Beyond tonogenesis: the role of speech reduction and redundant cues in the diversification of Otomanguean tonal systems

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Tone and sound change

- Lexical tone is common, occurring in about 42% of the world's languages (Maddieson, 2010).
- Tone has a fairly shallow time depth in certain language families, i.e. Athabaskan (Krauss, 2005), Austroasiatic (Haudricourt, 1954; Thurgood, 2007), and Mayan (Bennett et al., 2016; DiCanio and Bennett, 2018; England and Baird, 2017).
- Tone is much older in others, i.e. Tibeto-Burman (Benedict, 1972; Matisoff, 2003), Bantu (Hyman, 2018), Otomanguean (Dürr, 1987; Kirk, 1966; Longacre, 1957).

Research in phonetics has focused primarily on *incipient* tonogenesis and its phonetic precursors (Coetzee et al., 2018; Hombert et al., 1979; Hyslop, 2009; Mazaudon and Michaud, 2008; Silva, 2006; Svantesson and House, 2006).

Yet sound change does not stop once a language develops tone. Later developments may create greater tonal complexity.

The focus on incipient tonogenesis presumes lexical tone to be an innovation; the default language is non-tonal, but this bias has little basis from numbers from tonal typology (at least 42% of languages are tonal).

What types of factors contribute to greater tonal diversification and change in tone languages?

Overview

Investigation into low level phonetic variation in tone production as it relates to ongoing patterns of tonal change in Otomanguean languages.

1. Phonetic variation in the production of rising tones in Yoloxóchitl Mixtec in recent experimental work (DiCanio et al, submitted a) . **Tonal reduction –> phonologization.**
2. Phonetic variation in the production of the 2s clitic in Triqui (DiCanio (2016), DiCanio et al, submitted b). Morphologically-conditioned tone co-occurs with the reduction of triggering morpheme. **Contextual tonal cues –> loss of triggering morpheme**

Well-known factors are responsible for tonal diversification in phonology and morphophonology.

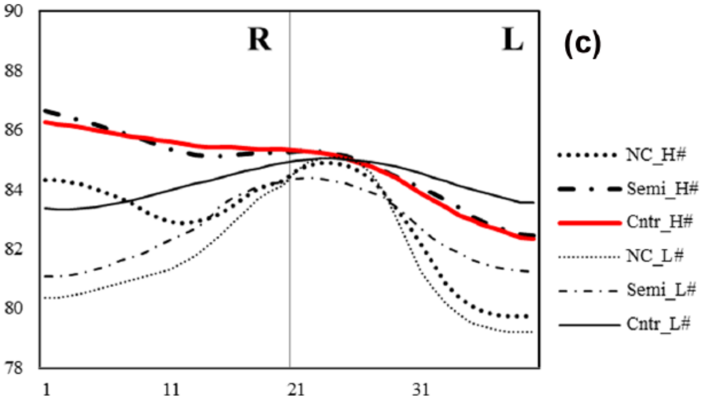
Study I: Tonal reduction

Patterns of speech reduction are ubiquitous (Cho, 2006; Gahl et al., 2012; Johnson, 2004) and may become phonologized (Lin et al., 2014; Parrell and Narayanan, 2018).

Tonal undershoot occurs when insufficient time is available to produce a target F_0 height or movement (Cheng and Xu, 2015; Xu, 1994; Xu and Sun, 2002).

Rising tones require larger temporal windows than falling tones or level tones (Ohala and Ewan, 1973; Sundberg, 1979; Xu and Sun, 2002).

In Taiwanese Mandarin, a target rise in F_0 (for a rising tone) is not achieved between a H and L tone during faster speech. A more level contour is produced.



(Cheng and Xu, 2015, 298).

Which contexts trigger tonal undershoot?

1. **Speech rate**: Faster speech rate –> greater tonal reduction/contraction (Cheng and Xu, 2015; Xu, 1994; Xu and Sun, 2002), though see DiCanio (2014).
2. **Phrasal position**: Tones are un-reduced in phrase-final position but may undergo truncation, compression, or simplification (Ladd, 2008, 180–183). (Peng, 1997; Morén and Zsiga, 2006; Zhang, 2006)
3. **Conflicting tonal environments**: It is harder to produce a rising tone between a high and low tone then the reverse; greater transitions between adjacent tones trigger coarticulation and/or reduction. (DiCanio, 2014; Xu, 1994)
4. **Information structure**: Tones are hyperarticulated under contrastive or narrow focus, and hypo-articulated under broad focus or in backgrounded contexts. (Chen, 2006; Chen and Gussenhoven, 2008; DiCanio et al., 2018; Kügler and Genzel, 2011; Xu, 1999)

Experiment 1: Positional effects on tone

Articulatory gestures have slower velocity and are lengthened in phrase-final position. (Barnes, 2006; Cho, 2006; Krivokapić and Byrd, 2012).

