Word and sentence-level prosody in complex tone languages

Christian DiCanio\textsuperscript{1}
\texttt{cdicanio@buffalo.edu}
Joshua Benn\textsuperscript{1}
\texttt{jbenn@buffalo.edu}
Rey Castillo García\textsuperscript{2}
\texttt{reyyoloxochitl@gmail.com}

Department of Linguistics
University at Buffalo\textsuperscript{1}
Secretaria de Educación Pública (Guerrero)\textsuperscript{2}
Motivation

Listen to & look at both instances of /yaa¹⁴/ ‘ash’. Why do they differ?
Coarticulation and prosody condition reduction and hyperarticulation. Lexical tones are shaped by similar forces.

1. How is prosodic focus realized in Yoloxóchitl Mixtec?

2. Is prosodic focus sensitive to lexical stress? Are its effects on tone asymmetrical with respect to stress?
Coarticulation and prosody condition reduction and hyperarticulation. Lexical tones are shaped by similar forces.

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Introduction

Pathway to answers

- Speech production experiment on the influence of prosodic focus and stress on tone and duration in Yoloxóchitl Mixtec (Otomanguean: Mexico).

- The language possesses lexical tone, but unlike previous work on the tone-prosody interface (Huang, 2004; Scholz, 2012; Xu, 1999), it also has lexical stress.

- In addition to answering these questions, these investigations provide descriptive insights into the prosodic system of an endangered language based on original fieldwork.
What is prosody?

The hierarchical phonological organization which structures utterances and directs the listener toward semantically-relevant content.

(Gussenhoven, 2004)
What happens in tone languages?

1. Intonational pitch accents at different prosodic boundaries influence tonal contour shapes, e.g. Kipare (Herman, 1996).

2. Intonational boundary tones influence tonal shapes at edges of domains, e.g. Shekgalagari (Hyman and Monaka, 2011), Thai (Luksaneeyanawin, 1998).

3. Prosodic prominence is marked via phonetic lengthening or pitch range expansion, e.g. Mandarin (Xu, 1999).
High tones in Mandarin undergo raising and F₀ range expansion when in focus (Xu, 1999).
Prosodic lengthening and tone

- Stressed syllables undergo greater prosodic lengthening under focus than unstressed syllables do.
  
  English (Turk and Sawusch, 1997; Turk and White, 1999), Dutch (Cambier-Langeveld and Turk, 1999), Swedish (Heldner and Strangert, 2001)

- Intonational pitch accents are aligned with stressed syllables in non-tonal languages (Gussenhoven, 1983).

- Are focus-related effects on tone restricted to stressed syllables? or is it mediated by durational effects?
Yoloxóchitl Mixtec (YM)

- All roots are minimally composed of bimoraic couplets, consisting of either monosyllabic stems with long vowels (CVV) or disyllabic stems with shorter vowels (CVCV) (Castillo García, 2007).

- Tone is both lexically and morphologically-contrastive.
  - Final syllables are prominent, though the current evidence is mostly based on distributional asymmetries.
    - Nasal vowels only occur on stem-final syllables.
    - Nine possible tones on a stem-final syllable, but only five on a non-final syllable.
## Disyllabic words in YM

Twenty-six tonal melodies, including one minimal enneadecuplet (19 words).

<table>
<thead>
<tr>
<th>Melody</th>
<th>Word</th>
<th>Gloss</th>
<th>Melody</th>
<th>Word</th>
<th>Gloss</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.1</td>
<td>ta¹ ma₁</td>
<td>without appetite</td>
<td>4.13</td>
<td>na⁴ ma¹³</td>
<td>is changing</td>
</tr>
<tr>
<td>1.3</td>
<td>na¹ ma³</td>
<td>to change (intr)</td>
<td>4.14</td>
<td>nda⁴ ta¹⁴</td>
<td>is splitting up</td>
</tr>
<tr>
<td>1.4</td>
<td>na¹ ma⁴</td>
<td>soap</td>
<td>4.24</td>
<td>ya⁴ ma²⁴</td>
<td>Amuzgo person</td>
</tr>
<tr>
<td>1.32</td>
<td>na¹ ma³²</td>
<td>I will change myself</td>
<td>4.42</td>
<td>na⁴ ma⁴²</td>
<td>I often pile rocks</td>
</tr>
<tr>
<td>1.42</td>
<td>na¹ ma⁴²</td>
<td>my soap</td>
<td>13.2</td>
<td>hi¹³ ni²</td>
<td>has seen</td>
</tr>
<tr>
<td>3.2</td>
<td>na³ ma²</td>
<td>wall</td>
<td>13.3</td>
<td>na¹³ ma³</td>
<td>has photographed oneself</td>
</tr>
<tr>
<td>3.3</td>
<td>na³ ma³</td>
<td>to change (tr)</td>
<td>13.4</td>
<td>na¹³ ma⁴</td>
<td>has piled rocks</td>
</tr>
<tr>
<td>3.4</td>
<td>na³ ma⁴</td>
<td>sprout</td>
<td>14.2</td>
<td>na¹⁴ ma²</td>
<td>I will not change</td>
</tr>
<tr>
<td>3.42</td>
<td>na³ ma⁴²</td>
<td>I will pile rocks</td>
<td>14.3</td>
<td>na¹⁴ ma⁴</td>
<td>to not change</td>
</tr>
<tr>
<td>4.1</td>
<td>ka⁴ nda¹</td>
<td>is moving (intr)</td>
<td>14.4</td>
<td>na¹⁴ ma¹³</td>
<td>to not pile rocks</td>
</tr>
<tr>
<td>4.2</td>
<td>na⁴ ma²</td>
<td>I am changing</td>
<td>14.13</td>
<td>na¹⁴ ma¹³</td>
<td>to not change oneself</td>
</tr>
<tr>
<td>4.3</td>
<td>na⁴ ma³</td>
<td>it is changing</td>
<td>14.14</td>
<td>nda¹⁴ ta¹⁴</td>
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<td>na¹⁴ ma⁴²</td>
<td>I will not pile rocks</td>
</tr>
</tbody>
</table>
Focus in Yoloxóchitl Mixtec

