Phonetic patterns 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 in larger utterances/units.
3. Models of speech production should be inclusive with respect to such cross-linguistic variability.

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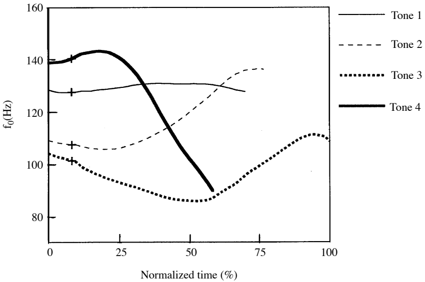
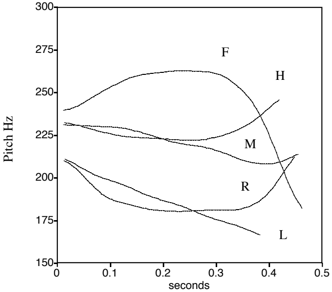
Structural differences? Mandarin vs. Thai



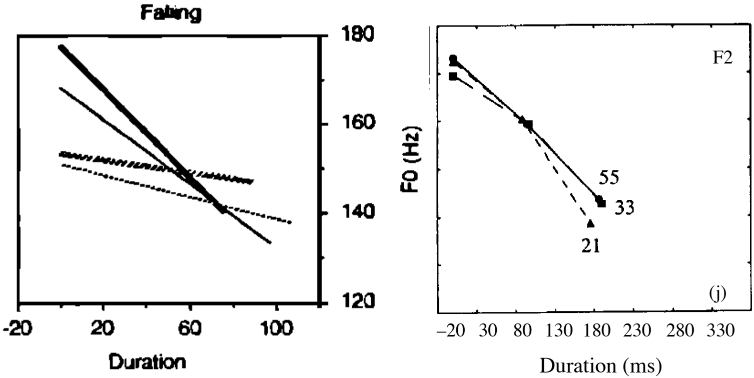


What does a falling tone look like? What accounts for a delayed fall in Thai?

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

Coordination differences? Mandarin vs. Taiwanese

Mandarin falling tones (left, (Xu, 1994)) undergo greater coarticulation than Taiwanese falling tones (right, (Peng, 1997)).



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. Active processes of dissimilation and range expansion in coarticulation, as opposed to assimilation/reduction (Xu, 1994; Gandour et al., 1994, 1999; Peng, 1997).

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Roadmap

1. Properties of the Oto-Manguean stock
2. Tonal domains and alignment
3. Tonal coarticulation
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

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).

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., 2012a)
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 levels (1/mora)?

Variation in tonal alignment

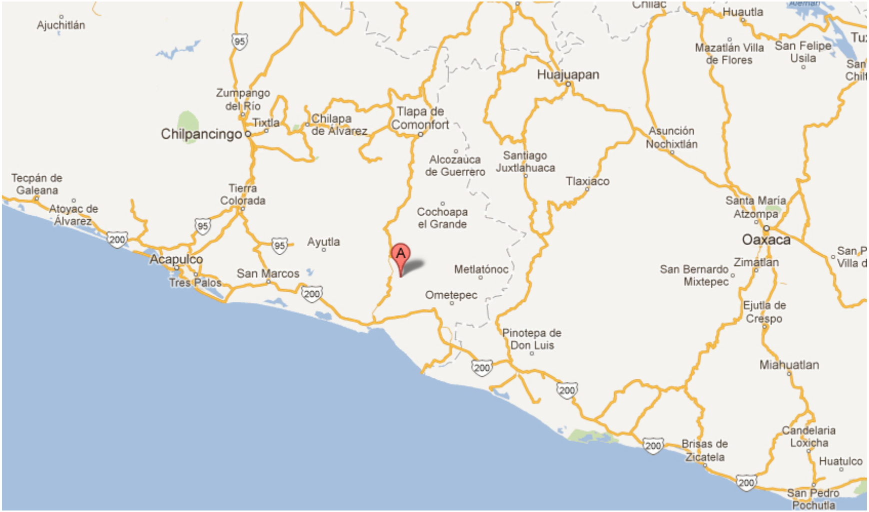
How we count tones is tied to the phonological domains for tone. What evidence is there for such domains in speech production in Oto-Manguean languages? (Phonology and the phonetics of alignment)

- 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).
- 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

Pattern consistent across word types:
/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*'

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*'

