OCP Effects in Suffixes with Burmese Creaky Tone

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Laryngeal features and Obligatory Contour Principle (OCP)

- Laryngeal features and dissimilation (OCP)
  - [voice]
    - Rendaku in Japanese (Vance 2015: 397-)
  - [spread glottis]
    - Deaspiration in Attic Greek & Grassman’s law (Steriade 1982: 234)
  - [long VOT] ‘ejectives’
    - co-occurrence restriction in Quechua (Gallagher 2014)
  - See also Bennett (2015) for other types of dissimilatory process in consonant phonology

- No known study that reports creaky voice being part of such a phonological process
Burmese

- A Tibeto-Burman language mainly spoken in Myanmar
- Speakers:
  - 32 million (as L1) and 10 million (as L2)
- Burmese is a tonal language

<table>
<thead>
<tr>
<th>Tone Type</th>
<th>Okell</th>
<th>IPA (Watkins 2000:145)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low tone</td>
<td>mu</td>
<td>[mù:] ‘nature’</td>
</tr>
<tr>
<td>High tone</td>
<td>mù</td>
<td>[mú] ‘drunk’</td>
</tr>
<tr>
<td>Creaky tone</td>
<td>mú</td>
<td>[mʊ́ʔ] ‘respect’</td>
</tr>
<tr>
<td>Stop tone</td>
<td>muq</td>
<td>[móʔ] ‘smooth’</td>
</tr>
</tbody>
</table>
Acoustics of Burmese tone
(Watkins 2000: 142-143)

Fundamental Frequency (F0)  Closed Quotient

/kəː kə́ː kə́ kə́ː/ (ကိုးကျစ္ ယောက်ကျစ္)
Experiment

- **Research question**
  - Are there OCP-effects for combinations of like tone (creaky-creaky and low-low)?

- Production of creaky vs. low tone
  - Noun + (Suffix) vs. Verb + Suffix

- Verbs have a clause boundary following them.
  - Is this clause-boundary marked by F0 or creakiness?
  - Nouns have no such clause boundary.

- Tokens have target words embedded in a sentence:
  - See appendix for the full list of sentences
Data collection

• Participants
  • Eight native Burmese Speakers (4 males, 4 females) between 27 and 41 years old
  • All residing in the USA, arriving after age 20.

• Recording session
  • Marantz PMD-661 digital Field Recorder
  • Shure WH-30 head-worn microphone
  • Quiet room

• Participants read randomized target sentences from a powerpoint file (three repetitions)
• The file was advanced by the researcher who monitored the disfluency or unnaturalness of read sentences.
Stimuli
- see the appendix for a full list

• 4 suffixes (2 low tone, 2 creaky tone)
• 8 roots
  • 2 low tone nouns, 2 creaky tone nouns
  • 2 low tone verbs, 2 creaky tone verbs
• 32 combinations + 4 unsuffixed (nominal) roots
  • only 4 unsuffixed nouns used because verbs have obligatory suffixes

• **36 stimuli x 3 repetitions = 108 tokens per speaker**
Methods: annotation

- A Praat script marked interval boundaries based on pauses.

- The 2nd author annotated vowels of target syllables based on the audio-visual cues.
  - The beginning and the end of a vowel were marked using information obtained from the formants in spectrograms.

- Another Praat script separated each target into a single file and automatically assigned a name to these files.
Methods: creakiness algorithm

• A creakiness detection algorithm for use in Matlab (Kane et al., 2013 and Drugman et al., 2014) was used to measure creakiness.

• A composite of acoustic measures that correlate with creakiness is used:
  • Spectral tilt (H2–H1)
  • F0 contour
  • Residual Peak Prominence (RPP)
  • Power Peak Parameters
  • Inter-Pulse Similarity
  • Intra-Frame Periodicity

• Degottex et al., 2014 originally trained the algorithm on databases with creaky sound tokens from English, Finnish, Swedish and Japanese.
Example of a result of the creakiness algorithm

- The creakiness algorithm was run on creaky syllables produced by two male speakers of Burmese
Methods: statistics

• Tokens were time-normalized prior to fitting a *Smoothing Spline ANOVA (SS-ANOVA)* model for both F0 and creakiness, following Gu (2014).

• Evaluation of the fitted model was done by predicting F0 and creakiness every 1 percentage point of the normalized time.

