characterized the first two tones (a and b) and the middle two (c and d) seem to categorize these two tones as natural classes. That indeed is the main claim of this paper: both the creaky and checked tone have the feature [+CONSTRICTEDGLOTTIS] ([+CG]) specified on their vowels. In contrast, the high and low tones are [-CG] (and thus [+SPREADGLOTTIS] ([+SG]) by default.

Note that the checked tone always occurs with a final glottal stop. Greeen (1995) analyzes this as resulting from an undominated constraint on place specificiation in codas in Burmese. Evidence for this being a true consonant exists in that the glottal stop becomes a voiceless obstruent in the environment of a following consonant, homoorganic in place and manner of articulation:

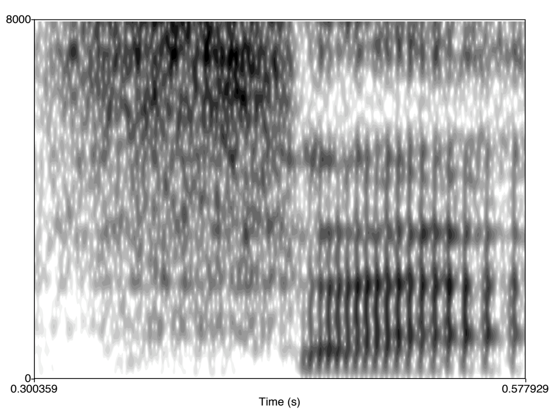
(3)	a.	jakkweʔ < jaʔkweʔ	'area, quarter'
	b.	louszaʔ < louʔzaʔ	'story'

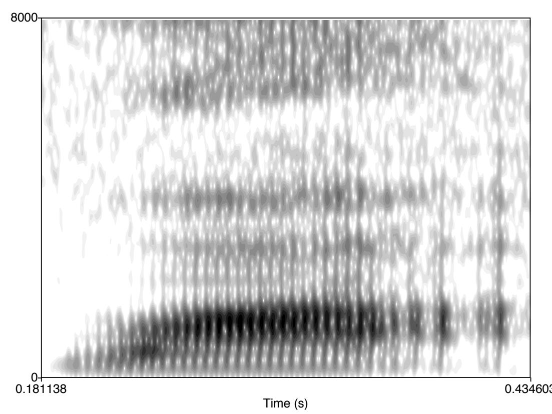
The point of this is simply that a tone is checked if and only if it has an obstruent coda, namely, a glottal stop. The glottal stop is assumed to have the features [+CG, +CONS] and no place features in the lexicon.

The generalizations about duration in (1) are very strong evidence for a basic contrast between the groups creaky and checked vs. high and low, supporting their division based on a single feature. When a group of 14 of each was taken in isolation and measured, their means were 141 and 288 milliseconds, respectively, strongly correlating with the appropriate category ($P=6.4^{E-9}$)[5]. Moreover, the tonal behavior of the two [+CG] vowels is nearly identical, both falling sharply, with an average drop of more than 45 Hz. In contrast, the [-CG] vowels exhibit no similar sharp fall in isolation, but instead a small drop immediately for the low tone and finally for the high tone. The behavior of the two [-CG] tones with respect to pitch and sandhi will be discussed further in section 4.

A final argument for the [+CG] specification for both creaky and checked vowels is that the ‘glottal stop’ of the checked tone is not actually a sharp glottal stop, but actually resembles the gradual constriction characteristic of creaky voice. Thus, note the similar final restrictions in the following pair of spectrograms:

(4) a. Spectrogram for ^{h}*sɛʔ* ‘machine’ b. Spectrogram for *wa̰* ‘fat’





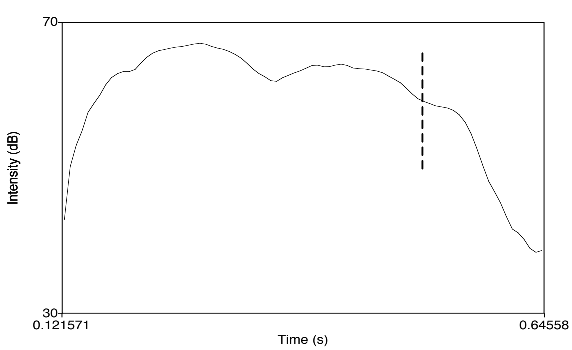
If anything, the creaky toned vowel has a more abrupt stop than the checked tone, which shows clear creaking towards its closure. However, the spectrograms show that creakiness is not restricted to the “creaky” tone, but is rather a property of both tones.