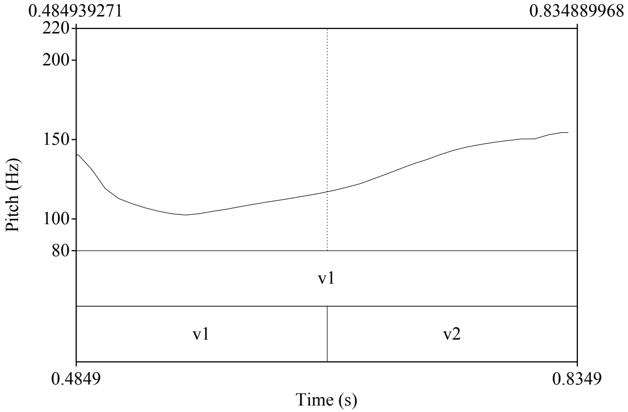
Rise+Fall	kwe^{13}e^2	ʃa^{14}a^3	ndi^{1}i^{42}	ɲu^{3}u^{42}
	'*linger*'	'*new*'	'*pink*'	'*night*'
High+Rise	nde^{4}e^{13}	kwi^{4}i^{14}	ka^{4}a^{24}	
	'*they enter*'	'*is peeling*'	'*slips*'	
Rise+Rise	ndo^{14}o^{13}	kwi^{14}i^{14}	ka^{14}a^{24}	
	'*to not stay*'	'*is not peeling*'	'*does not slip*'	

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

Alignment study

- "Complex" contours with initial rises should show earlier alignment than simple rises.
- 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.
- 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.

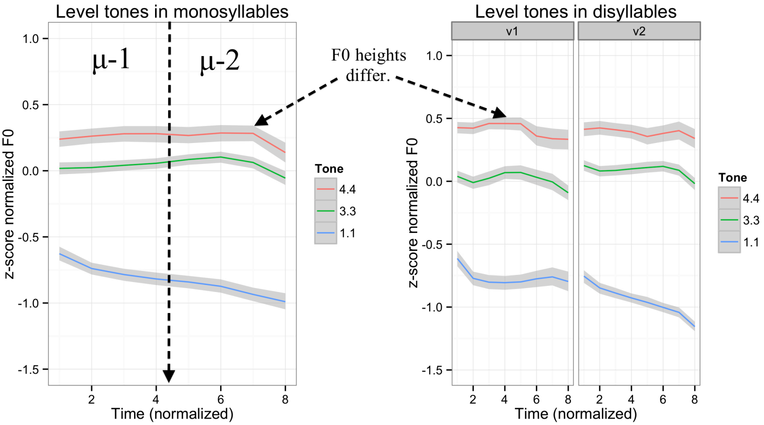
Expectations for alignment – parity across word types



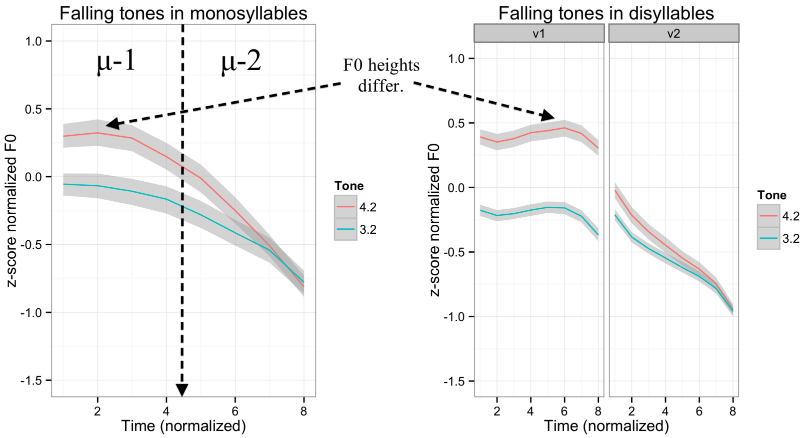
Test: to what extent do F_0 contours differ across word types?

Results

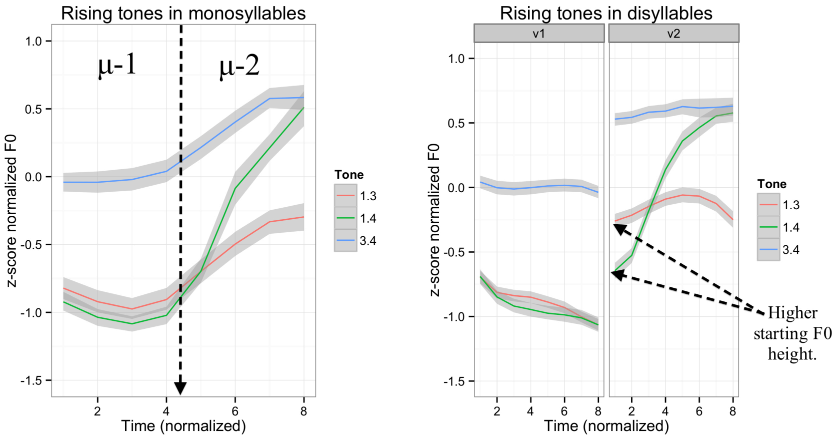
There is no general effect of word size. However, there was a significant tone x word size interaction (tone /4/)