• Plots include 95% Bayesian confidence intervals.
  • Overlapping between confidence intervals corresponds to time-regions where no evidence of a significant difference between tones was found.
Results – Contrastive F0

- Mean F0 is higher in creaky tone than low tone for both roots (left, red box) and suffixes (right, red box).
Results – Contrastive Creakiness

- Low-tone **roots** (left, in red circle) are creakier than creaky-tone roots, except creaky-tone roots without a suffix (the green line).
- All **suffixes** are quite creaky (right).
  - Low-tone suffixes are creakier than creaky-tone suffixes.
Results – F0 in Nouns & Verbs

- F0 is higher in verbs (emerald) than nouns (beige) independent of the presence of a suffix.
- This difference is more pronounced in creaky tone (left) than in low tone (right).
Results – Creakiness in Nouns & Verbs

- Creaky-tone nouns (beige) are creakier than creaky-tone verbs (emerald).
- Low-tone verbs (emerald) are creakier than low-tone nouns (beige).
Discussion – OCP Effects

• Research question
  • Are there OCP-effects for combinations of like tone (creaky-creaky and low-low).

• There is no OCP-effect in low tone vowels.
• In $C_{\text{root}}$-$C_{\text{suffix}}$ sequences, $C_{\text{root}}$ is not creaky, a possible OCP effect.
  • Note that $C_{\text{root}}$ without a suffix is creaky.
• However, $C_{\text{root}}$ in $C_{\text{root}}$-$L_{\text{suffix}}$ sequences is also not creaky.

![Graph showing creakiness in roots over normalized time with different tone sequences: C-C, C-L, C-zero, L-C, L-L, L-zero.](image-url)
Discussion – Prosodic Account

- **Observation:** Verbal roots (plus a suffix) are followed by a clause boundary, and are marked by:
  - Increased F0 in clause-final creaky tone syllables.
  - Increased creakiness in clause-final low tone syllables.

- **Hypothesis:** Prosodic boundaries are characterized by a composite of creakiness and F0.
  - When the clause-final syllable is low tone:
    - Prosodic boundary marked by increased creakiness.
  - When the clause-final syllable is creaky tone:
    - Prosodic boundary marked by increased F0.
  - The prosodic boundaries are phonetically marked by creakiness or F0, depending on the context (low or creaky tone).
Discussion –
Non-Prosodic Effect in Nouns

- Nouns differ from verbs in that they are not followed by a clause boundary.
- **Hypothesis:** *The tonal contrast in nouns is preserved.*
  - 4 of 8 speakers had (slightly) more creakiness in creaky-tone than in low-tone nouns (or following suffixes).
  - 1 of these 4 speakers did not have an F0 contrast in nouns (shown below).
  - The remaining 4 speakers did not show any creakiness contrast.
- We need more evidence that a creakiness contrast exists in nouns.
Discussion – Lack of Creakiness

• Creaky tones were not consistently creaky. Why?
  • Contrast is expressed via raised F0 instead of creakiness.
  • Genuine variability
    • 4 of 8 speakers show (weak) evidence of contrastive creakiness in nouns.
  • Prosody
    • Targets from only one position within a sentence (cf. Lee & Win 2014).
• Age of speakers
  • Our speakers are relatively young.
  • Diachronic Shift: F0 is the primary cue for creaky tone, and not creakiness in younger speakers.
Conclusion

• Creaky tone is characterized by raised F0 in 7 of 8 speakers.
• Prosodic boundaries are marked by increased F0 or creakiness, whichever is *not* the primary cue in the vowel.
  • Increased F0 in creaky-tone vowels
  • Increased creakiness in low-tone vowels.
• Creaky tone was not consistently characterized by creakiness in all but 1 of 8 speakers.
  • Speakers vary on creakiness levels.
  • F0 did not vary to the same extent.
• Future Research: Do Burmese speakers use F0 more than creakiness in perception of creaky tone?
  • Do high tone & killed tone also display context-dependent creakiness?
References

• Degottex, Gilles, Kane, John, Drugman, Thomas, Raitio, Tuomo and Scherer, Stefan (2014) COVAREP – A collaborative voice analysis repository for speech technologies. In *IEEE Int. Conf. on Acoustics, Speech and Signal Processing, ICASSP*, 960-964.
• Steriade, Donca (1982) Greek prosodies and the nature of syllabification. PhD dissertation. MIT.
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Appendix – Stimuli


1. Nga-gá nwe caiq-teh.
2. Nga-gá lu mè-deh.
5. T’āmin ma-yin mā-sà-ba-néh.
6. Thu-dó la-yin pyàw-ba.
9. È-da má-yin dhàdī t'à-ba.
15. Di hniq nwe-ha pu-deh.
17. Di zábwèh má-da lè-deh.
25. Thu-dó má-déh thi-q-ta-gá lè-deh.
26. Thu-dó lú-déh lu-bba.
30. Thu-dó la-ló cānaw-dó thwà-deh.
32. Da-gá lu-yéh nà-ba.
33. Thu-dó má-ló ywè-ba-deh.
34. Cānāw eiq-ko lū-ló paiq-s’an māshí-dáw-bù.
35. Thu-dó la-méh né-yéh lá-gá ò-gouq-pa.
36. Da-gá lá-yéh ālin-yaun-ba.
ありがとうございます。

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