

Maximizing Lexical Contrast in Burmese Tone: Evidence from F0 and Oq

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1 Introduction

This paper investigates lexical contrast of tones in Burmese. Burmese is a Sino-Tibetan language spoken primarily in Myanmar, though it is also spoken in small pockets of Thailand, Bangladesh, Malaysia, and the United States of America. There are approximately 32 million native speakers and it is the official national language of Myanmar. This paper recreates Gruber's methodology and expands on why the laryngeal tones neutralize between two low tones (low_low) and between a low and high tone (low_high), but not following a high tone, or between a high and a low tones (high_low).

Burmese has a four way tone contrast between low, high, creaky, and glottal, and uses pitch, pitch contour, duration, and phonation as cues, of which pitch and phonation are the two main cues (Gruber, 2011). As reported in Gruber (2011), the low and high tones are generally produced with modal voice, or even slightly breathy for high tones, while creaky and glottal stops are generally produced as creaky voice with glottal having an even smaller open quotient (Oq) than the creaky tone. Additionally, Yip (2002), reports that these phonation differences are mutually exclusive and that tones with laryngeal phonation use phonation to cue tone, while modal tones use pitch. However, when following a low tone, the laryngeal tones are neutralized and produced as modal (Gruber, 2011). Although this same neutralization is expected in a high_low environment, laryngeal tones are produced with slightly more creaky voice than of those following low tones.

The four tones also follow a max F0 pattern. In Gruber (2011), creaky tones were found to have the highest max F0, followed by glottal, high, and then low tones. These max-F0-based tonal differences are consistent in phrase initial positions, phrase medial positions, and when preceding a minor tone. Gruber (2011), also finds that in low_low environments, the glottal tone has a shorter duration and that the glottal and creaky tones have a steeper and sharper drop than the low tone.

After describing the methodology in section 2, the results of the experiment are presented in section 3. We offer a discussion section in section 4 to discuss similarities and differences between our results and those in Gruber (2011).

2 Methodology

2.1 Participants There were 3 male and 5 female native Burmese speakers from Myanmar for this experiment, between the ages of 22 and 44. Participants were all from Yangon, Myanmar.

2.2 Experiment The stimuli for this experiment included multiple words that began with the alveolar plosive /t/ and were followed by either /a/, /i/, or /u/. These target words were elicited using the frame sentence in (1). The environment of the frame sentence is low_low, where the underscore denotes the place of the target word. Some words may also have /ʔ/ or /N/ as a coda. Participants were asked to elicit each frame sentence 5 times, except for the first speaker who repeated each frame sentence 3 times, resulting in a total of 925 t-initial tokens.

- (1) ကျွန်တော် ___ ကို ရေးနေတယ်။
təənò ___-ko yéenedeh
“I am writing ___”

We would like to thank the Burmese participants and Ne Myo Aung from Gitameit Music Institute in Yangon, Myanmar, who coordinated the recruitment of the participants. This project is sponsored by the ILCAA joint research project, “Phonetic typology from cross-linguistic perspectives (PhonTyp)” (2021-2023).

2.3 Data Processing and Analysis The recorded items were chopped and annotated for the target word vowel using Praat Ver. 6.1.29. The max F0, F0 midpoint, and duration of each vowel were then found. The Oq of each target word was found using EGGNOG. This information was then imported into R and analyzed using a linear mixed model to determine significance between different interceptions. In this study, the fixed effects were tone and vowel, the outcome variables were MaxF0 and F0 midpoint, and the random effects included the participant, the repetitions, and the token.

3 Results

3.1 Max F0 The max F0 of each tone in the vocalic portion follows a pattern in Burmese where the highest max F0 corresponds with the creaky tone, followed by the glottal tone, the high tone, and finally the low tone. However, the difference between the glottal and creaky tones is not significant ($p = 0.24$) While the creaky tone consistently has the highest max F0, the glottal tone follows closely, particularly in female speech. There is also greater deviation in creaky and glottal tones than high and low tones. It is interesting to note that a large amount of outliers were observed in the glottal tone produced by male participants. This presence of outliers is possibly due to the perturbation effect of the post-vocalic glottal stop in preceding vocalic component. .