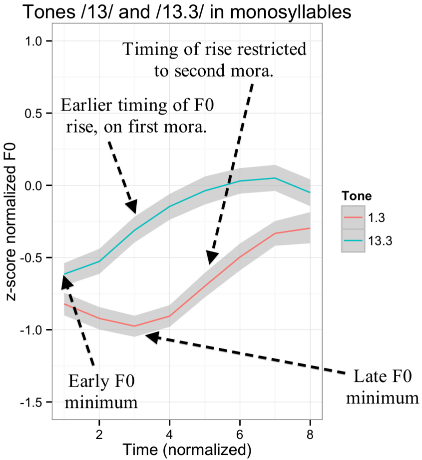
Falling tones are similar

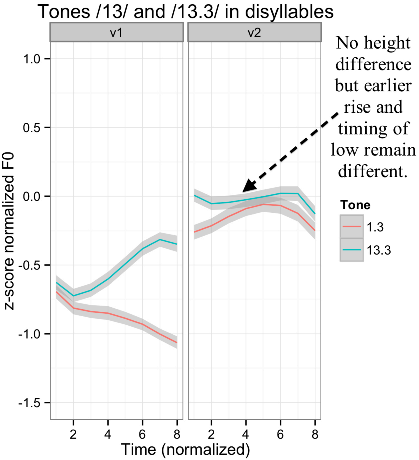


Rising tones are similar.

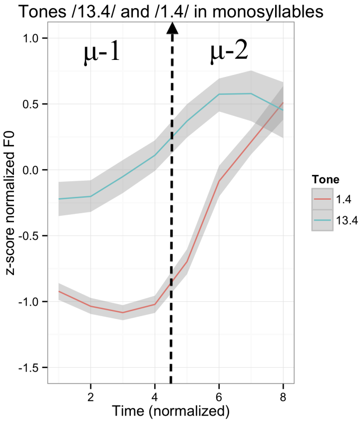


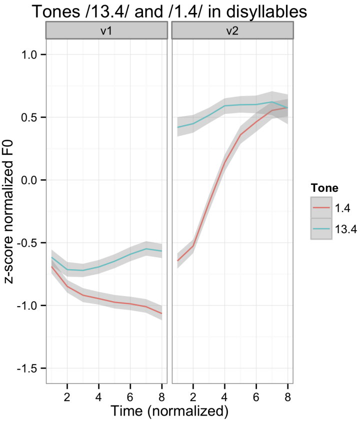
Complex vs. simple rises





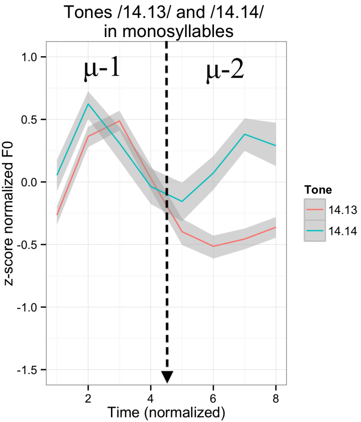
Late target attainment of tone /1/ in /1.4/, but early rise of tone /13/ in /13.4/.

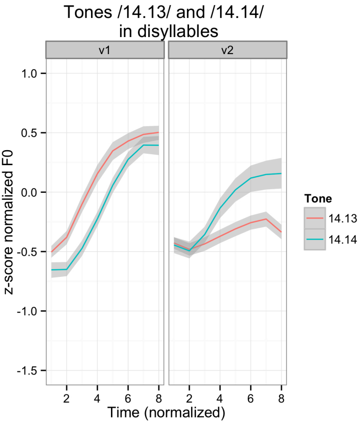




Double rises

Complete rise attained in first mora of vowel in monosyllables.





Discussion: Alignment

- 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.

Conclusions - Alignment

- Moraic structure not simply assumed to account for the distributional differences 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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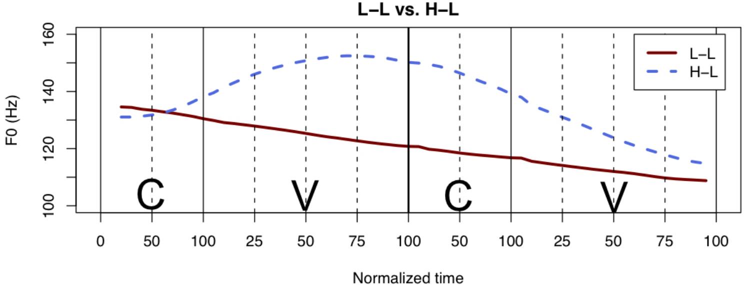
YM has a large inventory of tones, but it's not as many as you might assume.

