Phonetic Alignment in Yoloxóchitl Mixtec Tone

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1/06/12 - SSILA - Portland

Goals

1. Examine the alignment of F_0 maxima and minima with respect to prosodic units. Are tones phonetically aligned to syllables or to moras?

2. Provide a phonetic description of a complex tone system with 21 tonal patterns on monosyllabic words and 28 on disyllabic words.

3. Conclusion: Strong evidence for phonetic alignment *only* to moras. There is no evidence for the syllable as the tone bearing unit.

Typological Context

- Approximately 41.8% of the world's languages (220/527) are tonal (Maddieson, 2011).
- Of these, 60% (132/220) have only 1-2 lexical tone contrasts and 40% have three or more tonal contrasts (88/220).
- Among the tone languages with large inventories, languages with between 3-6 tonal contrasts are relatively common, e.g. Thai (5), Mandarin (4), Vietnamese (6), Cantonese (6), Yoruba (3).
- Languages with greater than 6 tones are rarer, but many (including Yoloxóchitl Mixtec) are Oto-Manguean, e.g. Itunyoso Trique (9) (DiCanio, 2008), Chatino (10) (Cruz and Woodbury, 2005), Tlacoatzintepec Chinantec (7) (Thalin, 1980), Chiquihuitlan Mazatec (17) (Jamieson, 1977).

Yoloxóchitl Mixtec

- Oto-Manguean: Mixtecan: Southern Baja / Guerrero (Josserand, 1983). Spoken in Guerrero, Mexico.

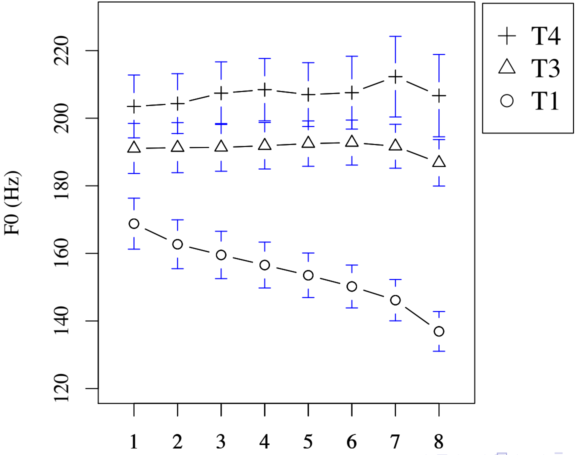
- Like other Mixtecan languages, all roots are composed of bimoraic couplets, consisting of either monosyllabic stems with long vowels (CVV) or disyllabic stems with shorter vowels (CVCV) (Castillo García, 2007).

- Four tonal levels contrast in the phonology, with a large number of contours derived from combinations of levels.

- Tone is phonologically associated with moras. Five tones may surface on the initial mora of a couplet, while nine may surface on the second. Tonal patterns are similar on monosyllables and disyllables.

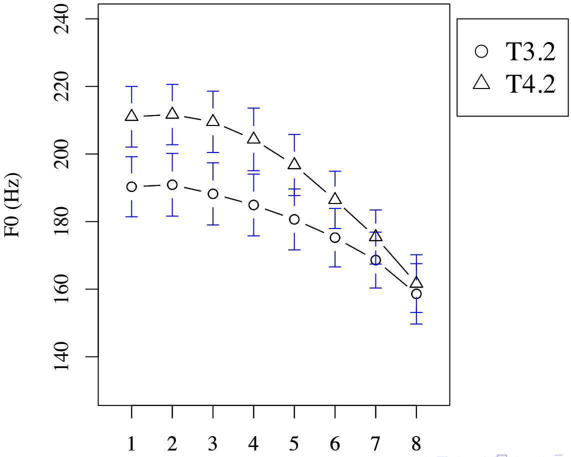
Level tones

nda^{1}a^1 '*flat*', ʃa^{3}a^3 '*fast*', nda^{4}a^4 '*black*'