(1) ni\textsuperscript{1}-ta\textsuperscript{3}ji\textsuperscript{3} yu\textsuperscript{3}\beta a\textsuperscript{4}=\texttilde o\textsuperscript{4} kwa\textsuperscript{4}yu\textsuperscript{2} nda\textsuperscript{3}?a\textsuperscript{4}=\texttilde o\textsuperscript{4}
PERF-give father=2S horse hand=2S
‘Your father gave you a horse.’

(2) yu\textsuperscript{3}\beta a\textsuperscript{4}=\texttilde o\textsuperscript{4} ni\textsuperscript{1}-ta\textsuperscript{3}ji\textsuperscript{3}=\texttilde ri\textsuperscript{4} kwa\textsuperscript{4}yu\textsuperscript{2} nda\textsuperscript{3}?a\textsuperscript{4}=\texttilde o\textsuperscript{4}
father=2S PERF-give=3S horse hand=2S
‘Your father gave you a horse.’

(3) yu\textsuperscript{3}\beta a\textsuperscript{4}=\texttilde o\textsuperscript{4} ni\textsuperscript{1}-ta\textsuperscript{3}ji\textsuperscript{3}=\texttilde ri\textsuperscript{4} kwa\textsuperscript{4}yu\textsuperscript{2} nda\textsuperscript{3}?a\textsuperscript{4}=\texttilde o\textsuperscript{4}
father=2S PERF-give=3S horse hand=2S
‘Your father gave you a horse.’
Stimuli elicitation

- Argument focus (after story)
  Rey: Who arrived?
  Speaker: John arrived.

- Contrastive focus (after story)
  Rey: Did Marcus arrive?
  Speaker: John arrived.

- Sentential focus (repetition)
  Rey: John arrived.
  Speaker: John arrived.
Methods

- Each answer/response was repeated six times by each respondent across two separate recording sessions (3 reps/session).
- Recording took place in San Luis Acatlán, a town near Yoloxóchitl.
- Each condition contained the same 28 target words which possessed nine tonal melodies: 1.1, 1.3, 1.4, 1.42, 3.2, 3.3, 3.4, 4.2, 4.4.
- Ten native speakers participated; a total of 5,040 utterances were analyzed (504/speaker).
- Target words segmented and analyzed using a script written in Praat (Boersma and Weenink, 2013).
- Normalized $F_0$ trajectories extracted over 5 time points and converted to log-normal values. Onset and vowel duration also extracted.
- Results analyzed using LMMs with lmertest (Kuznetsova et al., 2013). All reported results are significant.
Experiment: Focus and stress

Results: Duration

Onset consonant duration by stress and focus type

- No effect of focus in unstressed syllables

Vowel duration by stress and focus type

- Effect of stress on vowel duration only in sentential condition
Table: Durational patterns across focus types. Except for ratios and percentages, all numbers are in milliseconds.

<table>
<thead>
<tr>
<th>Focus Type</th>
<th>C₁</th>
<th>V₁</th>
<th>C₂</th>
<th>V₂</th>
<th>σ₁</th>
<th>σ₂</th>
<th>σ-ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sentential focus</td>
<td>70</td>
<td>77</td>
<td>95</td>
<td>90</td>
<td>141</td>
<td>185</td>
<td>1:1.31</td>
</tr>
<tr>
<td>Contrastive focus</td>
<td>77</td>
<td>92</td>
<td>120</td>
<td>99</td>
<td>169</td>
<td>219</td>
<td>1:1.30</td>
</tr>
<tr>
<td>Argument focus</td>
<td>76</td>
<td>94</td>
<td>136</td>
<td>107</td>
<td>170</td>
<td>242</td>
<td>1:1.42</td>
</tr>
<tr>
<td>Maximum Lengthening under focus</td>
<td>10%</td>
<td>22%</td>
<td>43%</td>
<td>19%</td>
<td>21%</td>
<td>31%</td>
<td></td>
</tr>
</tbody>
</table>
Results: Level tone melodies /1.1, 3.3, 4.4/

Globally, contrastive focus undergoes raising relative to argument/sentential focus. Argument focus induces raising only for certain tones.
Results: Rising tone melodies /1.3, 1.4, 3.4/

Tone /1/ on unstressed $\sigma$ does not rise, but tone on stressed $\sigma$ does.
Anticipatory falling trajectory of phonologically level tones in unstressed syllables under sentential focus.