Tone production and variability

The relative timing of tone varies by context and language.



How are tones coordinated with one another in Oto-Manguean languages?

What constrains the production of a sequence of lexical tones?

1. **Tonal context**: the production of a tone is sensitive to the F_0 height and slope of adjacent tonal targets.
2. **Speech rate**: rate impinges on the temporal demands for producing certain F_0 shapes.

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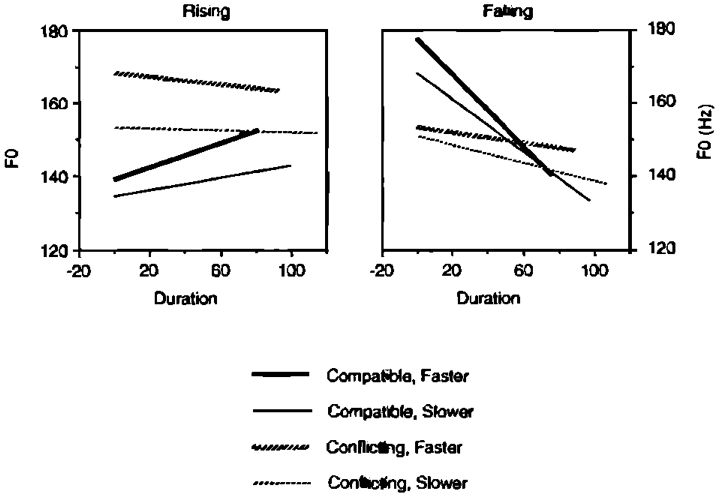
Tonal context and compatibility

- Phonetic contexts which cause more abrupt F_0 transitions between adjacent syllables are more likely to perturb F_0 than contexts causing gradual transitions (Xu, 1994).
- *Conflicting*: the tone offset does not match the following onset, e.g. Rise + Low.
- *Compatible*: the tone offset matches the following tone onset, e.g. Fall + Rise.

- Greater coarticulatory effects occur in conflicting contexts than in compatible contexts in Mandarin Chinese (Xu, 1994).



Tonal coarticulation and speech rate

- While all languages have some anticipatory and carryover effects, the latter is typically stronger (in Vietnamese, Thai, Mandarin) (Brunelle, 2009; Gandour et al., 1994; Xu, 1997).
- Generally, tonal coarticulation is assimilatory in nature, but *anticipatory* coarticulation is sometimes dissimilatory. High tones raise before low tones in Hokkien (Chang and Hsieh, 2012), Taiwanese (Peng, 1997), and Mandarin (Xu, 1997; Tilsen, 2013).
- As rate increases, fewer F_0 targets are successfully reached and contours flatten, as in French (Fougeron and Jun, 1998), Croatian, and English (Bradlow et al., 2003; Smiljanić and Bradlow, 2005).

Case study: Itunyoso Triqui

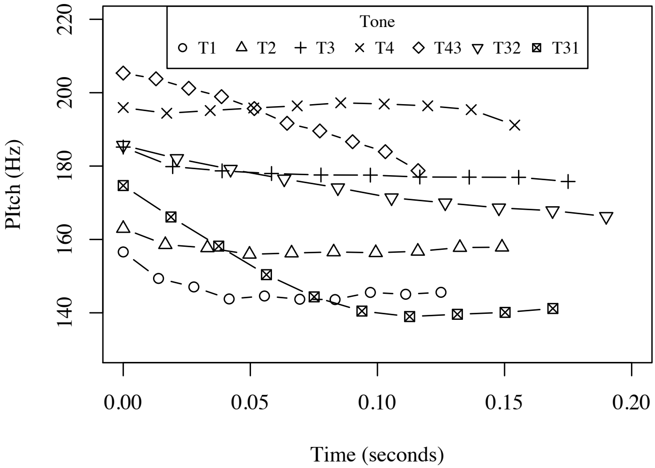
Spoken in the town of San Martín Itunyoso, in Oaxaca, Mexico, it is one of three Triqui variants.

Tone in Itunyoso Triqui

- Nine lexical tones contrast in word-final syllables, but only level tones occur in non-final syllables. Syllable structure is open with the exception of two possible glottal codas (DiCanio, 2008, 2012a, 2014).
- There are morphological tone changes, but no tone sandhi across words (DiCanio, submitted).