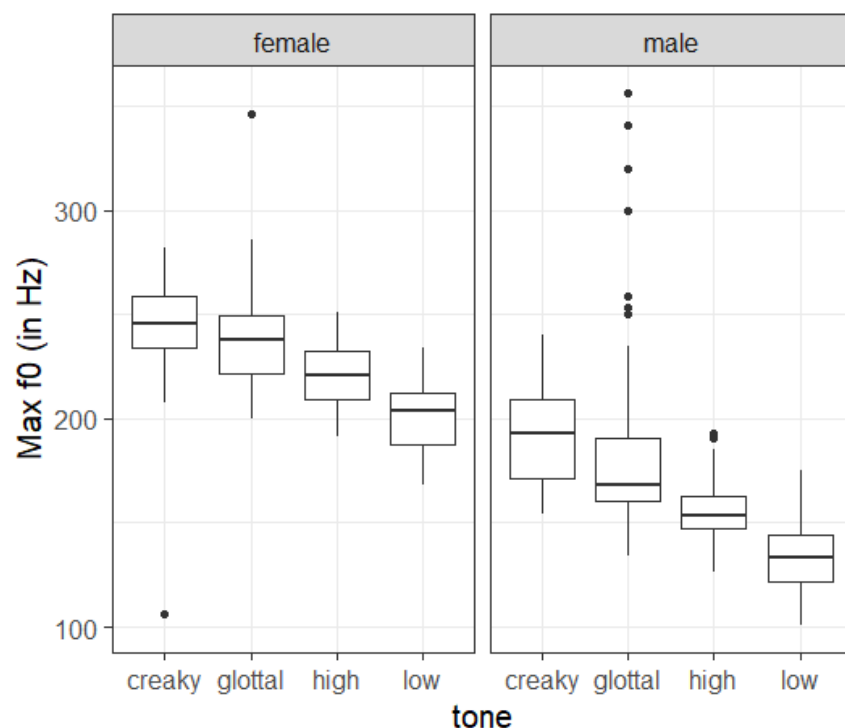


Figure 1: Figure 1 illustrates the max F0 of both female and male speakers of Burmese with the max F0 on the y-axis and tone on the x-axis.

3.2 F0 Midpoint The F0 midpoint was found to pattern similarly to max F0 where creaky tone has the highest max F0, and again, followed by glottal tone, high tone, and then low tone. However, the difference between the glottal and creaky tone is not significant ($p = 0.15$). Additionally, the F0 midpoint differs in that there is interspeaker variation. Some speakers have a tendency to produce a lower F0 in the laryngeal tones as opposed to the non-laryngeal tones. This suggests and adds evidence to the claim that Burmese tones do not only rely on F0 solely for a cue.

