Moraic alignment of Mixtec tone: exploring complex timing relations in Oto-Manguean tonal systems

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Typology and tonal systems

How useful is a typological perspective for the study of tonal phonetics?

1. Structural diversity is abundant.
   - Structural differences among languages contribute to phonetic variation in tone production/perception, even across well-known languages.
2. The phonetic timing of tones differs dramatically.
   - There is substantial cross-linguistic variation in how tones are coordinated with each other.
3. Models of speech production should be inclusive with respect to such cross-linguistic variability.

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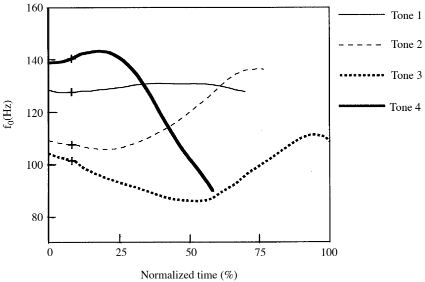
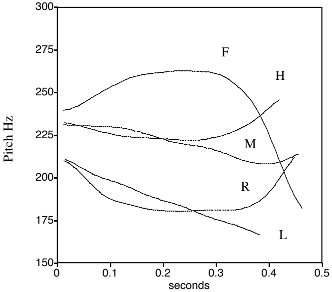
Structural differences? Mandarin vs. Thai





What does a falling tone look like? What accounts for a delayed fall in Thai?

(Figures from Xu (1997); Zsiga and Nitisaroj (2007))

A typological perspective will reveal the extent to which both structural and language-specific differences contribute to phonetic patterns related to tone.

Oto-Manguean languages possess a unique collection of structural properties and phonetic patterns which challenge some of the established ideas within the tonal phonetics literature.

1. Strong evidence for the mora as the TBU **and** the unit of planning, as opposed to the syllable (Prom-on et al., 2009; Xu and Prom-on, 2014; Zhang, 2004).

2. Maintenence of tonal contours and moraic alignment even in the context of word-medial glottalization; tonal contrast maintenence.

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Roadmap

1. Properties of the Oto-Manguean stock
2. Tonal domains and alignment
3. Experiment on tonal alignment in Yoloxóchitl Mixtec
4. Discussion

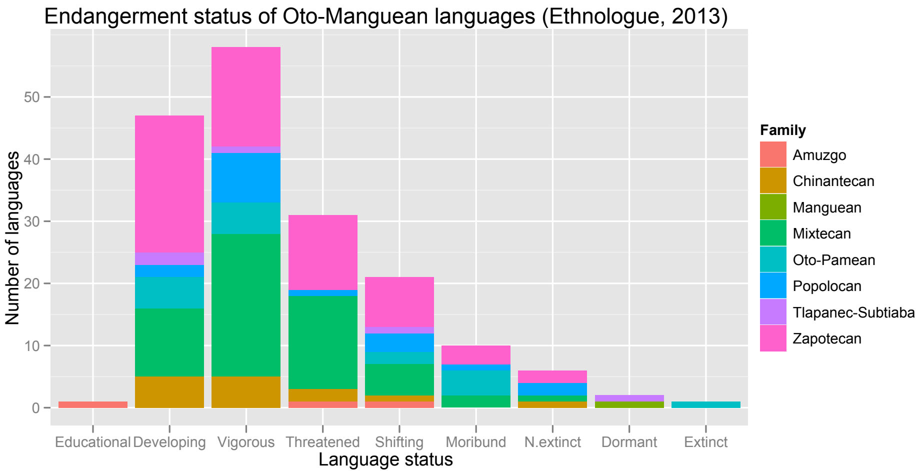
Language families in Mexico

Oto-Manguean languages

- With 177 languages, Oto-Manguean is the largest language family in the Americas (and 9^{th} largest in the world).
- A majority of these languages are spoken in the state of Oaxaca. In fact, 157 of the 285 languages spoken in Mexico are found in Oaxaca.
- Extensive diversity within language family largely correlates with biological diversity in the areas where it is spoken. Oaxaca is the most biologically diverse state in Mexico with the greatest number of endemic vascular plants (de Ávila, 2010).

- **Oto-Manguean:**
  - **Eastern:**
    - **Amuzgo**: Amuzgo
    - **Mixtecan**: Mixtec, Trique, Cuicatec
    - **Popolocan**: Mazatec, Ixcatec, Chocholtec, Popoloca
    - **Zapotecan**: Zapotec, Chatino
  - **Western:**
    - **Oto-Pamean**: Chichimec, Pame, Matlatzinca, Otomí, Mazahua
    - **Chinantecan**: Chinantec
    - **Subtiaba-Tlap.**: Subtiaba, Tlapanec
    - **Chorotegan**: Chiapanec, Chorotega

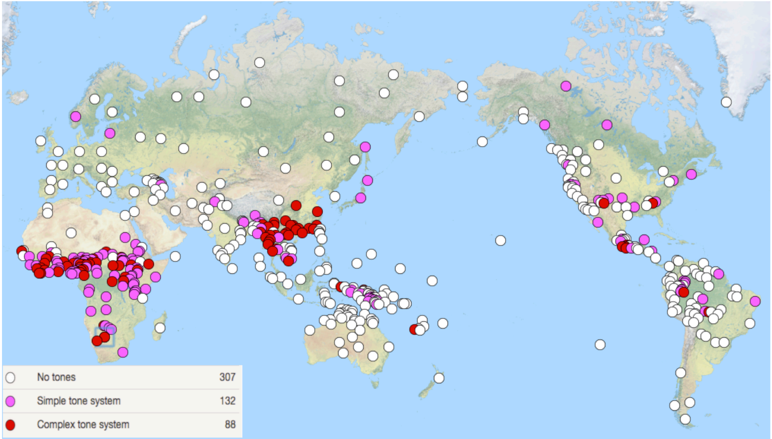
Roughly 40% (71/177) of Oto-Manguean languages are endangered ("threatened" or worse).