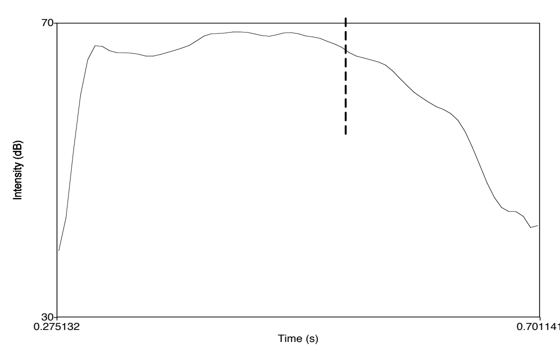
[5] All of the vowel /a/ in isolation, n=14 for each category with 7 of each tone.

These results are corroborated by Watkins (2000), which explicitly demonstrates the close correspondence in phonation between the creaky and checked tones by measuring the closed quotient change of the two syllables. Watkins concludes that the two tones are very similar with respect to phonation and vowel length, though he does observe differences in the nature of the final glottal stop. If the two tones are so similar, how do speakers distinguish them? A number of segmental contrasts provide cues: checked vowels occur in a more compressed, central vowel space, additionally the consonant gemination that occurs in context.

An independent question is whether there is any evidence that the high and low tone can be placed together in a natural class to contrast with the creaky and checked tones. Indeed, there is evidence for breathiness in both tones, often attributed to only a property of the high tone. Beyond the correlation in vowel lengths already discussed, another similarity is the sharp drop in intensity seen in the two tones, beginning at about halfway through the vowel and dropping sharply. This is presumably caused by a widening glottal closure leading to which would be predicted by decrease in the subglottal pressure resulting in a loss of amplitude:

(5) a. Intensity of *ʔəɲà* 'Upper Burma' b. Intensity of *ná* 'ear'

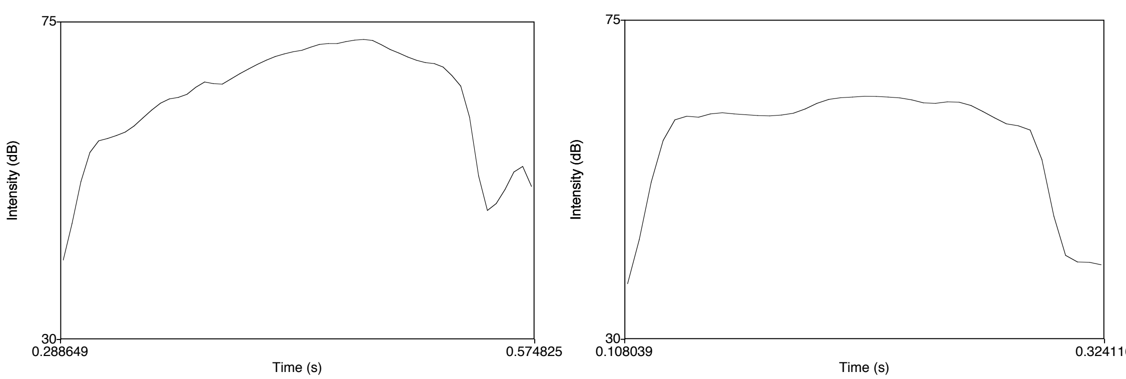




| ə | ɲ | à | | n | á |

Note that both intensity tracks can be seen as essentially as consisting of two components for each of the vowels in question, delineated by the dashed vertical lines in (5). Note that the left side of the line in both cases contains a small peak while the right side of the line involves a sharp fall. I contend that this similarity is the result of breathy articulation of the vowels, especially in the second half of their duration. This breathy property of high and low tones can be seen as direclty contrasting with the creakiness in checked and creaky tones:

(6) a. Intensity of *mɛʔ* 'upright' b. Intensity of *wa̰* ‘fat’



| m | ɛ | ʔ | | w | a̰ |

Little needs to be said about the intensity contours in (6) except that they do not show the sharp fall characteristic of the high and low tones. This is expected in that the articulatory gestures leading to the creaking of a vowel and breathiness are mutually exclusive, and that the creaking of a vowel requires a constriction of the glottis, creating greater subglottal pressure which is offset by a decreasing laryngeal opening, resulting in a stable or slightly rising intensity track. I take this evidence from intensity as sufficient to show that high and low tone have some significant articulatory similarities, enough to justify their grouping into a natural class characterized by [-CG]/[+SG].