Final lowering is common in tonal languages, but it may be tone-specific.

- It occurs for all tones, e.g. Kipare (Herman, 1996), Moro (Chung et al., 2016), Embosi (Rialland and Embanga Aborobongui, 2017)
- It only occurs with low and falling tones, e.g. Mambila (Connell, 2017), Taiwanese (Peng, 1997), Akan (Kügler, 2017).

How do tones change at prosodic boundaries? Where does tonal hyper/hypoarticulation occur?

Yoloxóchitl Mixtec (YM)

- Otomanguean, spoken in Guerrero, Mexico (∼4000 speakers).
- Phonological/phonetic fieldwork (Castillo García, 2007; DiCanio et al., 2014, 2018, 2019; Palancar et al., 2016).

Yoloxóchitl, Guerrero

- All roots are minimally composed of bimoraic feet: (a) monosyllabic stems with long vowels (CVV) or (b) disyllabic stems with short vowels (CVCV) (Castillo García, 2007). No codas.
- Glottalization is contrastive: /yo^{1}o^4/ '*moon*' vs. /yo^{1}ʔo^4/ '*crooked*'
- Final syllables are prominent.
  - Nasal vowels only occur on stem-final syllables.
  - Restricted vowel contrasts on non-final syllables.
  - 9 tones on stem-final syllables, but only 5 on non-final syllables.
  - Final syllable lengthening, consistent regardless of focus/position (DiCanio et al., 2018)

Tone is lexical and morphological

Tone is assigned to moras (DiCanio et al., 2014). 26 tonal melodies possible on disyllables and 20 on monosyllables.

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

Previous work

Older, impressionistic studies on related dialects have suggested that tone production is sensitive to word and phrasal position.

High > Falling in Diuxi Mixtec (Pike and Oram, 1976)

Low > Low falling in Ayutla Mixtec (Pankratz and Pike, 1967)

Though, in a more complex tonal system, like YM, one generally anticipates less sensitivity of tone to phrasal position (Connell, 2017).

Methods: positional effects on tone

- 20 tonal melodies were analyzed (1.1, 1.3, 1.42...) in disyllabic words in non-final contexts (before a PP/Adv) and utterance-final contexts.

ʃa^{4}ʃi^{24}=ɾa^{2} ^{n}di^{3}ʃi^{4} 'He is eating corn.'
ʃa^{4}ʃi^{24}=ɾa^{2} ^{n}di^{3}ʃi^{4} βi^{3}tĩ^{3} 'He is eating corn now.'

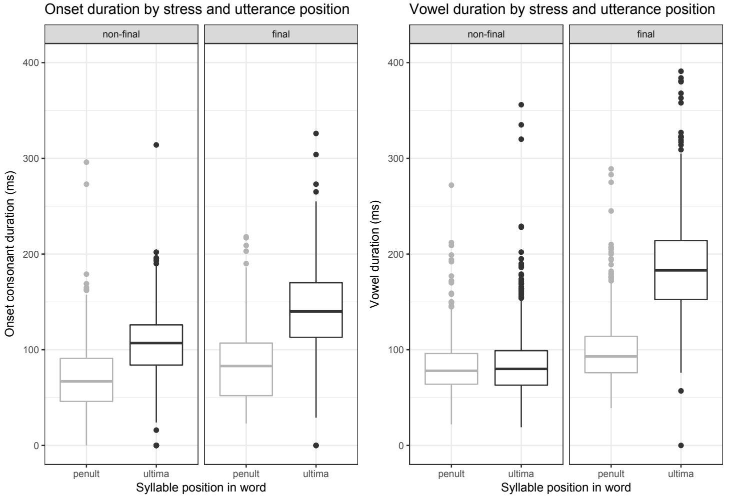
- 288 repetitions for each speaker (36 words x 2 conditions x 4 repetitions); 9 speakers.
- Normalized F_0 trajectories extracted over 5 time points and converted to log-normal values. Onset and vowel duration also extracted.
- Results analyzed using LMMs with lmertest (Kuznetsova et al., 2017). All reported results are significant.