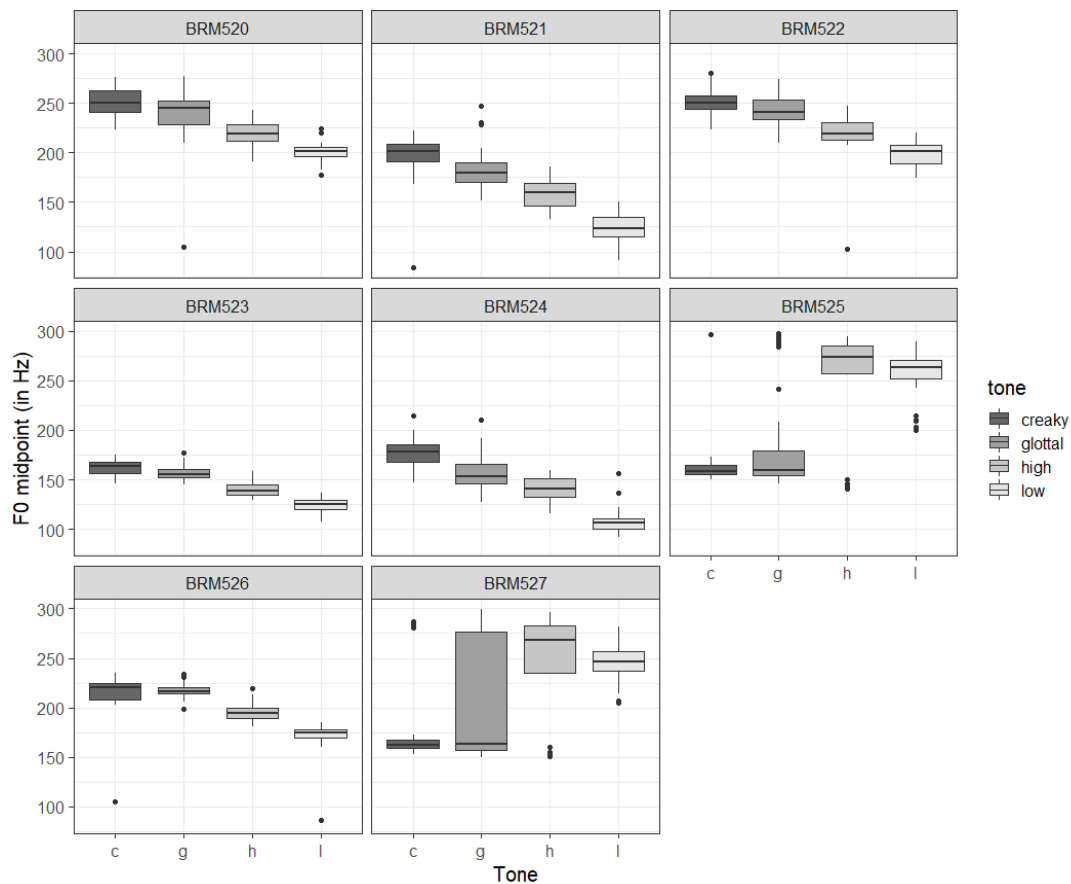


Figure 2: Figure 2 illustrates the average F0 midpoint per tone type per speaker with the frequency on the y-axis and the tone type on the x-axis. For illustrative purposes, the tone is also denoted as in the legend on the right.

3.3 Open Quotient Generally speaking also similar to Gruber (2011), all tones are generally modal with Oq values hovering around 50%, if not slightly breathy. The Oq of every tone is neutralized between the low_low environment used in this study. As illustrated in Figures 3-6, the mean Oq traces of all four tone types were nearly identical to each other following a low tone in medial positions, indicating a degree of glottal closure that is consistent with modal voicing rather than creaky voicing.

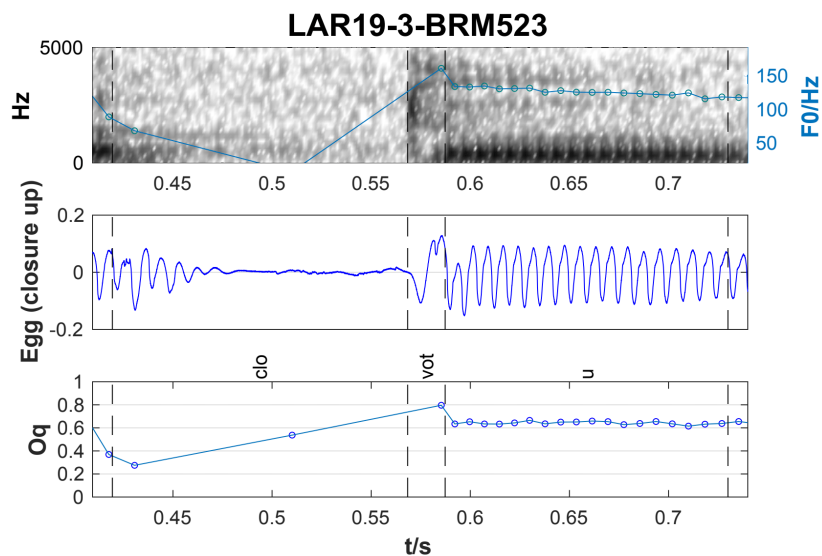


Figure 3: Figure 3 indicates the Oq of a low tone by a male speaker. The Oq indicates that the phonation leans more towards modal but is also slightly breathy.