Tone	IPA	Gloss	Tone	IPA	Gloss
4	βːe^{4}	'*hair*'	43	li^{43}	'*small*'
3	nːe^{3}	'*plough*'	32	nːe^{32}	'*water*'
2	nːe^{2}	'*to lie (tr.)*'	31	nːe^{31}	'*meat*'
1	nːe^{1}	'*naked*'	45	joɦ^{45}	'*my forehead*'
			13	jo^{13}	'*light, quick*'

Tones in open syllables, from (DiCanio, 2012b)



Method: stimuli

- How do tonal context and rate influence tone production in Triqui?
- Four tones were chosen and embedded in four different tonal contexts in natural sentences of 3 words.
- Example: nĩ^{3}ʔĩ^3 sĩh^{45} ja^{3}kʷeh^3 '*The man knows Oaxaca.*'
- The medial word was always monosyllabic while the adjacent words were always disyllabic.
- The resulting sentences were natural carrier sentences in the language of the form: Verb + Subject + Modifier (adj, object), c.f. Scholz (2012).

Method: tonal contexts and rate

Adjacent tone (L/R)	Medial tone
/2.2/	/45/
/3.3/	/4/
/3.32/	/43/
/3.45/	/2/

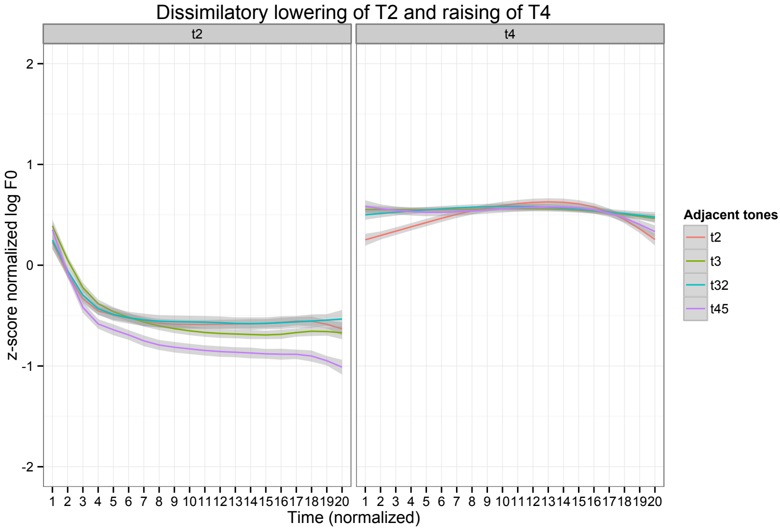
- Each of the 16 sentences were repeated five times by 8 speakers (4 male, 4 female) in two rate conditions (normal, fast).

- Normal rate: 3.45 45 3.45, [atʃĩh^{45} sĩɦ^{45} tʃa^{3}kah^{45}]
  '*The man is asking for a pig.*'
- Fast rate: 3.45 45 3.45, [atʃĩh^{45} sĩɦ^{45} tʃa^{3}kah^{45}]

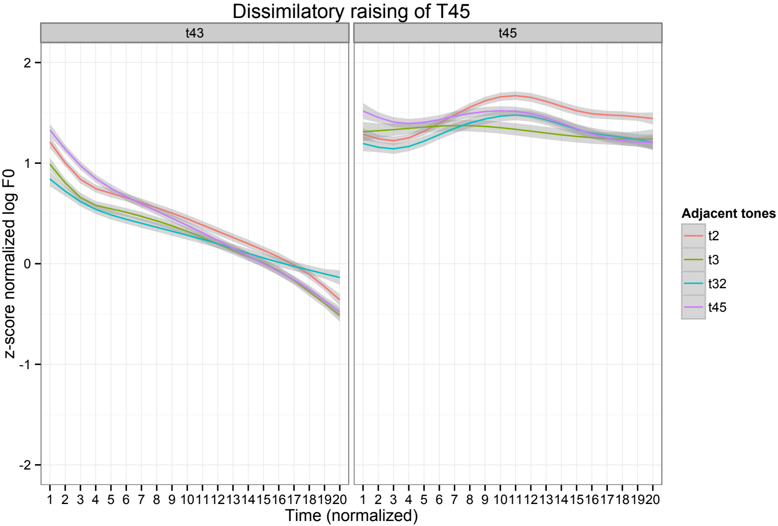
Measures

- Time-normalized F_0 data for the three vowels extracted using Voicesauce (Shue et al., 2009), at 20 points.
- F_0 data examined with several linear mixed effects model fit for each tone in each position (Left, Medial, Right) with 4 factors (Offset.difference X Time X Duration X Rate). Speaker was treated as a random effect with random intercepts and slope set for the effect of rate.
- The 20 time points were treated as continuous and recentered.
- Conservative measure of distance of z-score log F_0 from speaker's average for a given tone (a measure of variation).
- All results discussed here are significant at $p < .01$ via model comparisons using a χ^2 test with analysis of variance.