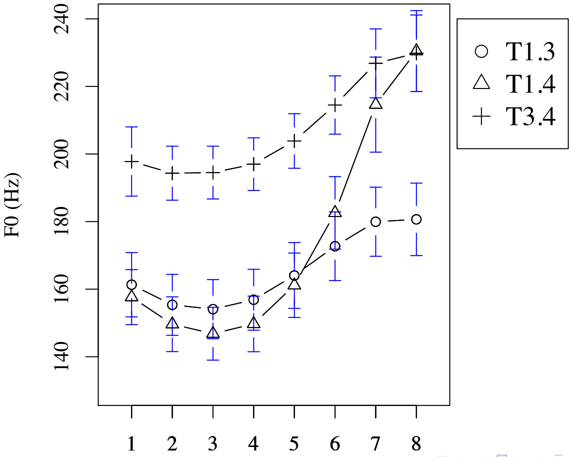
Falling tones

nda^{3}a^2 '*sloping*', nda^{4}a^2 '*where*'



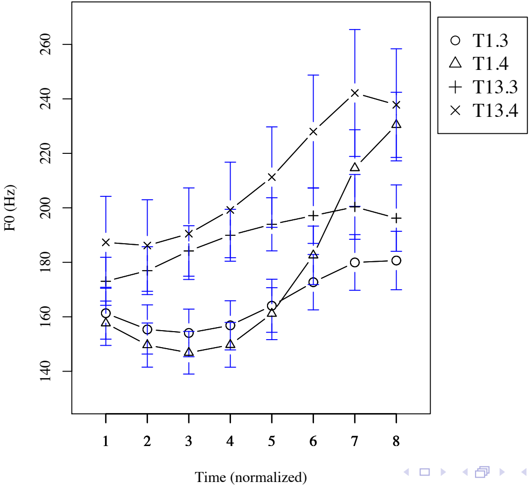
Simple rising tones

ta^{1}a^3 '*man*', ndo^{1}o^4 '*sugarcane*', nde^{3}e^4 '*strong*'



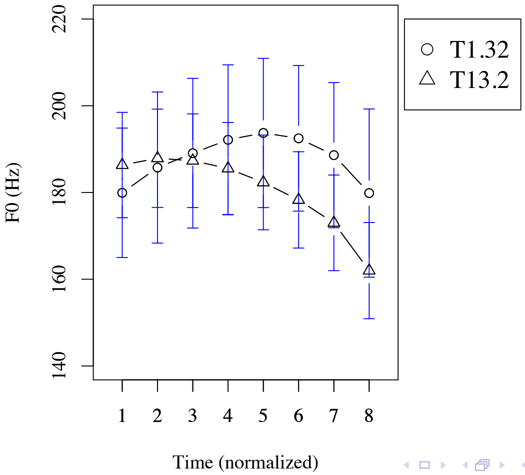
Complex rising tones

nda^{13}a^{3} '*went up*', tu^{13}u^{4} '*stripped*'



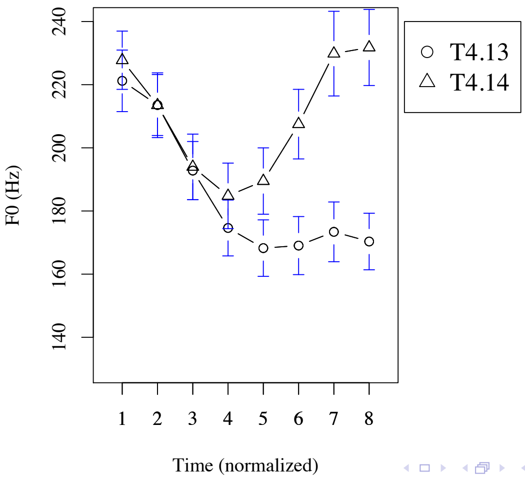
Concave tones contrasting in alignment

kwe^{13}e^{2} '*linger*', ʃi^{1}i^{32} '*resistant*'



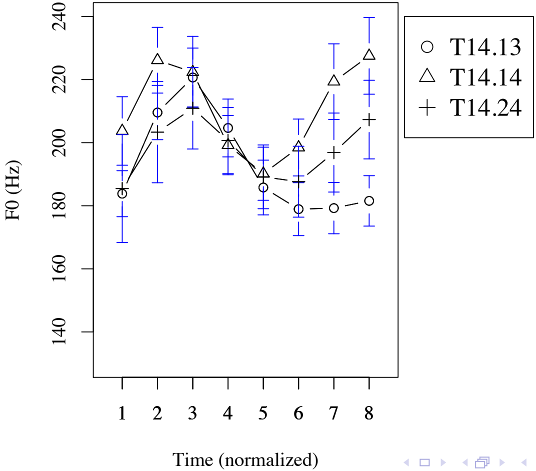
Convex tones

nde^{4}e^{13} '*they enter*', kwi^{4}i^{14} '*is peeling*'