In conclusion then, the four Burmese tones can generally be split into two categories distinguished by a single laryngeal feature which has a number of significant phonetic correlates. In the following section we investigate the representation of this feature as well as the tonal ±[HIGH] feature.

3. Analysis

The basic analysis which I present here is one in which, first, all stressed syllables in Burmese are bimoraic and footed, as in Green (1995), and that vowels in the high, low, and creaky syllables are bimoraic while the checked syllable of the tone is a monomoraic vowel followed by a moraic coda. The representation of the four tones is roughly as in (6) below:

(6) a. Creaky

```
σ
| \
μ  μ
|   |
V  V
 \  |
  \ [+CG]
   \/
    H
```

b. Checked

```
σ
| \
μ  μ
|   |
V  C
 \  |
  \ [+CG]
   \/
    H
```

c. High

```
σ
| \
μ  μ
|   |
V  V
|   |
|  [-CG]
|   |
H   L
```

d. Low

```
σ
| \
μ  μ
|   |
V  V
 \  |
  \ [-CG]
   \/
    L
```

The V and C nodes should be considered abstractions over the root node of the feature tree and the basic features, presumably [±CONS]; all the syllables but that occuring int the checked tone presumably share the feature [-CONS] between their morae.. The [±CG] features are presumably dominated by a unary [LARYNGEAL] node. The features H and L could be read as [+HIGH] and [-HIGH], respectively.

One important thing to note about the analysis in (6) is that the laryngeal feature always plays a role in determining the tone of the word: [-CG] is always associated with L and [+CG] always associated with H. In fact, only the high tone has a H feature, which is not derivative from L. Also note that, crucially for the high tone, the morae remain distinct in the feature tree, dominating separate root nodes. There is historical evidence for the high and low tones having some 'pure' tonal content (not derivative from laryngeal features), as some historicists trace those two tones back to Proto-Tibeto-Burman H vs. L (Benedict 1972a, 1972b). This contrast only existed in non-stopped syllables, corresponding to Burmese H and L tone. The important point for our purposes is only one tone needs to be associated directly with any TBU in Burmese, and there is evidence that that tone has been in Burmese for a very long time.

How are the rest of the tones associated? It seems generally likely for glottal constriction to be associated with high in Burmese. Indeed, this is simply a description of the facts: checked and creaky tone have consistently high pitch. Because Burmese has at least one tone which must be stipulated underlyingly, it makes sense that Burmese would generalize to the rest of the system. There are two phonetic explanations for this. The first is articulatory: there is an obvious correlation between more constricted vocal folds and higher pitch, as there is betweed spread vocal folds, lower intensity, and lower pitch. The second is accoustic: pitch can be seen as a Flemming (2004, 2006) shows that languages prefer to enhance contrasts between sounds.

This intuition could be captured for Burmese by undominated markedness constraints which prohibit the misalignment of larygeal and tonal features, which would presumably reduce the contrast which both of them mark. The correlation of glottal constriction and high tone, expressed in the ranking in (7), is presumably universal:

(7) *[+CG, -HIGH], *[-CG, +HIGH] >> *[+CG, +HIGH], *[-CG, -HIGH][6]

There are also corresponding constraint for associating spread glottis with low tone:

(8) *[+SG, +HIGH], *[-SG, -HIGH] >> *[+SG, -HIGH], *[-SG, +HIGH]

Thse two constraints effectively limit the tonal specification of the final syllable of both kinds of glottal specifications. Presumably, glottal specifications are obligatory in footed feet in Burmese.

In addition to these constraints restricting the distribution of tone, additional constraints are needed to restrict the distribution of the laryngeal features themselves as well as force the spreading of the laryngeal features to the medial syllable when it is unspecified for tone. For the first of these, there is a presumably a positional markedness constraint prohibiting either spread or constricted glottis in non-coda positions:

(9) $*\mu_{[+SG]}\mu]_{\sigma}$, $*\mu_{[+CG]}\mu]_{\sigma}$

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[6] Creaky phonation with low pitch is also perfectly plausuble.

