# Word and sentence-level prosody in complex tone languages

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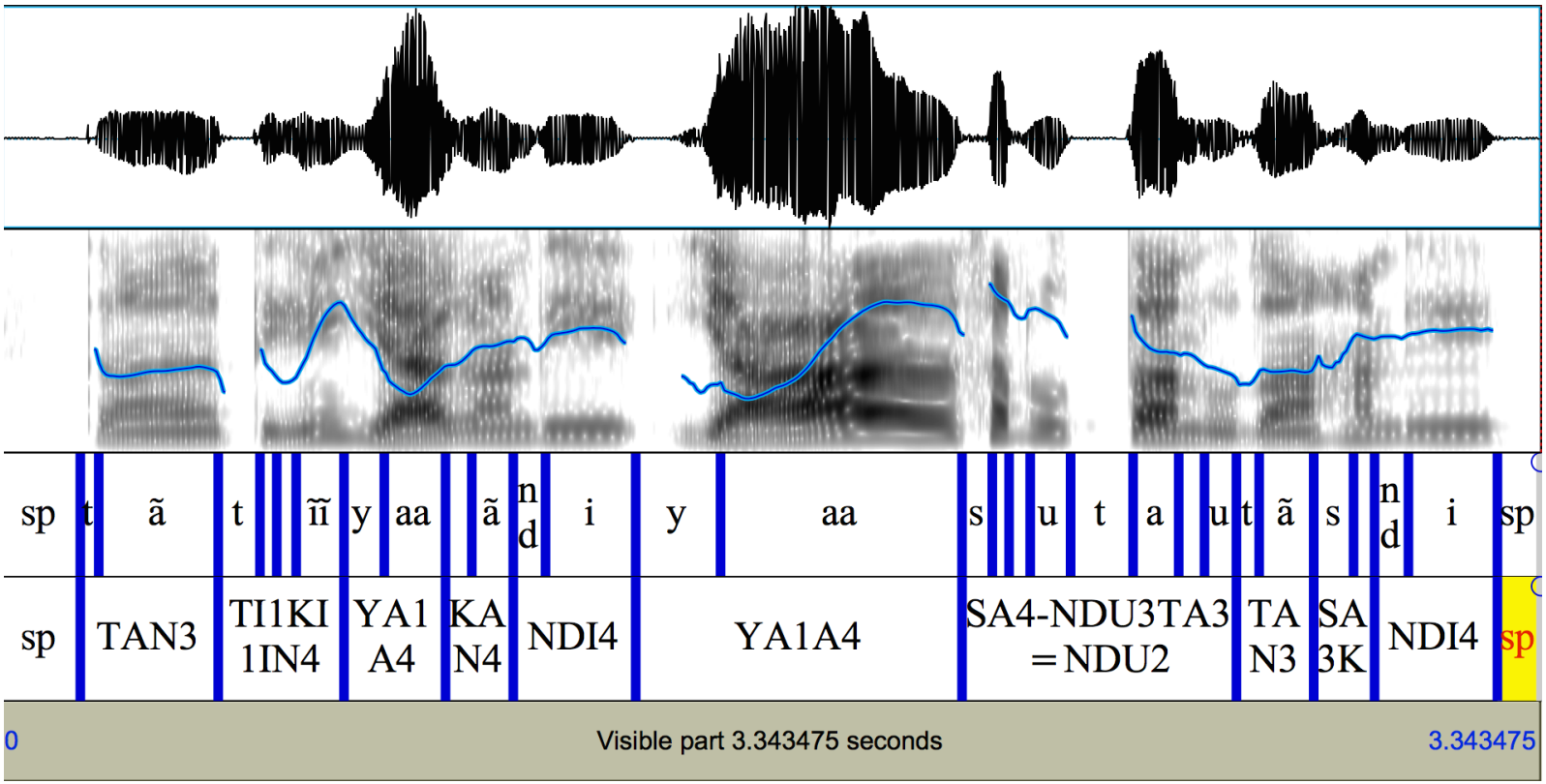
# Motivation

tã$^{3}$ ti$^{1}$kĩ$^{14}$ yaa$^{14}$ kã$^{4}$ ndi$^{4}$ yaa$^{14}$ sa$^{4}$-ndu$^{3}$ta$^{3}$=ndu$^{2}$ tã$^{4}$ sa$^{3}$kã$^{4}$ ndi$^{4}$




Listen to & look at both instances of /yaa$^{14}$/ 'ash'. Why do they differ?

# Research questions

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?