Double rising tones

ndo^{14}o^{13} '*to not stay*', kwi^{14}i^{14} '*is not peeling*', ka^{14}a^{24} '*does not slip*'



- Typically, the size of a tonal inventory is determined by the number of contrastive tones permitted to surface on a single syllable.
- This assumption may be problematic for determining inventory sizes for languages with apparently large tonal inventories.
- Assumption of moraic structure without independent evidence for it is also problematic.
- Analysing the alignment of F_0 targets within different prosodic units in words allows us to test which units best align with tone. Such units are clear targets for tonal association.

Phonetic tonal alignment to syllables

- Similar alignment across CVN and CV syllables at different speech rates in Mandarin. Tonal contrasts are aligned to syllables (Xu, 1998).
- Contour tone licensing is insensitive to moraic structure, but sensitive to rime sonority (Zhang, 2004). Contour tones surface on syllables with longer duration of voicing.
- Zhang finds that contour tones more often surface in monosyllabic words than in polysyllabic words. He argues that contour tone licensing is sensitive to the phonetic contraction of syllable length in larger words (Lehiste, 1970).

Tonal alignment to moras

- Earlier F_0 peak observed for H and HL tones in Kinyarwanda than for the LH tone. Both H and HL tones have a high tone associated with the first mora in bimoraic syllables. This earlier peak alignment supports a moraic alignment of tone and also accounts for a process of regressive high tone movement (Myers, 2003). Moraic structure is further supported by contrastive vowel length.
- Examining CVV, CVN, and CVVN syllables in Thai, Morén and Zsiga (2006) find that the inflection points of tonal contours align with the right edge of moras. Rising tones only begin to rise in the second mora (where a H is associated) and falling tones only fall in the second mora (where a L is associated). Consistent effect across speech rate.

Motivation for Study

- Studies examining moraic alignment do not make an explicit comparison between competing hypotheses (syllables vs. moras) and have data from relatively few speakers.

- Only monosyllabic words considered in Thai. Mixtec permits clearer comparison between bimoraic monosyllabic words and bimoraic disyllabic words. Is the phonetic alignment of contour tones sensitive to moraic structure in Mixtec?

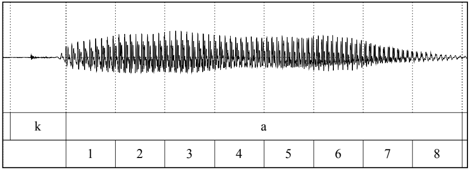
- If tone is aligned to moras in Mixtec, alignment of contour tones should be similar between monosyllabic and disyllabic words, as both are bimoraic.

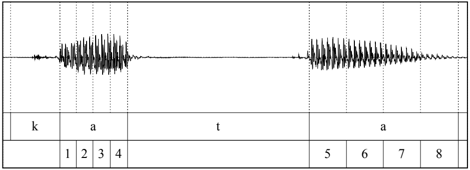
- If tone is aligned to syllables, then alignment of contour tones in monosyllables need not correspond to the alignment in disyllables.

Experiment 1: Mixtec Tone Production and Alignment

- Large data set consisting of 261 words in citation, balanced for tone, syllable structure, glottalization, and onset voicing.
- Recorded six repetitions per word, of which four were used. Six native speakers' data was analyzed (3 male, 3 female). (=6264 repetitions)
- F_0 values extracted using VoiceSauce (Shue et al., 2009). F_0 maxima and minima were extracted from this data using a script written in R (R Development Core Team, 2009).
- Four measures were extracted per mora in order in order to compare relative alignment of F_0 inflection points. These measures were normalized for time for the sake of comparison.

F_0 Analysis





- Two analyses of variance were performed. In the first test, F_0 was treated as the dependent variable, while Tone, Word size (monosyllabic, disyllabic), and Time (1-8) were treated as independent variables. Speaker was treated as an error term. The results of this test show raw differences in F_0.