These constraints would presumably restrict the speciification of spread or constricted glottis to the final mora of a word. To forse the spreading of tone to an unrestricted syllable is a markedness constraint aligning tone to both edges of a foot:

(10) ALIGN-L (T, σ)

This tone would require tone to spread to the first mora of a syllable (in a bimoraic foot) when that mora is unspecified for tone. It would presumably dominate other contstraints prohibiting spreading, etc. The high tone would trivially satisfy (10) in that tone is already specified on the left mora. Finally, the Obligatory Contour Principle (OCP) would constrain the representation of tone on all but the high tone to one where there is only a single tone feature per syllable.

A more detailed Optimality Theoretic analysis will not be persued here, but it is worth noting that the constraints I introduced in (7-10) constrain the possible representations of tone in footed (stressed) syllables to exactly those in (6). What is traditionally called tone in Burmese is actually a combination of tones inherent to a specific laryngeal feature and tone proper. This analysis has been impliciti in many of the existing descriptions of Burmese tone, however this paper represents the first attempt to deal with the attested patterns explicitly. The next section of this paper will deal with Burmese tone sandhi patterns, and show that they at least partially fall out from the analysis of the Burmese tone that has just been presented.

4. Tonal Realization and Sandhi

Most descriptions of Burmese tone include some warning about the difficulty of making generalizations about pitch. Indeed, not only pitch but intensity and duration become much more muted when Burmese words appear in context, in a phrase. The following table is records the measurements made of a single female speaker, age 22, uttering a noun-adjective pair in context. Note the strong correlation between position and tone change, and the compression of the constrasts in duration noted in section 2:

(11) Tones in context[7] (n=~10)

	Noun-Adj (P1-P2)	Duration (ms)	Intensity (dB)	ΔPitch[8] (Hz)
Checked	P1	91.4	66.5	+2.0
	P2	88.2	66.2	-13.1
Creaky	P1	127.2	68.1	+3.8
	P2	128.2	66.7	-25.2
High	P1	150.1	68.6	+19.9
	P2	148.3	67.4	-3.9
Low	P1	130.4	67.1	-2.0
	P2	140.0	64.8	-56.3

The most striking fact about (11) is that while duration and intensity have slight changes from the first to the second position, the change in pitch fluctuates wildly. It is precisely this property

[7] The exact context for the N-A pair was the translation of 'He said that x', which in Burmese translates with 'X' occuring sentence medially and with primary focus in the sentence, translating directly: He-[N-A-that]-said-DEC where the last element marks a declarative sentence. The 'that' element is a complmentizer, which is low toned, and is in the same prosodic constituent as the two words under examination. Thus, the noun was phrase initial while the adjective actually phrase medial. While the complementizer always had very low pitch and was unstressed, the adjective forms given in this section should properly be seen as occuring between an initial stressed syllable of a given tone and before a following word with unstressed low tone. As will be seen, however, the low tone does not have any effects on its surrounding tones.

[8] Change in pitch was measured by considering the difference between the pitch at its high and low points in the vowel. The negative or positive corresponds to whether the high point came before the low point or vice versa.

of Burmese tone that makes characterising its tones in terms of a strict pitch assignment so untenable. Confounding this fact is the additional problem that creaky and breathy cues fail to surface when a word is not phrase final. So while the data in (11) provides evidence against a strictly tonal analysis of the Burmese system, at the same time the 'tones' in position can only be analyzed by making reference to pitch (though duration is still predictable, only less salient).

How should we characterize the fluctuations in (11)? In the only analysis of Burmese sandhi in the literature, Sprigg (1964) suggests that each tone essentially has two surface representations (paraphrasing his words), and that the distribution of these representations is predictable based on syntactic context. This generalization seems correct: when all of the pitchtracks are examined for both positions for the tone, two distinct signatures emerge for each lexical tone; I will call these allotones. These roughly correspond to the tones which occur in the noun and adjective, which seems to indicate that these correspond generally to a word receiving primary stress in a phrase and a word receiving secondary or nonprimary stress. The latter is also the citation form, and thus is also licensed before a pause. There is not a strict correlation between position and tone, however: sometimes the wrong allotone appears in the wrong position, but this is predictable from its environment. The allotones are characterized below by Chao tone letters (Chao 1930):

(12) a. Creaky & Checked tone

1A: 45 1B: 53

b. High tone

2A: 35 2B: 434

c. Low tone

3A: 12 3B: 51

Note that these values roughly correlate with the change-in-pitch column in (11). Note also that the creaky and checked tones behave together again as a natural class, whereas the high tone and low tone are very different from either. All of this is expected by the analysis in the last section. I will uses the number+letter combinations in (12) to refer to the corresponding allotone below.