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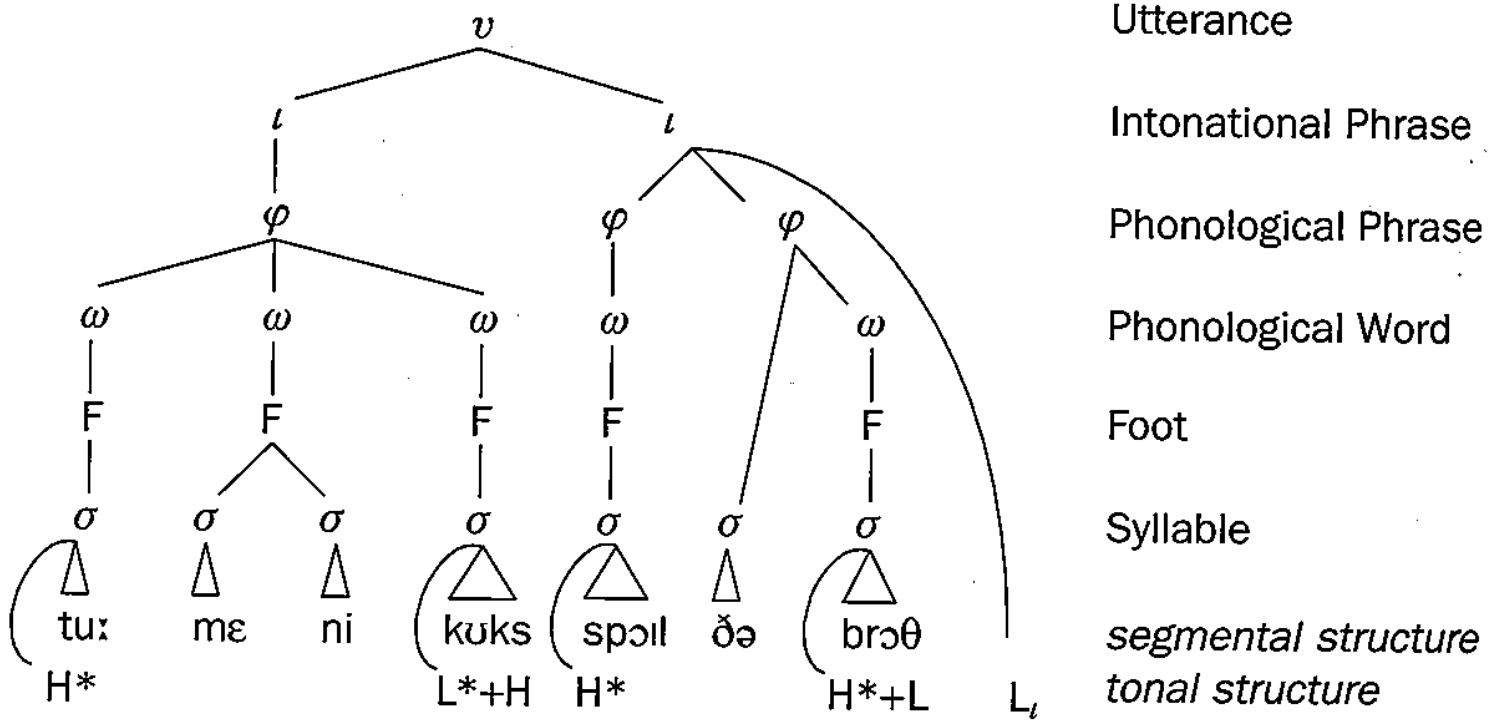
# Pathway to answers

- 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?

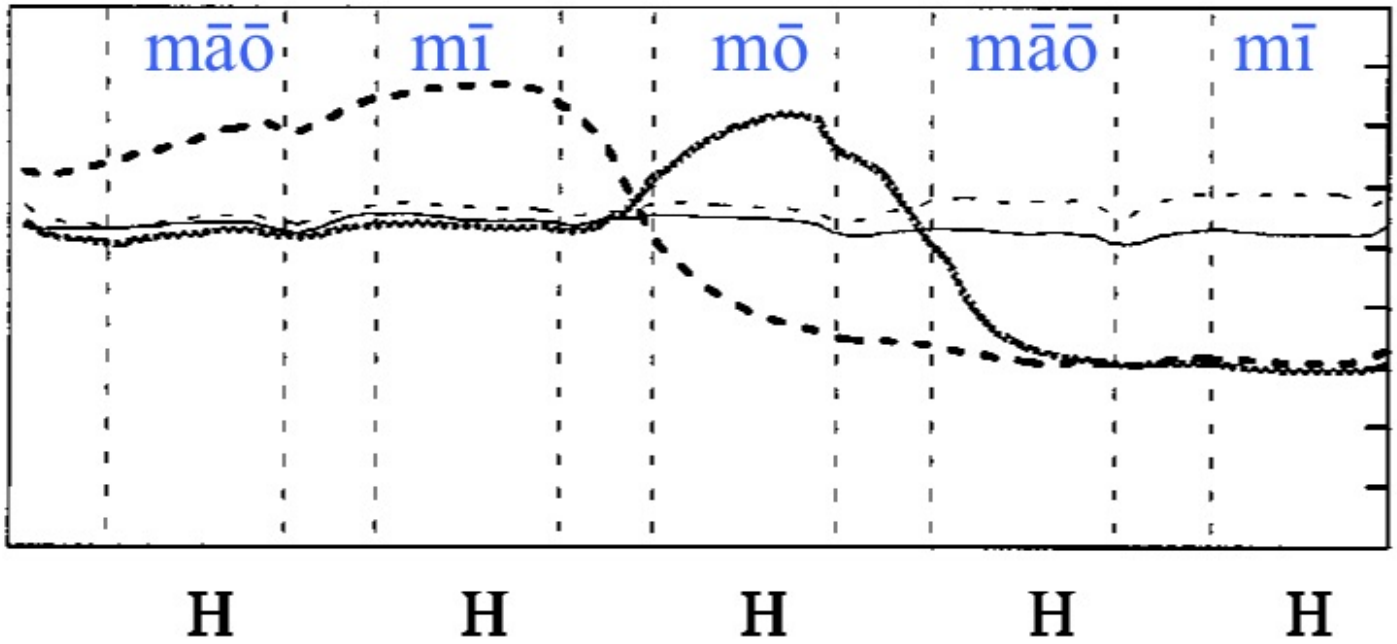
1. Intonational pitch accents at different prosodic boundaries influence tonal contour shapes, e.g. Kipare (Herman, 1996).