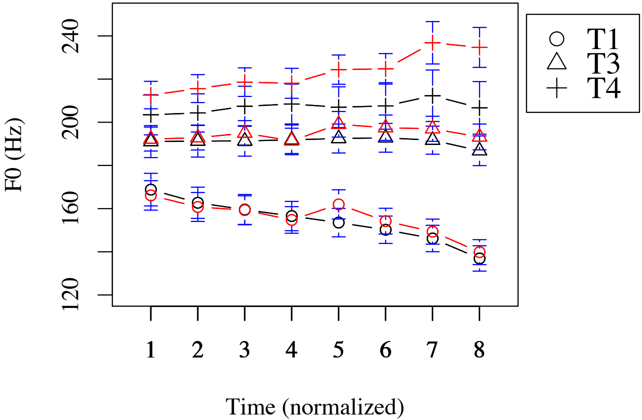
- In the second test, the locations of the F_0 maxima and minima were calculated across the 8 measurement bins for each word. The locations of these peaks were treated as dependent variables, while Tone and Word Size were treated as independent variables. Speakers was treated as an error term. The results of this test show differences in *relative* peak alignment.

Results: Tones Differences by word size

- No general effect of word size on F_0 was observed, but a significant tone X word size interaction was found ($F[12, 58] = 3.1$, $p < .01$).
- Post-hoc Tukey HSD test showed that rising or high tones rose higher in the second mora of disyllabic words than in monosyllabic words.