Medial target: level tones



Medial target: contour tones

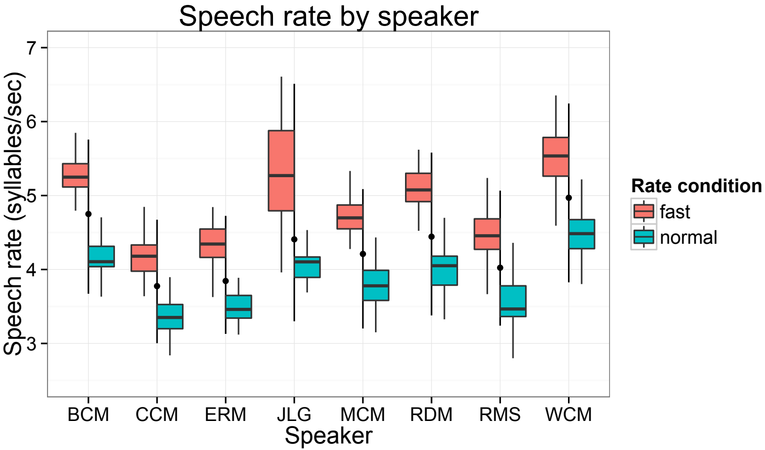


Summary - medial target

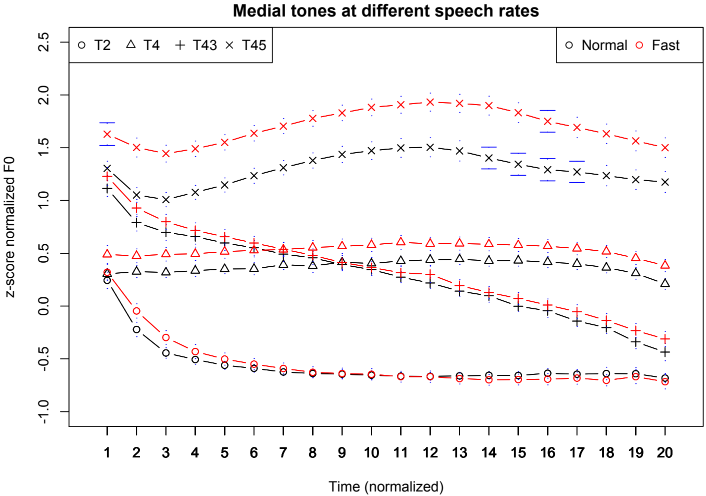
- Significant effects of the adjacent tones on the medial tone's F_0 trajectory, most notably for an adjacent /45/ and /32/.
- Not assimilatory, but dissimilatory.
- Tone /2/ lowers between contour tones /(3).45/.
- Tone /45/ (and tone /43/ to a lesser extent) raises between tones /2.2/.

Results II: Effect of rate on tone production

Average Normal:Fast speech rate = 1:1.26



F_0 range expansion



Discussion

- Tones remain distinct across contexts. This is different from Mandarin, where tones change drastically (Xu, 1994), but similar to findings in Thai (Gandour et al., 1999). Triqui and Thai both lack tone sandhi.
- More coarticulation occured when the following tone was a contour than when it was level.
- More dissimilatory effects were found in anticipatory contexts (medial), which is in-line with work on Taiwanese (Peng, 1997), Mandarin (Xu, 1998), Malaysian Hokkien (Chang and Hsieh, 2012), and Tianjin Chinese (Zhang and Liu, 2011).

Contrast preserving

- Expanding the pitch range and processes of dissimilation during in fast speech may aid the listener in the perception of tonal contrasts.
- Manuel's output constraint: "languages generally tend to tolerate less contextually induced changes in acoustic phonetic output if they are likely to lead to confusion of contrastive phones." (Manuel, 1990)
- Languages for which increased variability in F_0 does not result in decreased lexical identification do not undergo range contraction at a faster speech rate, as it is detrimental for perception.
- But if so, why doesn't Mandarin do this?

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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).
- Coarticulatory dissimilation may be a more common feature of languages with a larger number of tone levels and/or languages without tone sandhi processes.
- Range expansion during fast speech preserves these tonal contrasts too.

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).
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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. Models of tone production should attempt typological coverage.

Not every language show these patterns, but the patterns show us what constraints speakers control in tone production.