Effect of focus type on falling tonal melodies /1.42, 3.2, 4.2/
Discussion: durational results

- Contrastive/argument focus cause greater prosodic lengthening on the stressed syllable than the unstressed syllable.

- Focus induces lengthening on the prosodically-prominent constituent in the word, in agreement with the *focus-to-accent* principle (Gussenhoven, 1983).

- Lengthening occurs more on the onset than the vowel. Why?

- Similar findings in Swedish (Heldner and Strangert, 2001), where onsets are lengthened when a syllable contains a phonologically short vowel.

- All vowels in the CVCV disyllables here were also short. Vowel length may influence the domain of prosodic lengthening in YM.
Discussion: tonal effects

- Fronted, focal NPs undergo $F_0$ range expansion and tones are raised relative to the same NPs under sentential focus.

- Contrastive focus is distinguished from narrow focus by increased $F_0$ range and raising of tonal melodies.

- The effect of stress position on tone varied by melody.
  
  Strong focus $\times$ position interaction: T1.3, T1.4, T1.42
  
  Weak focus $\times$ position interaction: T1.1, T4.4, T4.2, T3.2
  
  No focus $\times$ position interaction: T3.3, T3.4
Tone /1/ is hyperarticulated under focus; lowering enhances syntagmatic contrast between it and the following tone.

The distance between tones in a /1.4/ melody is 2.5x as large under contrastive focus as under sentential focus.

Sentential focus is associated with local effects of tonal reduction, e.g. anticipatory coarticulation, contour levelling.

Focus induces processes of tonal hyperarticulation that enhance syntagmatic contrast on the word.

The longer window on a lengthened stressed syllable permits greater tonal hyperarticulation. This is an indirect effect of stress on tone.
Conclusions

- Focus prosody induces prosodic lengthening on stressed syllables, $F_0$ range adjustments, tonal raising, and tonal shape modifications.

- Focus induced tonal hyperarticulation, but only the durational effects were sensitive to the prosodic hierarchy.
Future directions & Acknowledgements

- Examination of vowel length effect - is the locus of prosodic lengthening the vowel when vowels are long?
- Consonant lenition rates vary by stress position as well, e.g. /k/ -> [ʁ]. Are rates of lenition governed by higher-level prosodic differences?
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Team Mixtec: Rey Castillo García (SEP, Mexico), Jonathan Amith (Gettysburg College), and Joshua Benn (University at Buffalo)
Prosodic marking

**Accentual marking of heads/edges** – intonational pitch accents are attracted to prominent positions in the prosodic hierarchy or on constituents with narrow focus (Gussenhoven, 2004; Pierrehumbert and Beckman, 1988).

**Non-accentual phonological marking of domains** – prominent positions in the prosodic hierarchy license the application of specific phonological processes, e.g. tone spreading domains (Hsu and Jun, 1996; Hyman, 1990; Hyman and Monaka, 2011; Lee, 2014), positional neutralization (Barnes, 2006).

**Phonetic marking of domains** – prominent positions in the prosodic hierarchy undergo processes of phonetic enhancement, e.g. domain-initial strengthening (Fougeron and Keating, 1997; Keating et al., 2000), focal $F_0$ range expansion (Xu, 1999), stress-related hyperarticulation (Byrd and Choi, 2010; de Jong, 1995; Krivokapić and Byrd, 2012).
Dynamical parameters (Cho, 2006)

Figure 2. Hypothetical movement trajectories that correspond to a change in each parameter. (a) show change in stiffness; (b) change in target; (c) change in intergestural timing; and (d) change by shrinking. Empty circles indicate the timepoint of the peak velocity attainment.

(1) Stiffness. Variation in articulatory movement duration is thought to be controlled by the stiffness parameter: the stiffer the spring (the articulator), the faster the movement. An idealized pattern in a pure change in stiffness is visualized in Figure 2a, and its corresponding kinematic relationships in Figures 3a-b. If stiffness is the only parameter underlying kinematic differences, there should be a change in peak velocity (i.e., the maximum velocity that the articulator attains during the gesture), but not in displacement (i.e., the amount of spatial distance that the articulator travels), therefore showing vertical distribution of the datapoints (Figure 3a). In addition, (with a change only in stiffness)
Effects

While explicit modelling is still lacking, the tonal changes associated with contrastive and argument focus appear to involve changes in the target (even in unstressed syllables) as well as stiffness (faster peak velocity).

Sentential focus is more likely to undergo local coarticulatory processes (contour levelling, tonal anticipation) since gestural stiffness is reduced.

Incidentally, this will affect intergestural timing as adjacent tonal patterns are more likely to influence a tone with reduced stiffness.
References


Kuznetsova, A., Brockhoff, P. B., and Christensen, R. H. B. (2013). *lmerTest (R package)*.