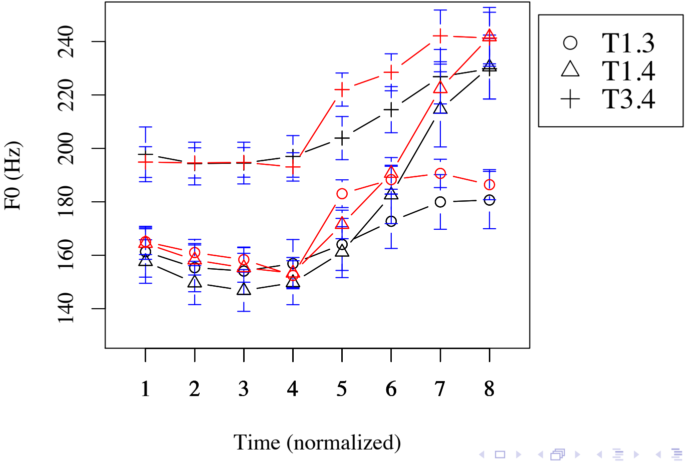
Level tones

Red = disyllabic, Black = monosyllabic

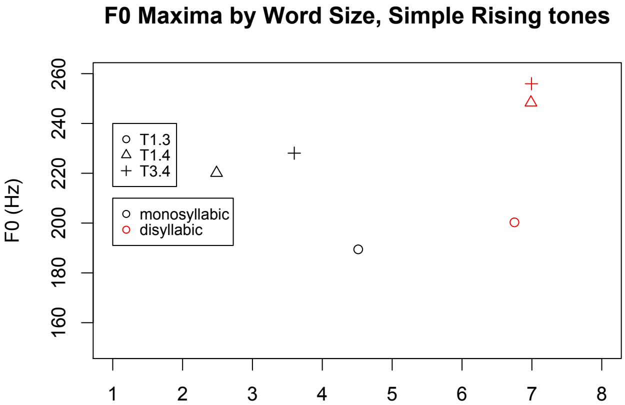


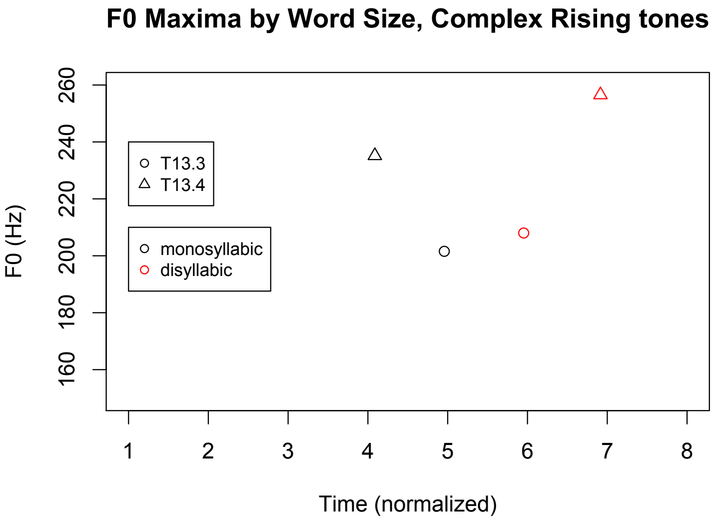
Rising tones

Red = disyllabic, Black = monosyllabic

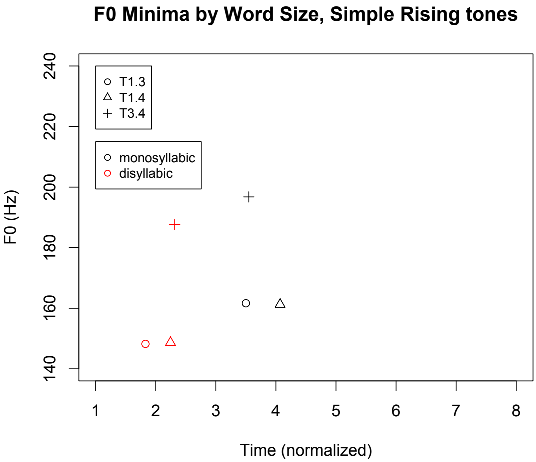


- No general effect of word size on the location of F_0 maxima or minima. However, strong tone x word size interactions were found.
- Post-hoc Tukey HSD test showed that the F_0 maxima of rising tones were aligned later in disyllables than in monosyllables (peak delay).



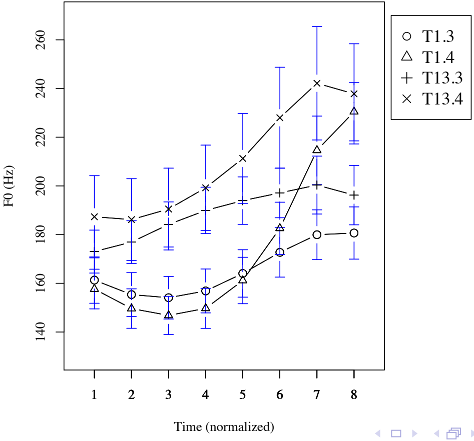

F0 Maxima by Word Size, Complex Rising tones
F0 (Hz)
160
180
200
220
240
260
T13.3
T13.4
monosyllabic
disyllabic
1
2
3
4
5
6
7
8
Time (normalized)

- Post-hoc Tukey HSD test showed that the F_0 minima of rising tones were aligned earlier in disyllables than in monosyllables. Yet, in both cases, F_0 minima were aligned with the first mora.



Results II: Peak Timing in Complex Rises in Monosyllables

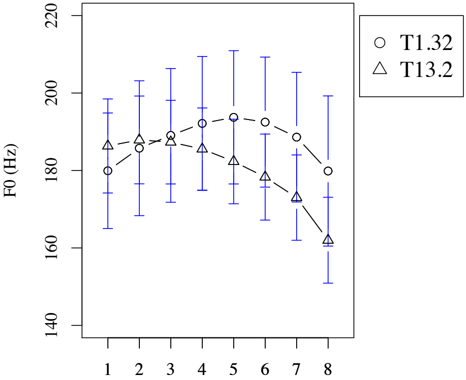
- Complex rises /13.3/ and /13.4/ have significantly higher starting points, demonstrating an earlier anticipation of a high tonal target.



- Slight fall on initial mora of simple rising tones, but no rise in F_0 until the second mora. This is akin to pattern for rising tone in Thai (Morén and Zsiga, 2006).
- Tonal anticipation in complex rises due to earlier F_0 target on mora, similar to Kinyarwanda.

Results II: Peak Timing in Concave Tones in Monosyllables

- Fall begins signficantly earlier in tone /13.2/ than in /1.32/. F_0 maximum occurs in the first mora for tone /13.2/ but in the second for tone /1.32/. This is in line with the moraic hypothesis.



Summary

- No general effect of word size on peak alignment.
- Alignment of F_0 maxima in rising tones is aligned later in disyllabic words.
- Location of F_0 maxima and minima in contour tones aligned with moras.

Discussion

Tones are phonetically aligned to moras in Yoloxóchitl Mixtec:

- Peak alignment in monosyllables and disyllables is similar.
- Contrasts simply in terms of alignment, e.g. 13.2 and 1.32, 13.3 and 1.3, 13.4 and 1.4, all correspond closely with moraic structure.
- Counter Zhang's (2004) argument that tonal licensing is not constrained by moraic structure. Alignment was not considered in his proposal.