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).

# Example

High tones in Mandarin undergo raising and $F_0$ 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).

| Melody | Word | Gloss | Melody | Word | Gloss |
|---|---|---|---|---|---|
| 1.1 | ta$^{1}$ma$^{1}$ | *without appetite* | 4.13 | na$^{4}$ma$^{13}$ | *is changing* |
| 1.3 | na$^{1}$ma$^{3}$ | *to change (intr)* | 4.14 | nda$^{4}$ta$^{14}$ | *is splitting up* |
| 1.4 | na$^{1}$ma$^{4}$ | *soap* | 4.24 | ya$^{4}$ma$^{24}$ | *Amuzgo person* |
| 1.32 | na$^{1}$ma$^{32}$ | *I will change myself* | 4.42 | na$^{4}$ma$^{42}$ | *I often pile rocks* |
| 1.42 | na$^{1}$ma$^{42}$ | *my soap* | 13.2 | hi$^{13}$ni$^{2}$ | *has seen* |
| 3.2 | na$^{3}$ma$^{2}$ | *wall* | 13.3 | na$^{13}$na$^{3}$ | *has photographed oneself* |
| 3.3 | na$^{3}$ma$^{3}$ | *to change (tr)* | 13.4 | na$^{13}$ma$^{4}$ | *has piled rocks* |
| 3.4 | na$^{3}$ma$^{4}$ | *sprout* | 14.2 | na$^{14}$ma$^{2}$ | *I will not change* |
| 3.42 | na$^{3}$ma$^{42}$ | *I will pile rocks* | 14.3 | na$^{14}$ma$^{3}$ | *to not change* |
| 4.1 | ka$^{4}$nda$^{1}$ | *is moving (intr)* | 14.4 | na$^{14}$ma$^{4}$ | *to not pile rocks* |
| 4.2 | na$^{4}$ma$^{2}$ | *I am changing* | 14.13 | na$^{14}$ma$^{13}$ | *to not change oneself* |
| 4.3 | na$^{4}$ma$^{3}$ | *it is changing* | 14.14 | nda$^{14}$ta$^{14}$ | *to not split up* |
| 4.4 | na$^{4}$ma$^{4}$ | *is piling rocks* | 14.42 | na$^{14}$ma$^{42}$ | *I will not pile rocks* |

# Focus in Yoloxóchitl Mixtec

(1) ni$^{1}$-ta$^{3}$ʃi$^{3}$ yu$^{3}$βa$^{4}$=õ$^{4}$ kwa$^{4}$yu$^{2}$ nda$^{3}$ʔa$^{4}$=õ$^{4}$
PERF-give father=2S horse hand=2S
'Your father gave you a horse.'

Sentential focus

(2) yu$^{3}$βa$^{4}$=õ$^{4}$ ni$^{1}$-ta$^{3}$ʃi$^{3}$=ɾi$^{4}$ kwa$^{4}$yu$^{2}$ nda$^{3}$ʔa$^{4}$=õ$^{4}$
father=2S PERF-give=3S horse hand=2S
'Your father gave you a horse.'

Argument focus

(3) yu$^{3}$βa$^{4}$=õ$^{4}$ ni$^{1}$-ta$^{3}$ʃi$^{3}$=ɾi$^{4}$ kwa$^{4}$yu$^{2}$ nda$^{3}$ʔa$^{4}$=õ$^{4}$
father=2S PERF-give=3S horse hand=2S
'Your father gave you a horse.'

Corrective focus

# Stimuli elicitation

- Argument focus (after story)

  Rey: Who arrived?
  Speaker: John arrived.

- Contrastive focus (after story)

  Rey: Did Marcus arrive?
  Speaker: John arrived.