Tone in Oto-Manguean languages

- All are tonal and many have *very large* tonal inventories. At least three tones are reconstructed at the earliest levels (Kaufman, 1990; Rensch, 1976).
- Laryngeal/glottal features which are often orthogonal to tone (Silverman, 1997).
- Complex onsets are possible, but most languages lack codas. Most languages have polysyllabic words.
- Complex morphology on verbs and with personal clitics which frequently involves tone (Campbell et al., 1986; Palancar, 2009; Suárez, 1983) and classic processes of tone sandhi (Goldsmith, 1990; Pike, 1948).

Distribution of tone languages



(Maddieson, 2010)

Tonal complexity (Maddieson, 2010)

	Languages	Percentage
Non-tonal	307	58.2%
Tonal	220	41.8%
	Languages	**Percent of tone languages**
1-2 tones	132	60%
3+ tones	88	40%

Languages with between 3-6 tonal contrasts are relatively common, e.g. Thai (5), Mandarin (4), Vietnamese (6), Cantonese (6), Yoruba (3).

Complex tonal systems

How many tones occur in Oto-Manguean languages?

Language	Tones	
Northern Pame	2	(Berthiaume, 2004)
Mazahua	4	(Knapp Ring, 2008)
Tlacoatzintepec Chinantec	7	(Thalin, 1980)
Itunyoso Triqui	9	(DiCanio, 2008)
Yoloxóchitl Mixtec	10	(DiCanio et al., 2012)
San Juan Quiahije Chatino	11	(Cruz, 2011)
Chiquihuitlan Mazatec	17	(Jamieson, 1977)
Quiotepec Chinantec	19+	(Castillo Martínez, 2011)

But how do you count? Is the TBU the stem? the syllable? the mora?

Quetzalapa Chinantec

Five tone levels with contours (rising tones excluded). Words courtesy of Isabel Alhondra.

Tone	Word	Gloss
55	tsoʊ	'*his/her fault*'
44	tsoʊ	'*illness*'
33	tsoʊ	'*he/she goes*'
22	tsoʊ	'*straight*'
21	tsoʊ	'*sin*'
32	tsoʊ	'*male*'
42	tsoʊ	'*people*'

What is the TBU here though? Are there only 5 (1/mora)? or are there more?

Tone and glottal features

Glottal contrasts and phonation are orthogonal to tone in many Oto-Manguean languages, e.g. Jalapa Mazatec (Kirk et al., 1993; Silverman et al., 1995), but co-dependent in others, like Zapotec.

Figure: Tone and phonation in San Lucas Quiaviní Zapotec (Chávez Peón, 2010)

Tone	Phonation	Word	Gloss
High	modal	gʲiːa	'*will go home*'
Low	modal	gʲiːa	'*agave root*'
Low	breathy	gʲi̤ːa̤	'*rock*'
Low	creaky	gʲḭːa̰	'*flower*'
Low	checked	gʲiʔa	'*market*'

Variation in tonal alignment

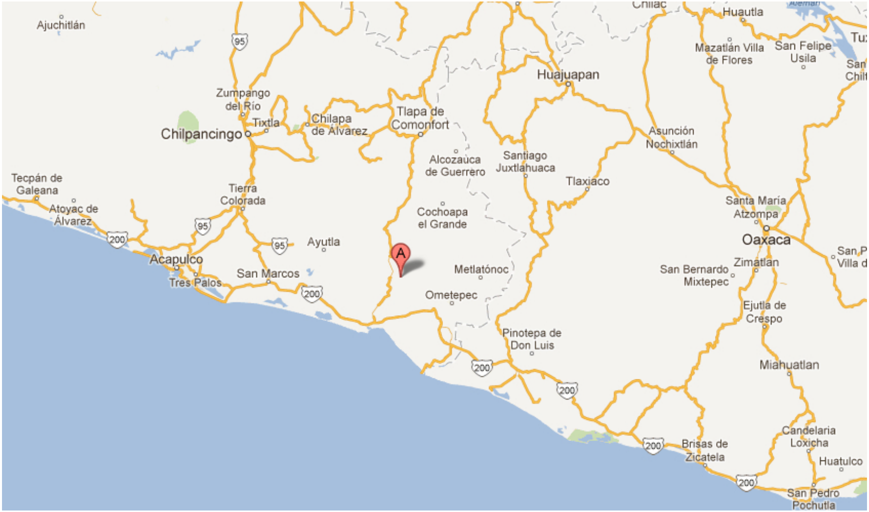
How we count tones is tied to the phonological domains for tone. What evidence is there for such domains in speech production in Oto-Manguean languages? (Phonology and the phonetics of alignment)

- Intonational pitch accents are anchored to segmental targets/onsets (Atterer and Ladd, 2004; Ladd et al., 1999; Ladd, 2004).
- Lexical tones are aligned to syllables (Gao, 2008, 2009; Prom-on et al., 2009; Xu, 1998; Xu and Prom-on, 2014).
- Lexical tones are aligned to moras (Myers, 2003; Morén and Zsiga, 2006).