Redux: Structure of Mixtec Tone

- Phonological analysis of Yoloxóchitl Mixtec tone assumes five different tones contrasting in the initial mora of a word and nine contrasting in the second mora.
- Moraic structure not simply assumed to account for the distributional differences, but supported by phonetic data regarding alignment.
- Typological considerations into the size of tonal inventories need to look carefully at the nature of the tone-bearing unit in particular languages, lest we mischaracterize apparent (or hidden) complexity.

Thank you!

Acknowledgements: Douglas H. Whalen, Tine Mooshamer, Daragh Sibley

Vowel duration by tone type

Little correspondence between complexity of tone type and vowel duration.

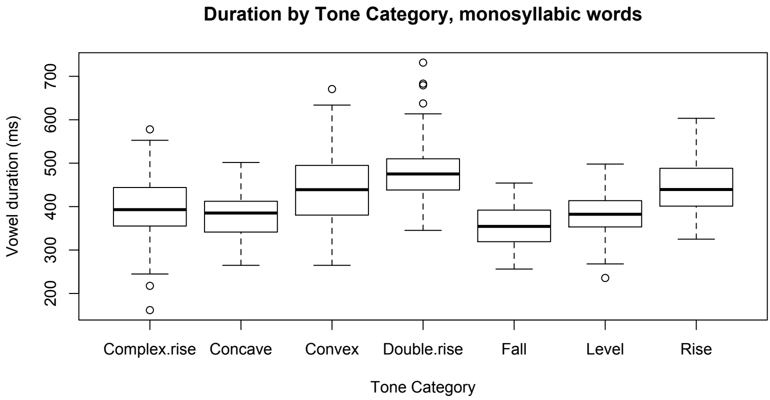


Table: Tone in Yoloxóchitl Mixtec Monosyllables (4 = high, 1 = low)

Tone$_{\mu 2}$	Tone$_{\mu 1}$ 1	3	4	13	14
1	nda^{1}a^1 '*flat*'	X	X	X	X
2	X	nda^{3}a^2 '*sloping*'	nda^{4}a^2 '*where*'	kwe^{13}e^2 '*linger*'	X
3	ta^{1}a^3 '*man*'	ʃa^{3}a^3 '*fast*'	X	nda^{13}a^3 '*went up*'	ʃa^{14}a^3 '*new*'
4	ndo^{1}o^4 '*sugarcane*'	nde^{3}e^4 '*strong*'	nda^{4}a^4 '*black*'	tu^{13}u^4 '*stripped*'	X
13	X	X	nde^{4}e^{13} '*they.enter*'	X X	ndo^{14}o^{13} '*to not stay*'
14	X	X	kwi^{4}i^{14} '*is peeling*'	X	kwi^{14}i^{14} '*is not peeling*'
24	X	X	ka^{4}a^{24} '*slips*'	X	ka^{14}a^{24} '*does not slip*'
32	ʃi^{1}i^{32} '*resistant*'	X	X	X	X
42	ndi^{1}i^{42} '*pink*'	ɲu^{3}u^{42} '*night*'	X	X	X

Extrinsic perturbation effects

- Laryngeal features influence F_0 targets in speech.

- Glottalization induces F_0 perturbations on adjacent vowels, resulting in either lowering (DiCanio, 2012; Gerfen and Baker, 2005; Kingston, 2005) or raising (Hombert et al., 1979; Thurgood, 2002). How does glottalization influence tonal targets and tonal alignment in Mixtec?

Are such extrinsic perturbation effects predictable?

There is evidence that the magnitude and extent of laryngeal perturbation effects vary across different languages. One of the sources of this variation is the presence of contrastive features in a language which target the particular source of the microprosody. If such features exist, there is less phonetic freedom for a particular phonetic byproduct to influence the speech signal.

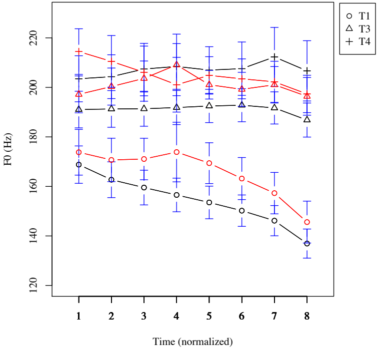
Mixtec is (very) tonal, so one might predict these effects to be minimized. Yet, evidence from related languages show that glottalization-induced pitch effects persist even among related languages with substantial tonal inventories (DiCanio, 2012; Gerfen and Baker, 2005).