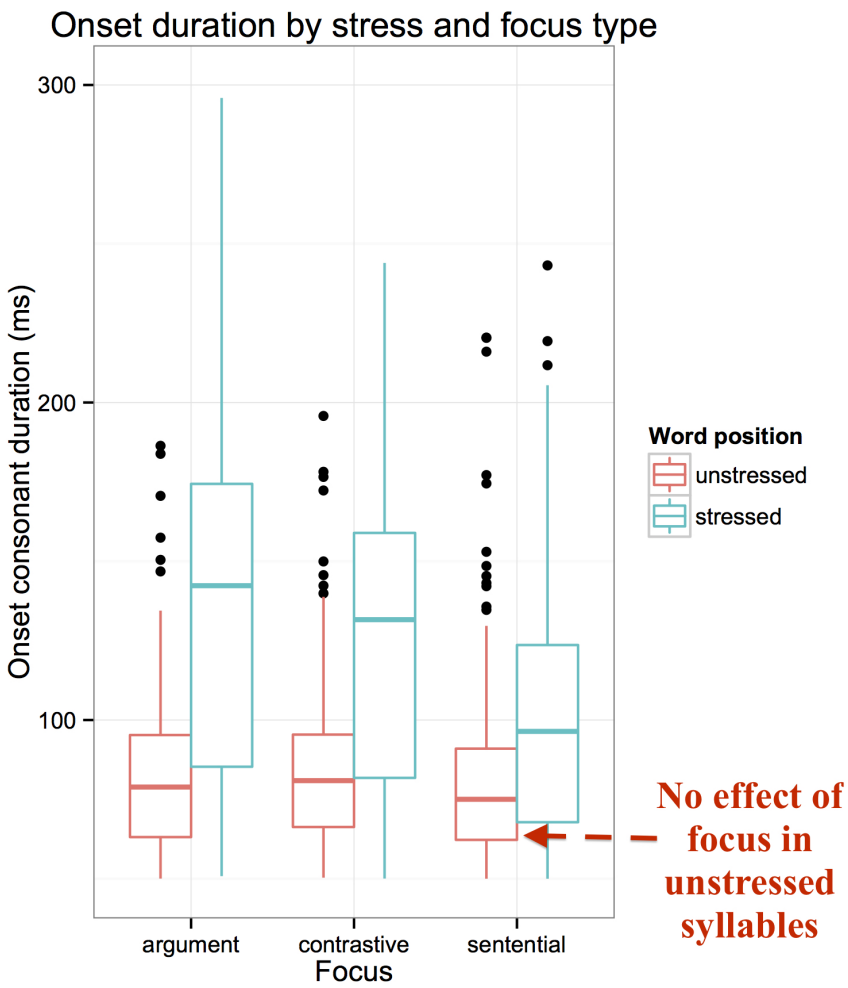
- Sentential focus (repetition)

  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.