Syllables or moras?

- 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 and even are sensitive to polysyllabic shortening (Lehiste, 1970; Turk and Shattuck-Hufnagel, 2000).
- Earlier F_0 maxima observed for H and HL tones in Kinyarwanda than for the LH tone, suggesting moraic alignment (Myers, 2003).
- The inflection points of Thai tonal contours align at the right edge of moras. Trajectories only begin in the second mora (Morén and Zsiga, 2006; Zsiga and Nitisaroj, 2007).

Case study: Yoloxóchitl Mixtec



Tonal phonology

- Like other Mixtecan languages, 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).
- Glottalization is a feature of the couplet and occurs word-medially in monosyllables and disyllables. It is orthogonal to tone, i.e. not a feature of tonal contrasts. Similar tonal melodies surface on glottalized words as on non-glottalized words.

$\text{ndoʔ}^1\text{o}^4$	'*basket*'	$\text{ndaʔ}^1\beta\text{a}^1$	'*be turned off*'
ndo^1o^4	'*sweet sugarcane*'	$\text{nda}^1\beta\text{a}^1$	'*undivided branch*'

Table: Tone in YM (4 = high, 1 = low)

Level	nda^{1}a^{1}	ʃa^{3}a^{3}	nda^{4}a^{4}		
	'*flat*'	'*fast*'	'*black*'		
Falling	nda^{3}a^{2}	nda^{4}a^{2}			
	'*sloping*'	'*where*'			
Rising	ta^{1}a^{3}	ndo^{1}o^{4}	nde^{3}e^{4}	nda^{13}a^{3}	tu^{13}u^{4}
	'*man*'	'*sugarcane*'	'*strong*'	'*went up*'	'*stripped*'

Rise+Fall	kwe^{13}e^{2}	ʃa^{14}a^{3}	ndi^{1}i^{42}	ɲu^{3}u^{42}
	'*linger*'	'*new*'	'*pink*'	'*night*'
High+Rise	nde^{4}e^{13}	kwi^{4}i^{14}	ka^{4}a^{24}	
	'*they enter*'	'*is peeling*'	'*slips*'	
Rise+Rise	ndo^{14}o^{13}	kwi^{14}i^{14}	ka^{14}a^{24}	
	'*to not stay*'	'*is not peeling*'	'*does not slip*'	

If the syllable is the unit of tone planning, how many distinct types?

The mora as the TBU

If the mora is considered as the TBU, the number of possible tonal patterns on a single syllable is reduced.

Moreover, just five possible tones occur on the initial mora regardless of word type (monosyllables, disyllables, with and without glottalization).

- Five possible tones on the initial mora: 1, 3, 4, 13, 14
- Nine possible tones on the final mora: 1, 2, 3, 4, 13, 14, 24, 32, 42

/βi^{3}ta^{42}/ '*soft*' vs. /ñũ^{3}ũ^{42}/ '*night*'
/ñũ^{3}ũ^{2}/ '*town*' vs. /ñũʔ^{3}ũ^{2}/ '*fire*'
/nu^{14}u^{3}/ '*face*' vs. /ʃa^{14}tu^{3}/ '*soft corn tortilla*'

Mixtec morphology (Castillo García, 2007)

Habitual verbs are formed by replacing the tone on the initial mora with tone /4/.

ʃa^{1}a^{1}	'*to arrive*'	ʃa^{4}a^{1}	'*to be arriving*'
kã^{3}ã^{2}	'*to perforate*'	kã^{4}ã^{2}	'*to be perforating*'
kaʔ^{1}a^{1}	'*to drown*'	kaʔ^{4}a^{1}	'*to be drowning*'

A transitivity alternation on verbs with tonal melody /1.4/ replaces the tone on the initial mora with /3/.

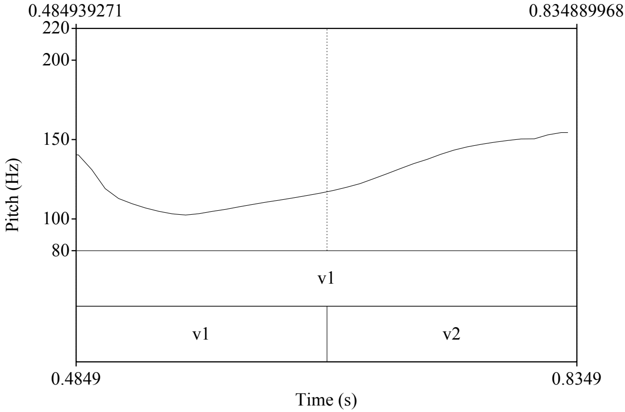
kwi^{1}i^{4}	'*to peel (intr)*'	kwi^{3}i^{4}	'*to peel (tr)*'
kũ^{1}ũ^{4}	'*to be ground (intr)*'	kũ^{3}ũ^{4}	'*to grind*'
ku^{1}ʃi^{4}	'*to be cut up*'	ku^{3}ʃi^{4}	'*to cut up*'

It's unclear how one could target individual tone levels on monosyllabic words without moras.