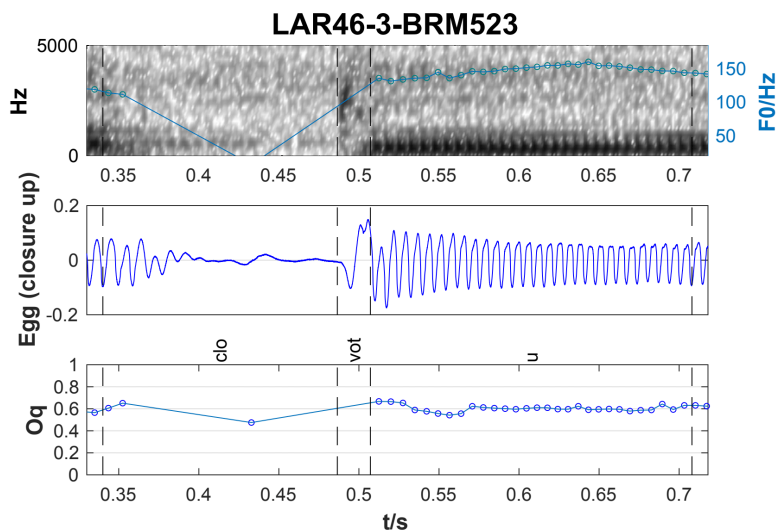


Figure 4: Figure 4 illustrates the Oq of a high tone spoken by a male speaker. The Oq indicates that the phonation of the high tone leans towards breathy or modal.

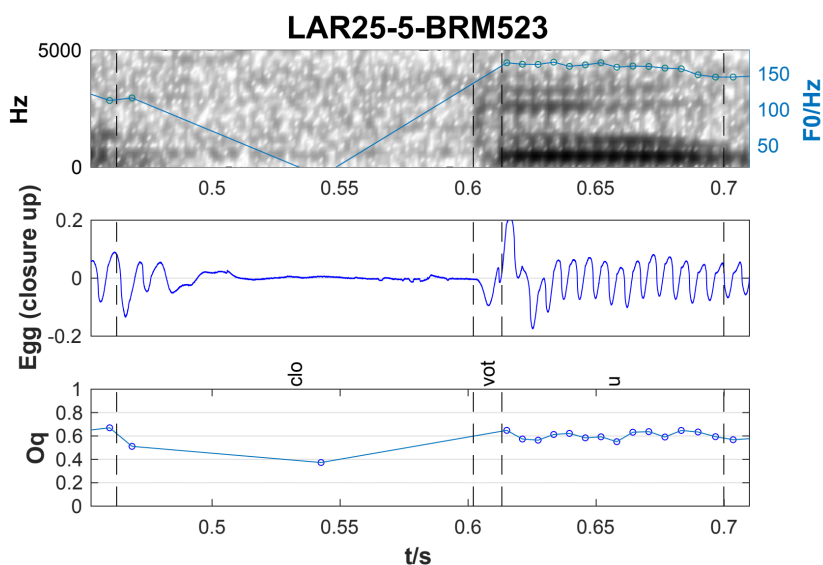


Figure 5: Figure 5 illustrates the Oq of a glottal tone spoken by a male speaker (BRM523). The Oq indicates that the phonation of the glottal tone is similar to the low and high tone.