# Results: Duration



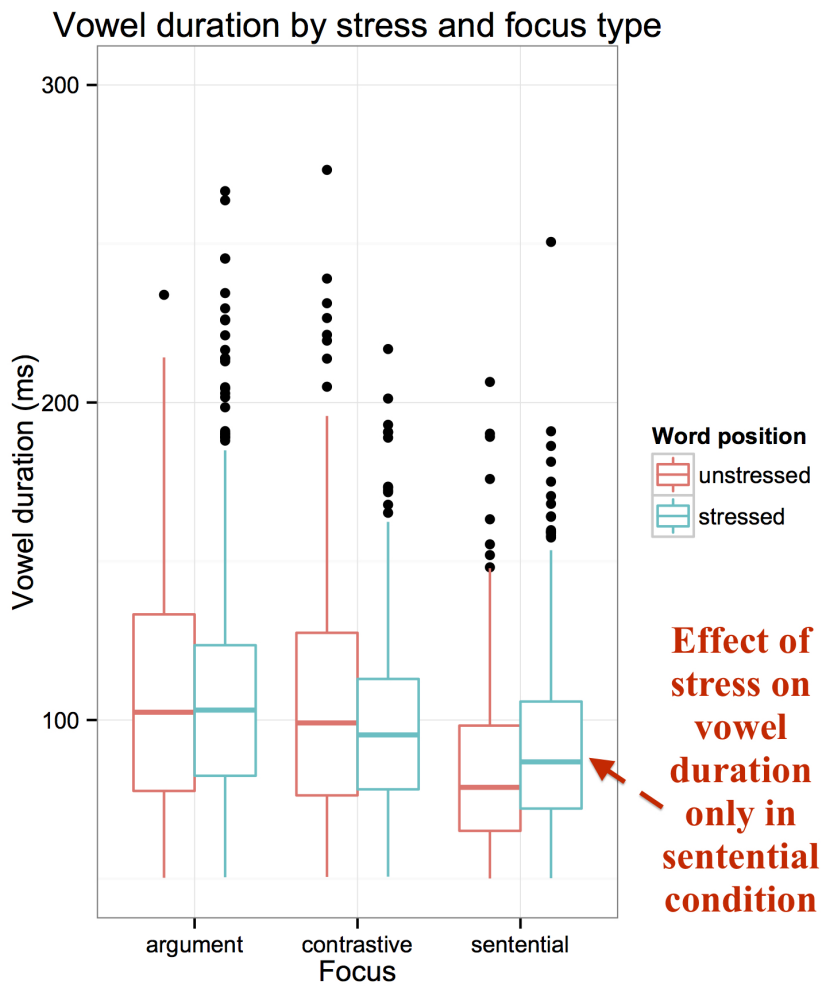
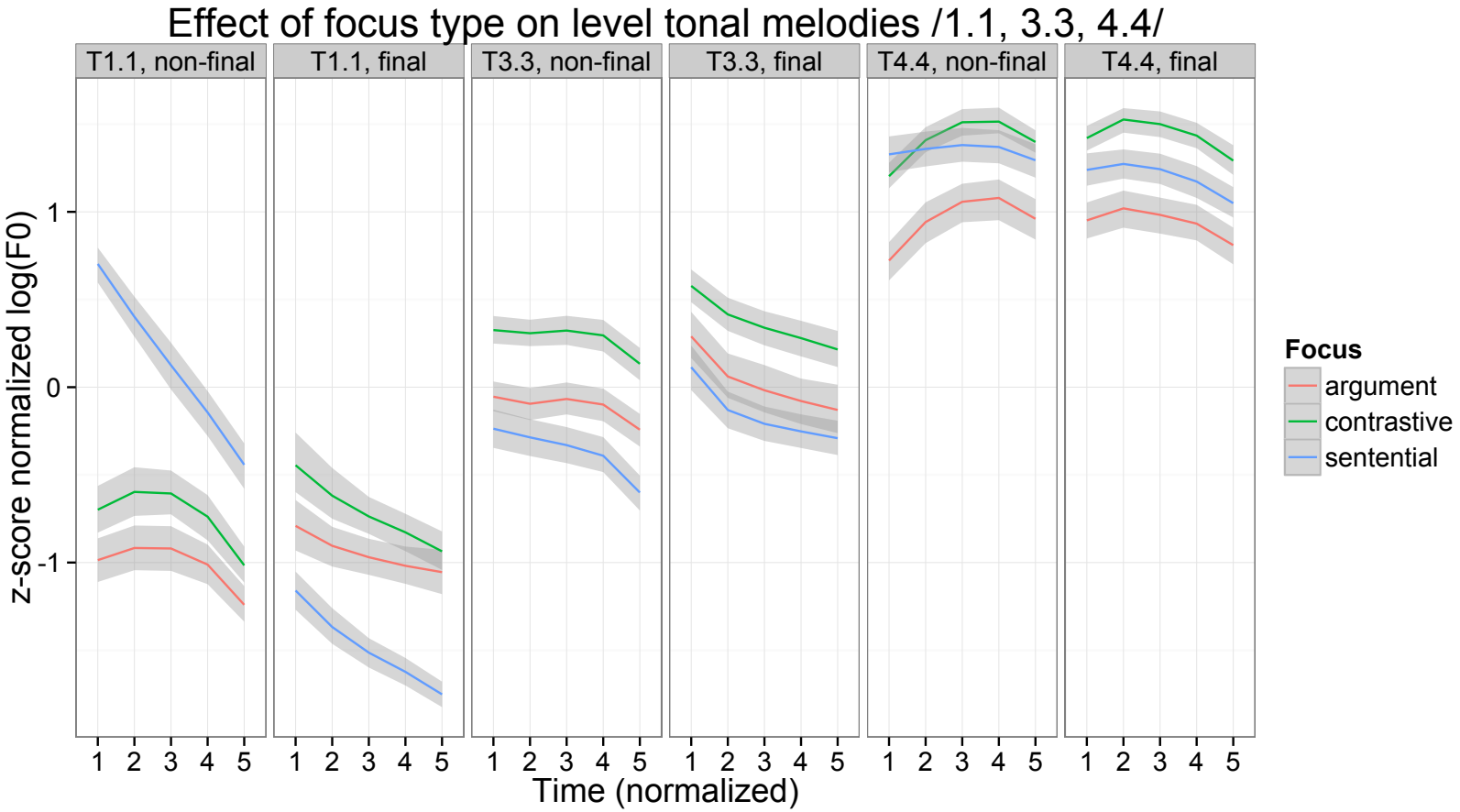