Note that the A allophone in (12) always rises. This seems to be the general signature of the stressed word in Burmese, and in all of these cases the pitchtrack does not hit a peak in the first syllable but rises throughout the whole word. Generally, these tones correlate with either being initial or second in the phrase, which is presumably linked to stress, though that remains unclear at this point.

Finally, note that while (12b) is predicted to be a falling tone by its representation, it is never actually falling in context. Thus, the high tone is the only case where there is a distinction between the B tone in (12) and the citation form in isolation. This fact brings up a number of issues which extend beyond this scope of this paper, and we will move on to the actual sandhi facts.

If the two pitch patterns in (12) always emerged 'as is' nothing more would need to be said. However, this is not the case. Three distinct sandhi processes can be seen when the tones occur in context, summarized below in the traditional rule format:

(13) a. /1/⇒[1B] / _ 3

b. /1/ ⇒ [1A] / 2 _

c. /2/ ⇒ [2A] / _ 1, 3

These three processes should really be seen with (13a) in isolation and (13b,c) arising from the same basic processes. The sandhi are predicted by the relevant representations as follows. First, recall that the high tone (2) bears a H associated with its first mora. This H is directly attached to the first mora, unlike the other forms. thus, With this in mind, one way of explaining (13a) would be by positing an OCP-triggered dissimilation which forces the H on creaky and checked tones to only be realized on their first mora, which is presumably what the representation of the 1B allotone is:

(14)
```
σ        σ
| \      | \
μ  μ     μ  μ
|   |    |   |
V  V     V  V
 \   |   |   |
  \[+CG] |  [-CG]
   \≠    |   |
    H    H  L
```

This proces is not triggered when the high tone occurs before the creaky or checked tones because the H features are not underlying linked to adjacent syllables there. It remains generally, unclear, though, why the high tone then surfaces as rising in the initial position in my analysis.

As for the sandhi processes in (13b, c), they both actually provide evidence that the low tone never actually has a second allotone, and that the 3b form is simply the result of spreading a H feature to the right, presumably triggered by the general preference for H to L in the language (perhaps due to underspecification) combined with the underlyingly unspecified nature of the first mora in low syllalbes. The inverse of (13c) is shown below wherein the underlyingly low (11 or 12) realization of the low tone becomes a falling tone after a H word:

(15)

```
σ       σ
| \     | \
μ  μ    μ  μ
|   |   |   |
V  V    V  V
 \  |  /    |
  [+CG]    [-CG]
   \ | /     |
     H       L
```

An unresolved issue in this analysis is why even a high tone triggers spreading before a low tone. Again, it seems that this might be explainable in terms of underspecification.

The process in (13b) may have a similar explanation, as suggested. It may be that the falling allotone for creaky and checked tones (1B) is actually due to an OCP-induced deletion of H followed by spreading. The tone may not fall as low due to the fact that the [+CG] feature remains.

A plethora of issues clearly remain undiscussed in this analysis, and while a optimality theoretic analysis has been suggested at a number of points, its implementation remains a further project that is certain to highlight certain inadequacies and remaining issues in the analysis proposed above.

5. Conclusion

This paper has shown that a deeply explanatory and predictive account of Burmese tone can be given in an analysis where phonation features and tone interact. This analysis has the following advantages: (i) it allows a natural explanation for the grouping of the tones into natural classes, distinguished by the feature [±CG], justified by phonetic data (ii) it gives a natural explanation for the lack of low tone in creaky and checked syllables (iii) it gives a natural explanation for the falling or low behavior of both high and low tones (iv) it is historically realistic, preserving a tonal distinction in the tonal language and preserving preexisting features (glottal closure) in the syncronic analysis (accounting for creakiness) and (v) it provides important steps towards an explanation of the sandhi patterns which we observe in Burmese.

It seems that neither a three-way phonation analysis (as proposed in Bradley (1982)) nor a purely tonal analysis would never be able to capture the naturally shared properties of high and low vs. creaky and checked, richly attested in the suprasegmental phonology of Burmese.

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