Types of tonal *melodies* examined

- Level melodies: 1.1, 3.3, 4.4
- Falling melodies: 4.3, 4.2, 4.1, 3.2
- Rising melodies: 1.3, 1.4, 3.4
- Final falling tones: 1.42, 3.42, 1.32
- Final rising tones: 4.24, 4.13

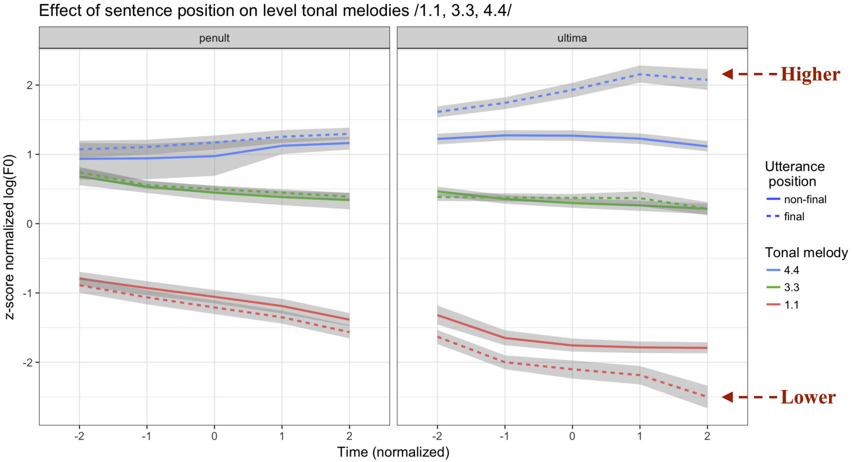
Results 1: Duration

Utterance-final lengthening of final syllables



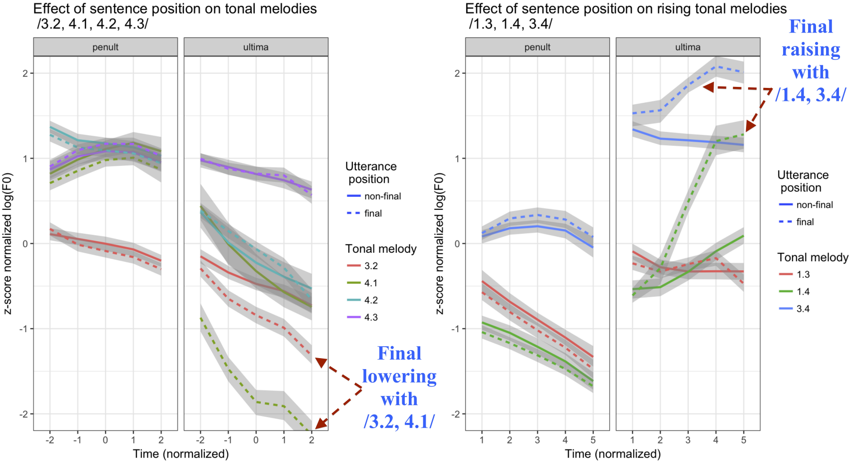
Results II: level tonal melodies

Utterance-final raising of high tones, lowering of low tones



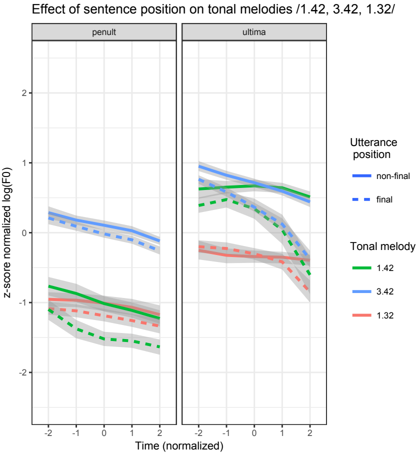
Results III: falling and rising melodies

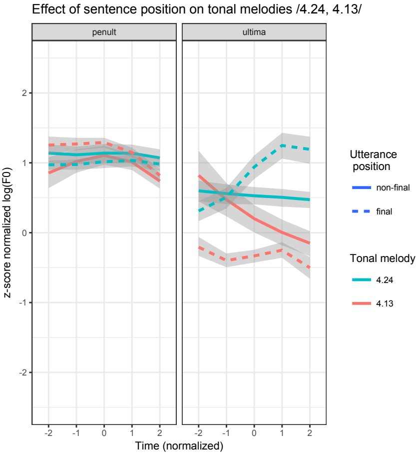
Utterance-final raising of high tones, lowering of low tones



Results IV: melodies with final contours

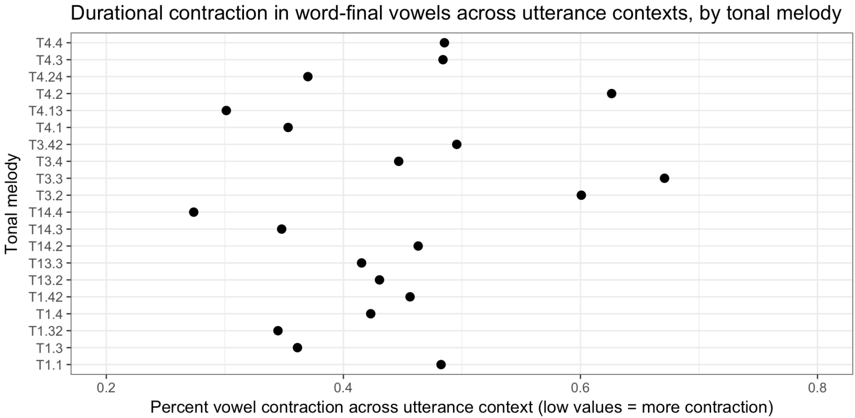
Utterance-final lowering of falling tones, but what's happening with the rising tones?