Table: Durational patterns across focus types. Except for ratios and percentages, all numbers are in milliseconds.

| | $C_1$ | $V_1$ | $C_2$ | $V_2$ | $\sigma_1$ | $\sigma_2$ | $\sigma$-ratio |
|---|---|---|---|---|---|---|---|
| Sentential focus | 70 | 77 | 95 | 90 | 141 | 185 | 1:1.31 |
| Contrastive focus | 77 | 92 | 120 | 99 | 169 | 219 | 1:1.30 |
| Argument focus | 76 | 94 | 136 | 107 | 170 | 242 | 1:1.42 |
| Maximum Lengthening under focus | 10% | 22% | 43% | 19% | 21% | 31% | |

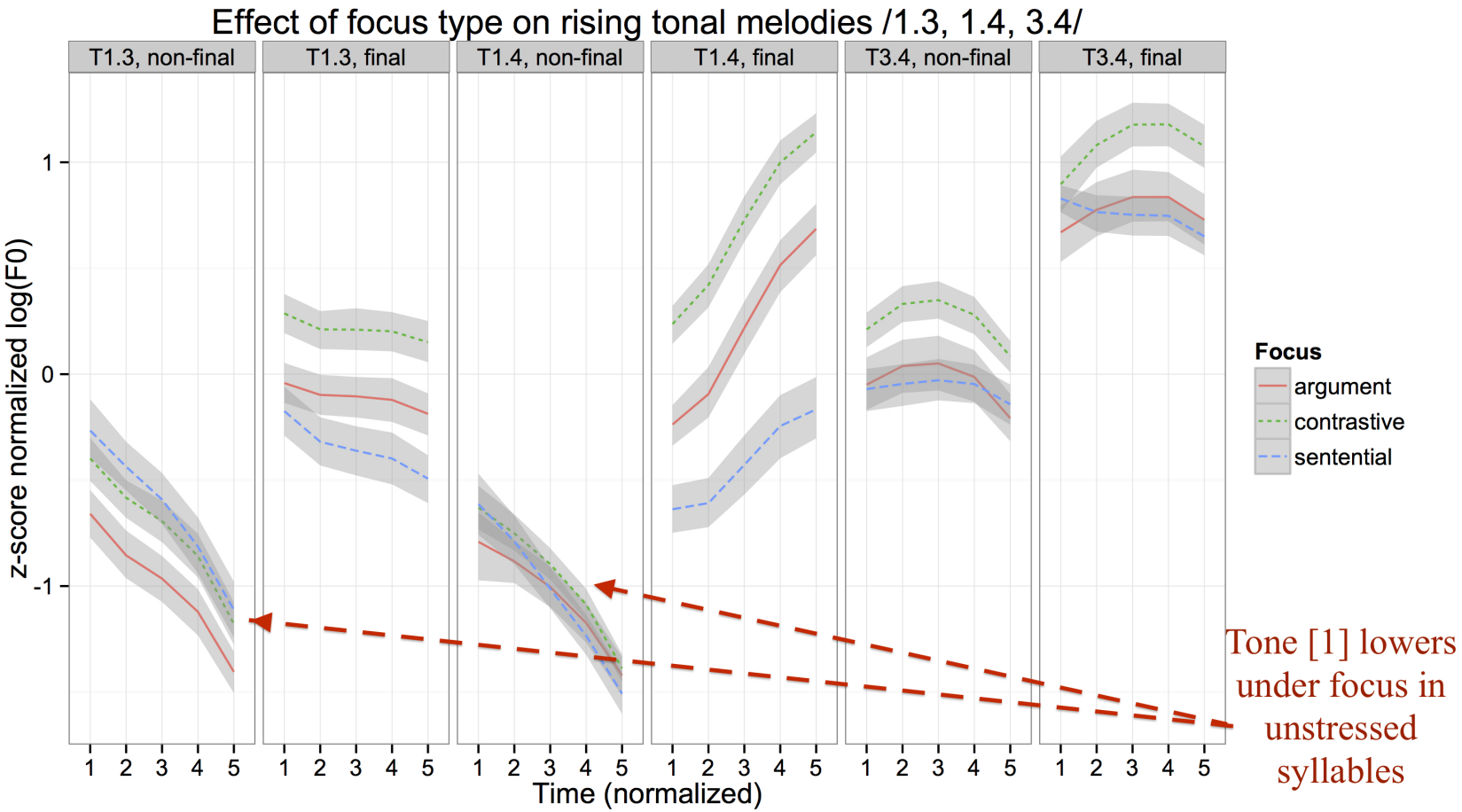
# Results: Level tone melodies /1.1, 3.3, 4.4/

Globally, contrastive focus undergoes raising relative to argument/sentential focus. Argument focus induces raising only for certain tones.



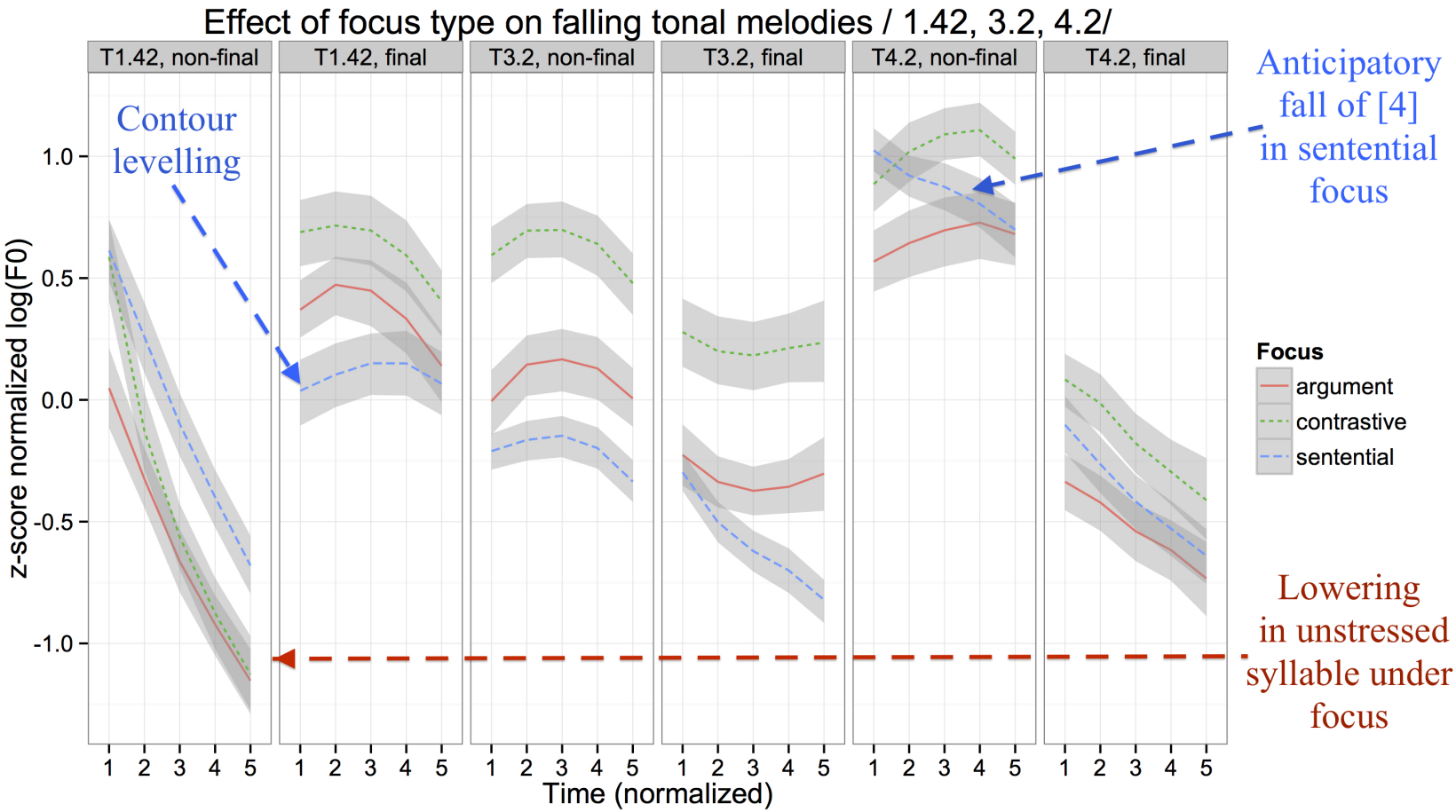
# Results: Rising tone melodies /1.3, 1.4, 3.4/