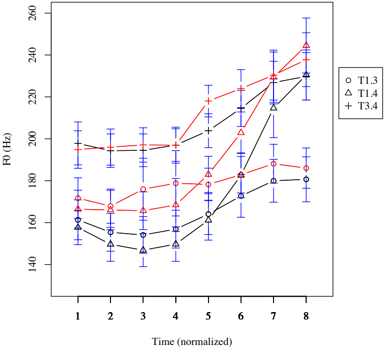
Procedure

- Extraction of F_0 values from monosyllabic words in elicited corpus without glottalization and with medial glottalization, e.g. /ndo^{1}ʔo^4/ '*basket*'.
- Comparison of F_0 values following voiceless (stop, fricative) and voiced (prenasalized stop, sonorant) onsets in monosyllabic and disyllabic words.
- Similar analysis method as Experiment 1.

Results: Glottalization

- No general effect of glottalization on F_0 values, but significant tone x glottalization interactions ($F[12, 49] = 3.9$, $p < .001$).
- Low level tones (T1, T3) and low rising tones (T1.4, T1.3) show significant F_0 raising preceding glottalization.





Summary

- No general effect of voicing on F_0 targets in tone production.
- Glottalization has an F_0 raising effect, so it asymmetrically influences tones with lower F_0 targets.

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.

Cruz, E. and Woodbury, A. (2005). El sandhi de los tonos en el Chatino de Quiahije. In *Memorias del Congreso de Idiomas Indígenas de Latinoamérica-II*. University of Texas, Austin.

DiCanio, C. T. (2008). *The Phonetics and Phonology of San Martín Itunyoso Trique*. PhD thesis, University of California, Berkeley.

DiCanio, C. T. (2012). Coarticulation between Tone and Glottal Consonants in Itunyoso Trique. *Journal of Phonetics*, 40:162–176.

Gerfen, C. and Baker, K. (2005). The production and perception of laryngealized vowels in Coatzospan Mixtec. *Journal of Phonetics*, 33:311–334.

Hombert, J. M., Ohala, J. J., and Ewan, W. (1979). Phonetic explanations for the development of tones. *Language*, 55(1):37–58.

Jamieson, A. R. (1977). Chiquihuitlan Mazatec Tone. In Merrifield, W. R., editor, *Studies in Otomanguean Phonology*, pages 107–136. Summer Institute of Linguistics, University of Texas at Arlington.

Josserand, J. K. (1983). *Mixtec Dialect History*. PhD thesis, Tulane University.

Kingston, J. (2005). The phonetics of Athabaskan tonogenesis. In Hargus, S. and Rice, K., editors, *Athabaskan Prosody*. Amsterdam: John Benjamins.

Lehiste, I. (1970). *Suprasegmentals*. MIT Press, Cambridge, MA.

Maddieson, I. (2011). Tone. In Dryer, M. S. and Haspelmath, M., editors, *The World Atlas of Language Structures Online*. Max Planck Digital Library, Munich.

Morén, B. and Zsiga, E. C. (2006). The Lexical and Post-Lexical Phonology of Thai Tones. *Natural Language and Linguistic Theory*, 24:113–178.

Myers, S. (2003). F_0 Timing in Kinyarwanda. *Phonetica*, 60:71–97.

R Development Core Team, Vienna, A. (2009). R: A language and environment for statistical computing [computer program]. http://www.R-project.org, R Foundation for Statistical Computing.

Shue, Y.-L., Keating, P., and Vicenik, C. (2009). VOICESAUCE: A program for voice analysis [computer program]. *Journal of the Acoustical Society of America*, 126(2221(A)).

Thalin, A. (1980). Tlacoatzintepec Chinantec Syllable Structure. *SIL-Mexico Workpapers*, 4:1–8.

Thurgood, G. (2002). Vietnamese and tonogenesis. *Diachronica*, 19(2):333–363.

Xu, Y. (1998). Consistency of tone-syllable alignment across different syllable structures and speaking rates. *Phonetica*, 55:179–203.

Zhang, J. (2004). Contour Tone Licensing and Contour Tone Representation. *Language and Linguistics*, 5(4):925–968.