Alignment study

- 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.
- "Complex" contours with initial rises should show earlier alignment than simple rises, e.g. /13.3/ vs. /1.3/.
- Examined F_0 alignment in large elicited corpus of 261 words x 6 repetitions x 10 speakers.
- LMER with word size, normalized time, and tone as DVs, speaker as a random effect.

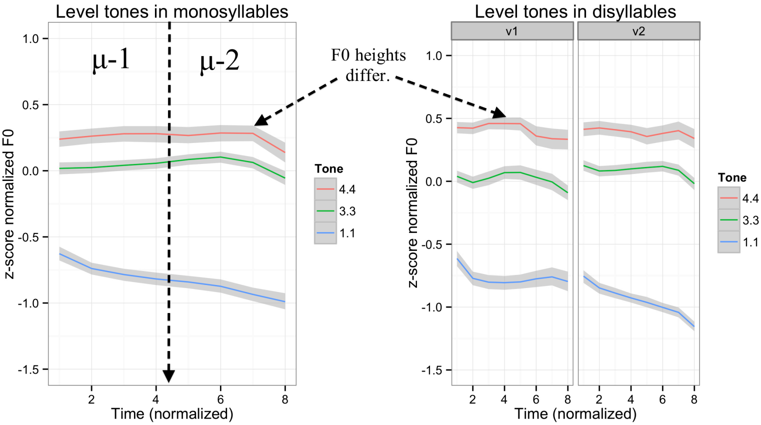
Expectations for alignment – parity across word types



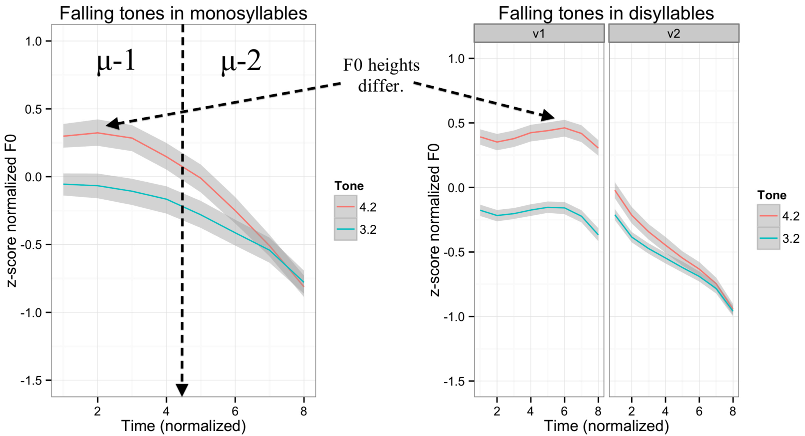
Test: to what extent do F_0 contours differ across word types?

Results

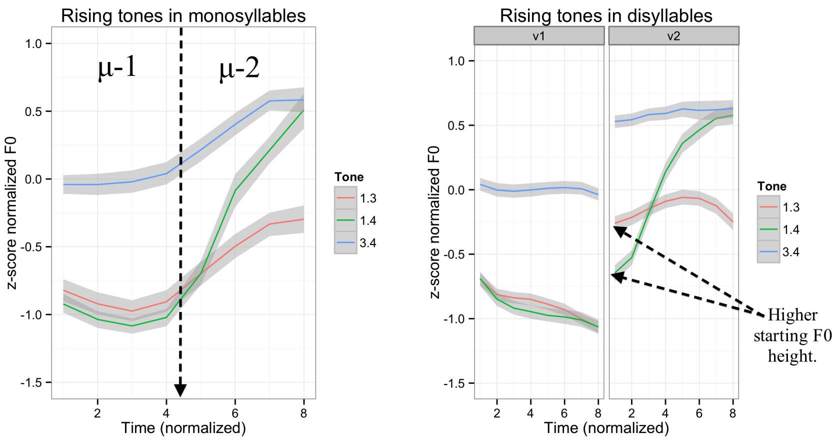
There is no general effect of word size. However, there was a significant tone x word size interaction (tone /4/)