Tone /1/ on unstressed $\sigma$ does not rise, but tone on stressed $\sigma$ does.



# Results: Falling tone melodies /1.42, 3.2, 4.2/

Anticipatory falling trajectory of phonologically level tones in unstressed syllables under sentential focus.



# 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 x position interaction | T1.3, T1.4, T1.42 |
| Weak focus x position interaction | T1.1, T4.4, T4.2, T3.2 |
| No focus x 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/ > [ɣ]. Are rates of lenition governed by higher-level prosodic differences?
- Support via NSF DEL/RI grant 1603323, *Understanding Prosody and Tone Interactions through Documentation of Two Endangered Languages*
- Team Mixtec: Rey Castillo García (SEP, Mexico), Jonathan Amith (Gettysburg College), and Joshua Benn (University at Buffalo)

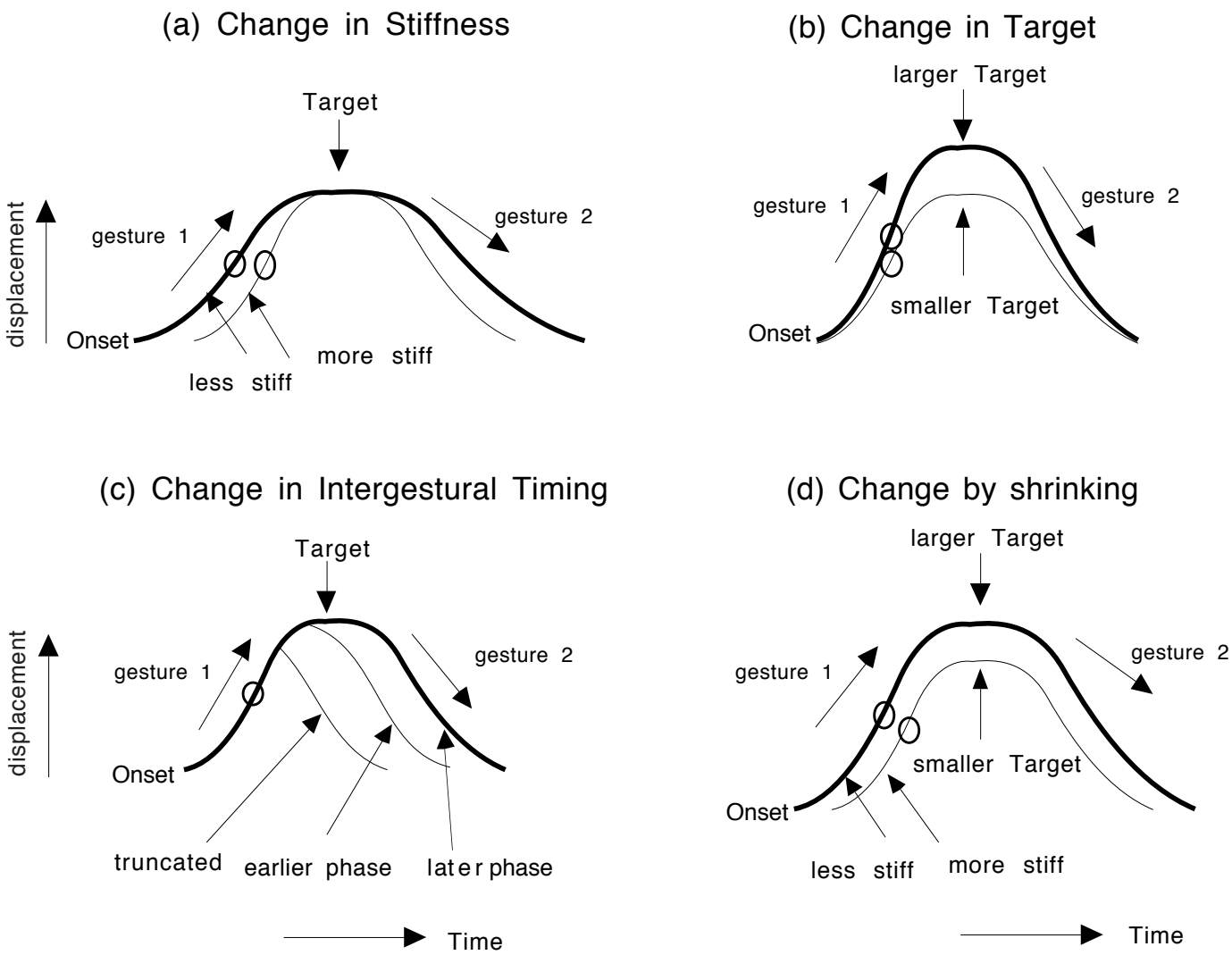
# Prosodic marking

**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)



# 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.

Barnes, J. (2006). *Strength and Weakness at the Interface: Positional Neutralization in Phonetics and Phonology*. Berlin, New York: Mouton de Gruyter.

Boersma, P. and Weenink, D. (2013). Praat: doing phonetics by computer [computer program]. www.praat.org.

Byrd, D. and Choi, S. (2010). At the juncture of prosody, phonology, and phonetics – the interaction of phrasal and syllable structure in shaping the timing of consonant gestures. In Fougeron, C., Kuehnert, B., Imperio, M., and Vallee, N., editors, *Laboratory Phonology 10*, pages 31–59. Mouton de Gruyter.

Cambier-Langeveld, T. and Turk, A. E. (1999). A cross-linguistic study of accentual lengthening: Dutch vs. English. *Journal of Phonetics*, 27:255–280.

Castillo García, R. (2007). Descripción fonológica, segmental, y tonal del Mixteco de Yoloxóchitl, Guerrero. Master's thesis, Centro de Investigaciones y Estudios Superiores en Antropología Social (CIESAS), México, D.F.

Cho, T. (2006). Manifestation of prosodic structure in articulatory variation: Evidence from lip kinematics in English. In Goldstein, L. M., Whalen, D. H., and Best, C. T., editors, *Laboratory Phonology 8: Varieties of Phonological Competence*. Berlin, New York: Mouton de Gruyter.

de Jong, K. J. (1995). The supraglottal articulation of prominence in English: Linguistic stress as localized hyperarticulation. *Journal of the Acoustical Society of America*, 97(1):491–504.

Fougeron, C. and Keating, P. A. (1997). Articulatory strengthening at edges of prosodic domains. *Journal of the Acoustical Society of America*, 101(6):3728–3740.