Future directions

1. Modelling of coarticulation and rate effects in Triqui in a general production model (TADA) under NSF grant (Whalen & Xu).
2. Investigating tonal coarticulation data in Yoloxóchitl Mixtec.
3. Investigating tonal variability in Mixtec corpus data using forced alignment (DiCanio et al., 2012b, 2013).
4. Investigating the use of dynamic cues by native listeners in tone perception.

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WHERE DISCOVERIES BEGIN

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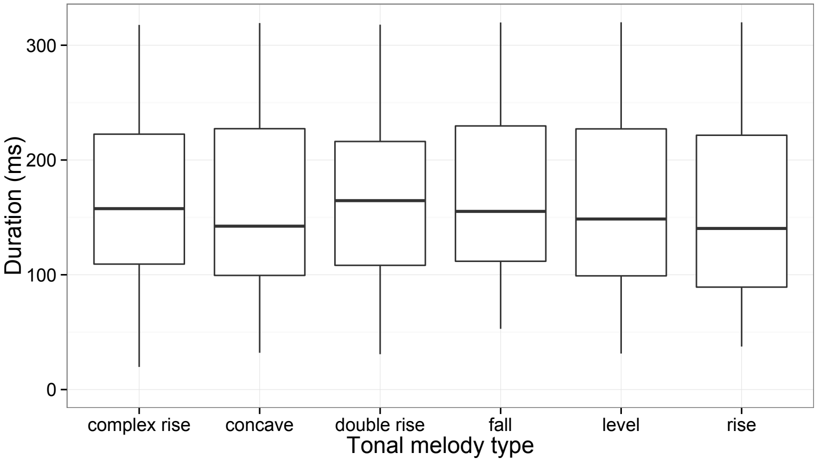
- Hosung Nam, Doug Whalen, Jonathan Amith, Rey Castillo García
- The Yoloxóchitl Mixtec and Itunyoso Triqui communities, kùruaa nihírèh! ([ku^{2}ɾu^{4}a^{43} ni^{3}ʔi^{4}ɾeʔ^{1}])!

Thank you!

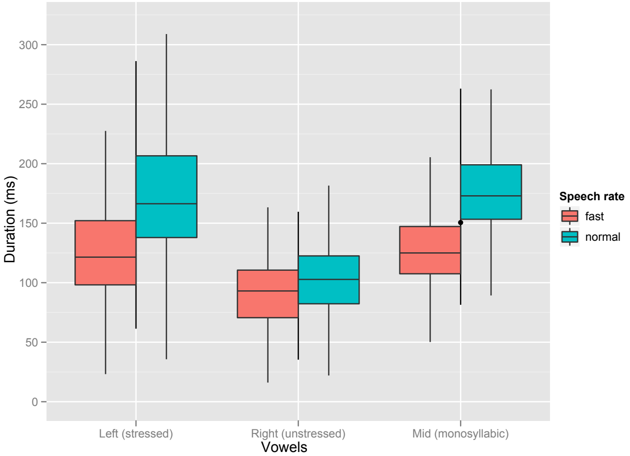
Duration of tone in YM

Little difference in duration among tones in monosyllables.