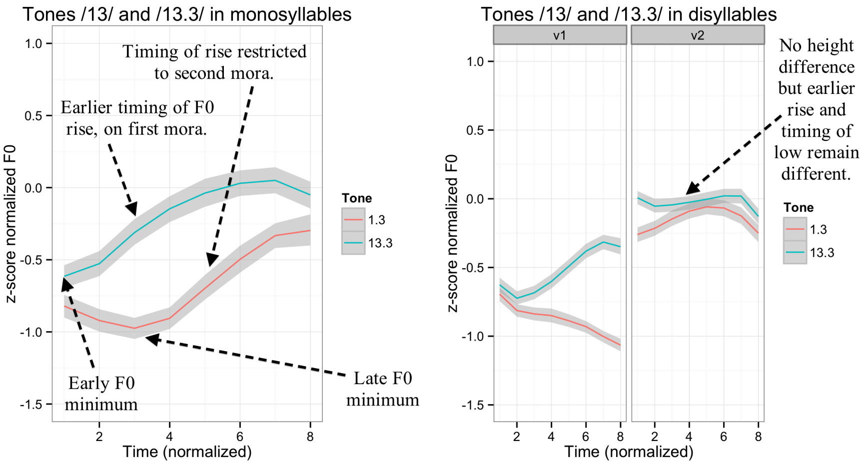
Falling tones are similar



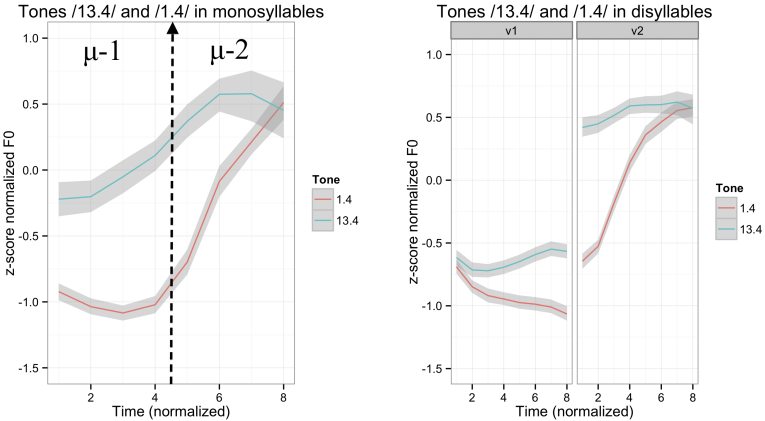
Rising tones are similar.



Complex vs. simple rises

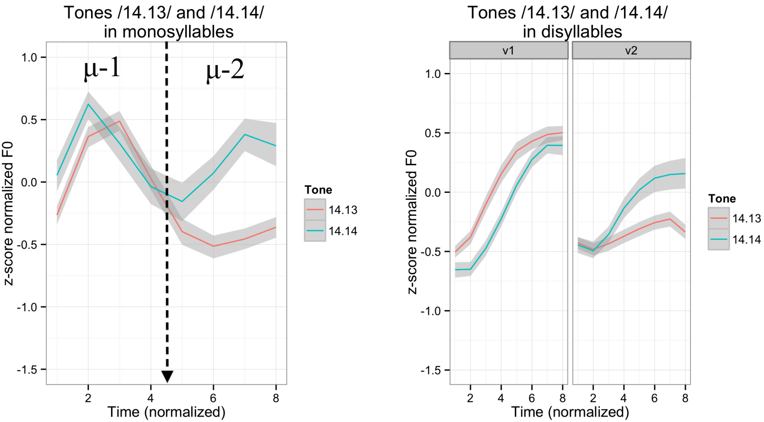


Late target attainment of tone /1/ in /1.4/, but early rise of tone /13/ in /13.4/.



Double rises

Complete rise attained in first mora of vowel in monosyllables.



Results - overview

- No general effect of word size on alignment – not predicted if the syllable is the unit of tone planning.
- Interactions between word size and tone with respect to F_0 height (not time), for melodies /1.3, 1.4, 4.14, 4.2, 4.4/.
- Strong evidence for alignment to the mora, even within a monosyllabic long vowel.
- Strong similarity across word sizes also suggests phonetic alignment to the mora.
- Counter Zhang's (2004) argument that tonal licensing is not constrained by moraic structure. Alignment was not considered in his proposal.

Discussion: Alignment

- Moraic structure not simply assumed to account for the tonal distributional differences and alternations in Mixtec, but it is supported by phonetic data examining 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.
- We just didn't know that languages could do this!

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- We just didn't know that languages could do this!

YM has a large inventory of tones, but it's not as many as you might assume.

Glottalization and tone

- Glottalization is known to influence the F_0 of tonal targets, though to varying degrees.
- Medial glottalization induces F_0 lowering for only the highest tone (/45/) in Itunyoso Trique, but final glottal stops have no consistent effect on any tone (DiCanio, 2012).
- Creaky phonation does not induce F_0 changes on H, M, and L tones in Jalapa Mazatec (Garellek and Keating, 2011).
- Glottalization is often coextensive with slight dips in F_0 and amplitude in Coatzospan Mixtec (Gerfen and Baker, 2005).

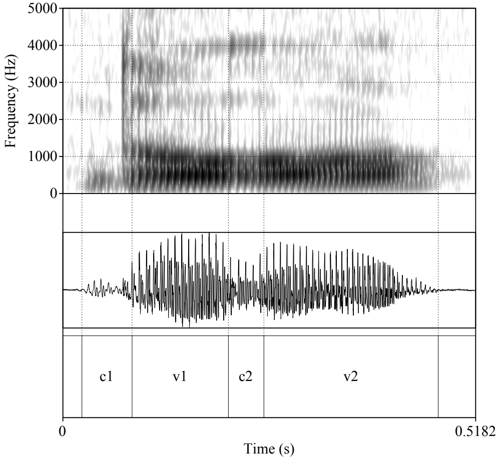
Glottalization and alignment

General prediction is that creaky phonation will lower F_0 (Blankenship, 2002; DiCanio, 2008; Dilley et al., 1996; Garellek, 2012; Gordon and Ladefoged, 2001).