Gussenhoven, C. (1983). Focus, Mode, and the Nucleus. *Journal of Linguistics*, 19(2):377–417.

Gussenhoven, C. (2004). *The Phonology of Tone and Intonation*. Research Surveys in Linguistics. Cambridge University Press.

Heldner, M. and Strangert, E. (2001). Temporal effects of focus in Swedish. *Journal of Phonetics*, 29(329–361).

Herman, R. (1996). Final lowering in Kipare. *Phonology*, 13:171–196.

Hsu, C.-S. and Jun, S.-A. (1996). Is tone sandhi group part of the prosodic hierarchy in Taiwanese? *Journal of the Acoustical Society of America*, 100:2824.

Huang, Y.-H. (2004). Focus condition in spontaneous Taiwanese Mandarin. Master's thesis, National Chiao Tung University, Taiwan.

Hyman, L. M. (1990). Boundary tonology and the prosodic hierarchy. In Inkelas, S. and Zec, D., editors, *The phonology-syntax connection*, pages 109–125. Chicago: University of Chicago Press.

Hyman, L. M. and Monaka, K. C. (2011). Tonal and Non-tonal Intonation in Shekgalagari. In Frota, S., Elordieta, G., and Prieto, P., editors, *Prosodic categories: Production, Perception, and Comprehension*, pages 267–290. Springer Verlag.

Keating, P., Cho, T., Fougeron, C., and Hsu, C.-S. (2000). Domain-initial articulatory strengthening in four languages. In Local, J., Ogden, R., and Temple, R., editors, *Papers in laboratory phonology 6*, chapter 10. Cambridge University Press.

Krivokapić, J. and Byrd, D. (2012). Prosodic boundary strength: an articulatory and perceptual study. *Journal of Phonetics*, 40(3):430–442.

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

Lee, S. J. (2014). Domains of H tone spreading and the noun class prefix in Xitsonga. *Southern African Linguistics and Applied Language Studies*, 32(1):21–34.

Luksaneeyanawin, S. (1998). Intonation in Thai. In Hirst, D. and Di Cristo, A., editors, *Intonation Systems: A survey of twenty languages*, chapter 21, pages 376–394. Cambridge University Press.

Pierrehumbert, J. B. and Beckman, M. E. (1988). *Japanese tone structure*. Cambridge: MIT Press.

Scholz, F. (2012). *Tone sandhi, prosodic phrasing, and focus marking in Wenzhou Chinese*. PhD thesis, Leiden University.

Turk, A. and White, L. (1999). Structural influences on accentual lengthening in english. *Journal of Phonetics*, 27(2):171–206.

Turk, A. E. and Sawusch, J. R. (1997). The domain of accentual lengthening in American English. *Journal of Phonetics*, 25:25–41.

Xu, Y. (1999). Effects of tone and focus on the formation and alignment of F0 contours. *Journal of Phonetics*, 27:55–105.