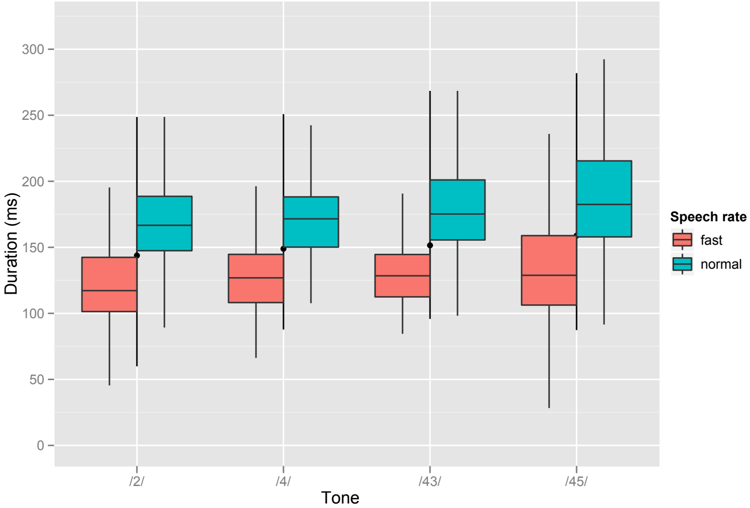


Duration differences for the Triqui vowels

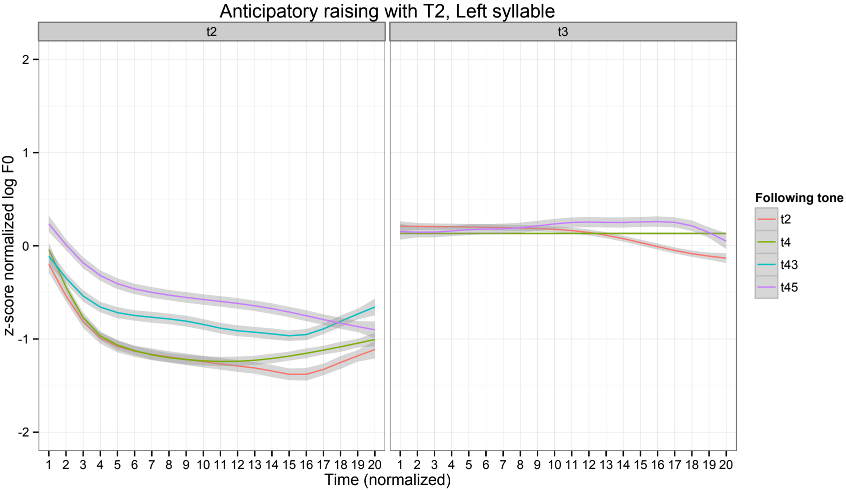
No difference in duration between stressed vowels, but unstressed vowels were shorter.



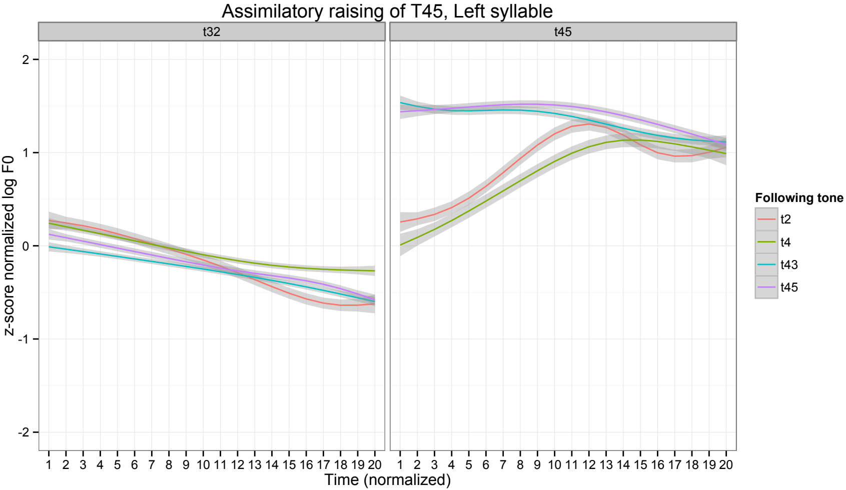
Tones did not differ substantially in duration in medial monosyllabic words.



Left target: level tones



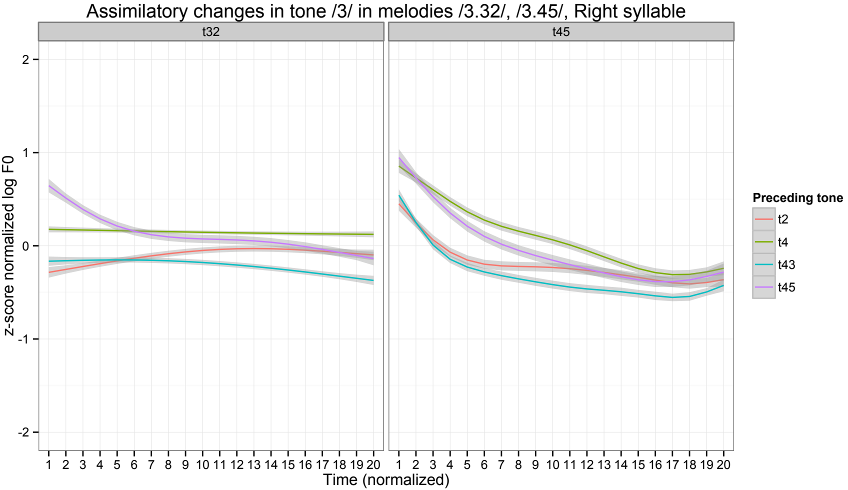
Left target: contour tones



Summary - left target

- Significant effects of the following tone on the preceding tone's F_0 trajectory, most notably for a following /45/ and /43/.
- Tone /2/ raises before contour tones /43, 45/, but is unaffected by following level tones.
- Tone /45/ is realized with an earlier F_0 peak before contour tones /43, 45/ than before following level tones.
- It is not simply the presence/absence of a higher tone which causes tonal coarticulation here, but the presence of a contour.

Right target: level tones



Larger summary

- Strong anticipatory effects on word preceding medial monosyllable and strong carryover effects on following word too.
- Dissimilatory effects on word which varies in tone in the elicitation frame, but only with highest/lowest adjacent targets.

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