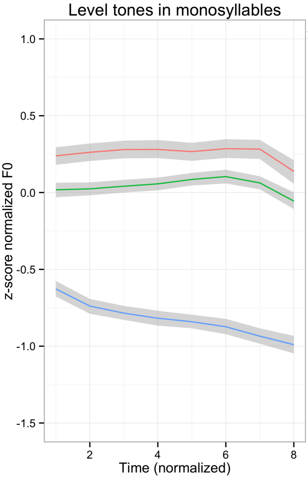
Is this the case in Yoloxóchitl Mixtec and does an F_0 change alter the alignment of tones on moras?

Glottalization in YM

ndoʔ^{1}o^{4} '*basket*'

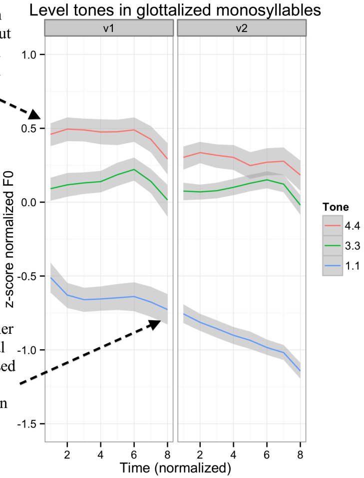


Glottalization in level tones - monosyllables

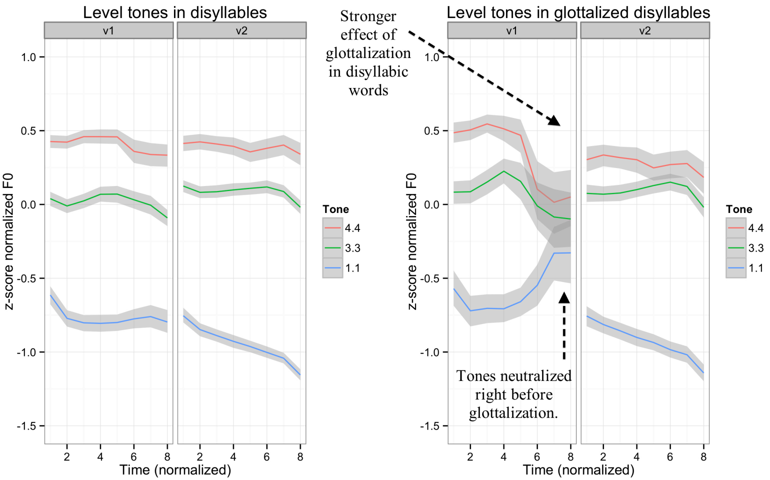


Higher F0 on initial mora, but lowered with glottalization

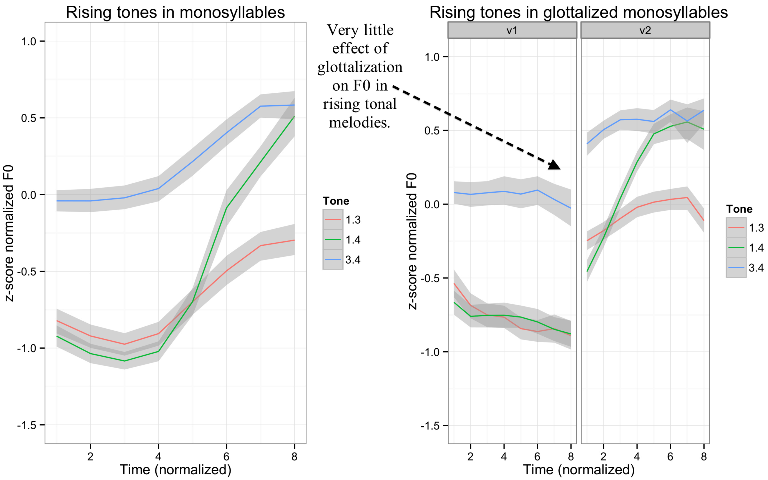
Slightly higher F0 on initial mora but raised with glottalization



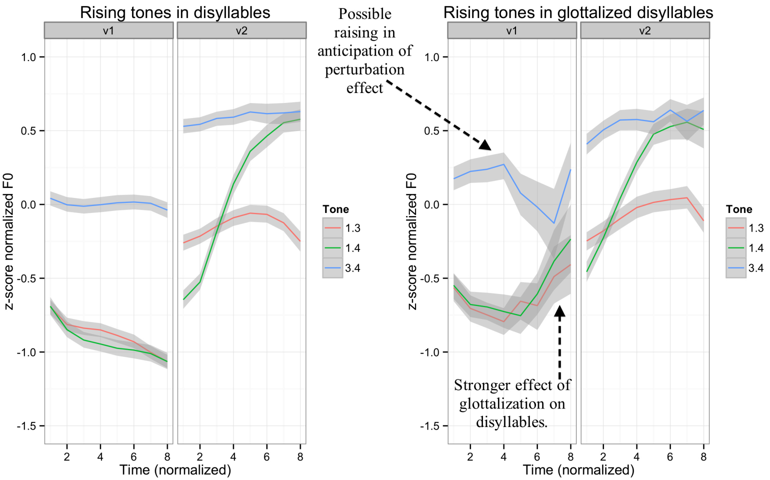
Glottalization in level tones - disyllables