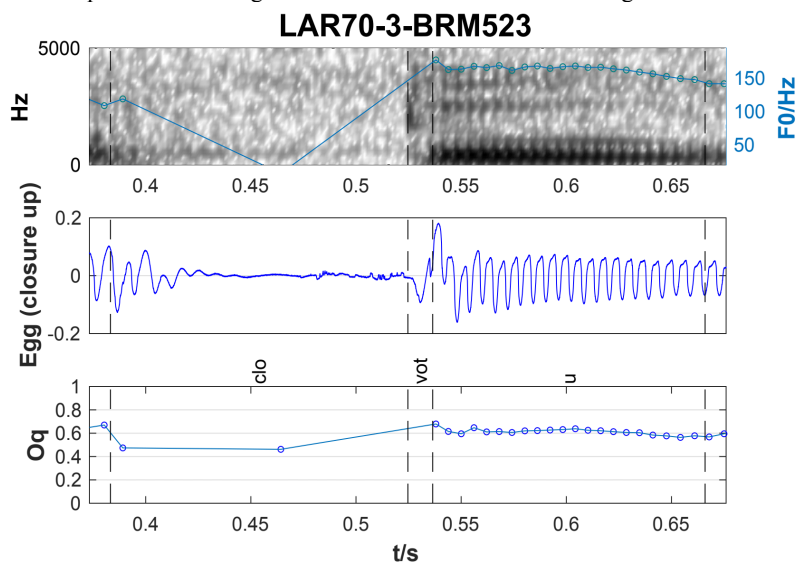


Figure 6: Figure 6 gives a representation of the Oq of a creaky tone spoken by a male speaker (BRM523). The Oq indicates that the phonation of the creaky voice is, similarly to the other 3 tones, breathy or modal.

4 Discussion

4.1 *Contrasting tones* As found with the non-laryngeal tones, F0 alone is not enough to explain pitch-tone relationships in Burmese. While patterns of high and low tones are invariable across speakers, interspeaker variation in the laryngeal tones is seen in some speakers. Kingston (2005) reports that tonal variation is found in Athabaskan languages where pitch may raise or lower because of the adduction of vocal folds. Additionally, Mazaudon (2014) reports that speakers of Tamang, another Sino-Tibetan language, use a bundle of cues to differentiate between tones rather than just one. A similar occurrence to both Kingston (2005) and Mazaudon (2014) may be happening with the speakers here as well, and thus the interspeaker variation of lowered pitch or of variable pitch in the glottal and creaky tones is phonetically grounded.

4.2 *Neutralization of phonation* The neutralization of laryngeal tones can be explained by analysis of phonetic undershoot. Phonetic undershoot is a process that can be motivated by coarticulation. In this case, the phonation of the glottal and creaky tones may be influenced. Low and high tones are modal in Burmese and producing a creaky phonation in between two modal tones may be difficult to accomplish. This neutralization also suggests that F0 is more primary than phonation as a cue. If phonation were a primary cue, then neutralization of pitch would be expected instead to reach the max height of the laryngeal tones.

This then lends to the question: What exactly are the cues for laryngeal tones? Both the creaky and glottal tones are similar, where the difference between the max F0 and F0 midpoints is not significant. Additionally, the Oq of the glottal and creaky tones are similar. Thus, there must be some other cue working here to differentiate the two. A possible explanation can be syllable structure (cf. Lee 2007). The glottal tone of Burmese has a more abrupt ending than the creaky tone. This suggests that the glottal tone is phonologically CVC rather than CV, like the creaky tones. If the glottal tone is phonologically CVC then this also suggests that syllable structure may be a cue for tone on top of phonation and F0. This also opens discussion and future research about how to define what a tone is.

5 Conclusion

In conclusion, lexical tone in Burmese is maximally contrasted through the use of both phonation and F0. Generally speaking, F0 is the primary cue, meaning that in any situation where one of the two acoustic cues can be sacrificed, it will be phonation rather than pitch. While there is some interspeaker variation, in general, the F0 is higher in the tonal distinction hierarchy. Phonation is neutralized following low tones rather than pitch. This phonation neutralization is possibly explained by phonetic undershoot where in between two modal tones, the creaky phonation will not occur. Further research will be needed to see whether the interspeaker variation of F0 is perceivable between different speakers, particularly between the glottal and creaky tones which appear to be acoustically less salient than the low and high tones.

6 References

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