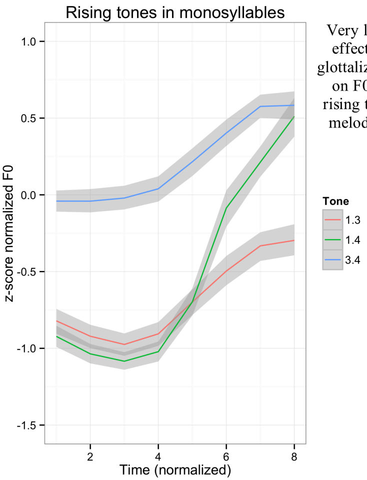
Glottalization in rising tones - monosyllables



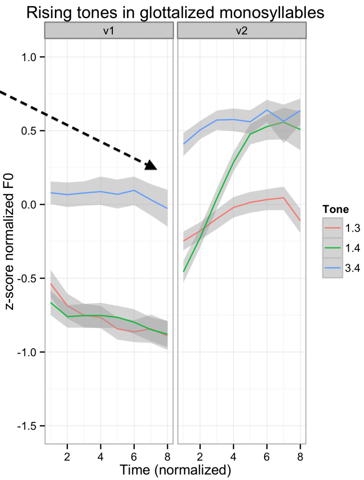
Glottalization in rising tones - disyllables



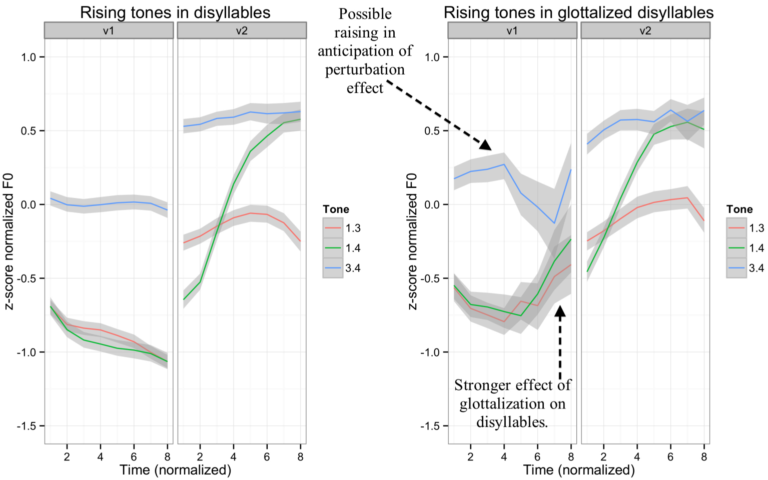
Glottalization in rising tones - monosyllables



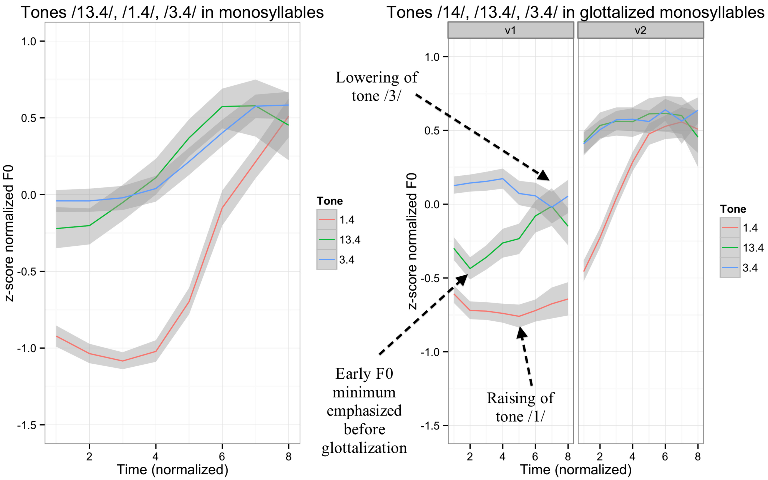
Very little effect of glottalization on F0 in rising tonal melodies.



Glottalization in rising tones - disyllables



Glottalization in complex rising tones



Results - overview

Glottalization induced significant effects on F_0, but these varied substantially by tone.

Lower tones (/1/) underwent F_0 raising while higher tones (/4/) underwent lowering.

The influence of glottalization on tone was asymmetrical too – the effect was much stronger in pre-glottalized vowels than post-glottalized vowels.

The effect of glottalization on tone was stronger in disyllabic words than in monosyllabic words.

However, alignment remained unchanged, even in monosyllabic words.

Discussion - glottalization and alignment

- Variable effects of glottalization on F_0 of tonal targets resembles reported patterns of historical tone change in Mixtecan (Dürr, 1987).

- Stronger effect of glottalization on disyllabic words may result from a general pattern of phasing to maintain contrast (Silverman, 1997). Stronger F_0 effects near a V-C transition are less perceptually costly than those in a V-V transition.

- Location of minima/maxima maintained on mora despite presence of phonation-induced F_0 perturbations.

Discoveries from Oto-Manguean languages

- Structural differences between languages influence tonal alignment.
- The target of a tone need not be what we consider the typical unit of speech planning (the syllable) (Krakow, 1999; Goldstein et al., 2007).
- Glottalization induces variable effects on tone: high tones lower but low tones raise.
- Presence of non-modal phonation does not alter moraic alignment; primarily a local phonetic process.

Investigating complexity

There is not only a unique complexity to the phonology of Oto-Manguean tonal systems, but also unique phonetic processes.

1. Our attempts to understand and model tonal processes should come to grips with this.
2. Suggests the need for a fusion between fieldwork and experimental research on tone (or at least a fusion of researchers).
3. Not every language show these patterns, but the patterns show us what constraints speakers control in tone production.

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Is *alignment* the missing dimension in research on tonal contrasts?

Future directions

1. While the current study is limited to words in isolation, we are investigating Mixtec tonal variability in spontaneous corpus data and in controlled coarticulatory contexts using forced alignment (DiCanio et al., 2013).

2. Modelling of tonal coarticulation and speech rate effects in Itunyoso Triqui in a general production model (TADA) under NSF grant (Whalen & Xu).

3. Investigating the use of dynamic F_0 cues by native listeners in tone perception.

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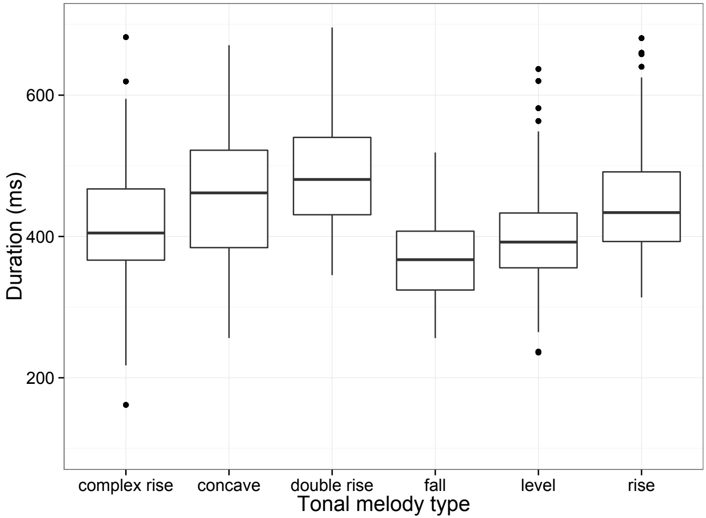
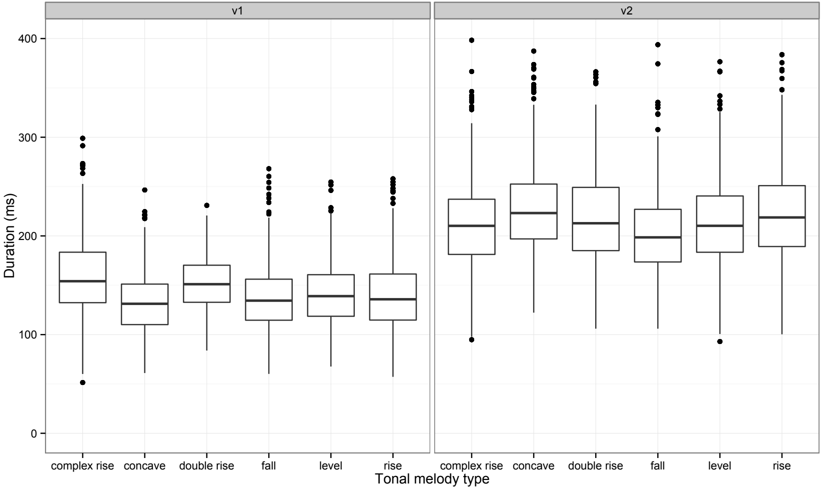
Thank you!

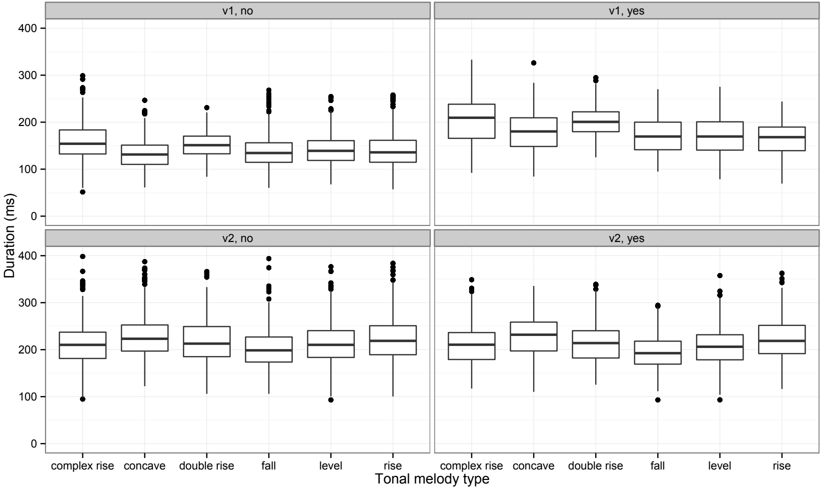
Duration of tone in YM



Duration in disyllables



Duration in disyllables - glottalized



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