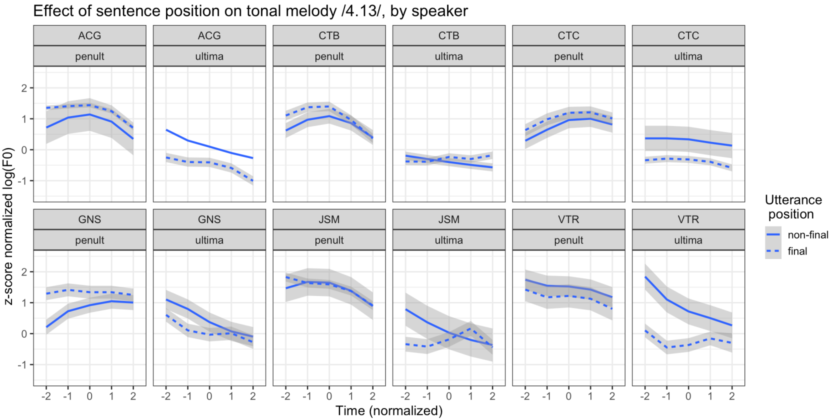
What's going on?

Extreme compression occurs in in utterance non-final position. Rising tones are compressed to $< 40\%$ of their duration in final position.



Final tone /13/

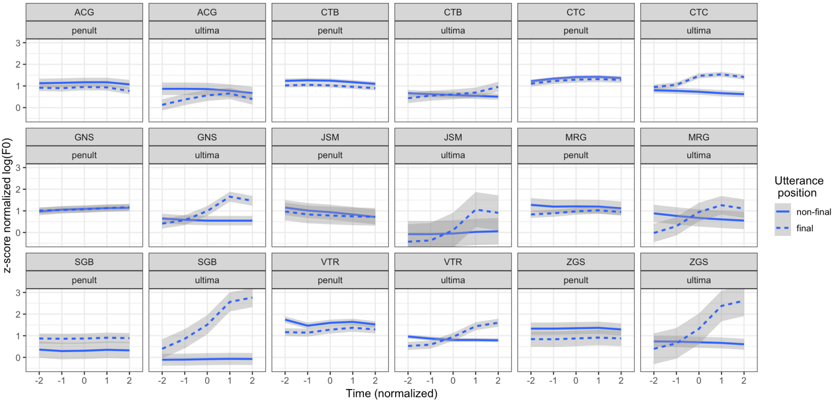
For 3/9 speakers, this tone was too short (<50 ms) to be analyzed. For 6/9 speakers, this tone was consistently levelled in non-final position. For 3/6 of these speakers, it was **also** levelled in final position.



Final tone /24/

Though all speakers level tone /24/ in non-final position, it retains a positive slope in final position. This appears to be emerging allotony: /24/ > [3]/_T.

Effect of sentence position on tonal melody /4.24/, by speaker



Is this tonal change?

Most Mixtec languages have three level tones. The source of a fourth level tone is primarily via the levelling of existing contours (ML, LM, etc) within Guerrero Mixtec varieties (c.f. Mendoza Ruiz (2016)).

Table: Guerrero Mixtec "4th" tone correspondences

	Yoloxóchitl	Alcozauca
'fried'	ka^{13}sũ^{1}	ka^{2}sũ^{1}
'went down'	nu^{13}u^{3}	nu^{2}u^{3}
'HAB.blow'	ti^{13}βi^{2}	ti^{2}βi^{2}
'HAB.knock.down'	ʃa^{13}ni^{2}	ʃa^{2}ni^{2}

In related Guerrero varieties, tone */13/ (historical LM) > /2/.

Interim discussion - positional effects on tone

1. Vowels are lengthened in phrase-final position.

2. Phrase-final position is marked by F_0 range expansion. The highest tone /4/ raises and lower/falling tones (/2, 1, 42, 32/) lower. Tone /3/ does not change.

3. Rising tones (/13, 24/) have level allotones in non-utterance-final position and sometimes in utterance-final position too.

4. Change of /13/ > /2/ in Alcozauca Mixtec matches the variation observed in Yoloxóchitl Mixtec.

What is the mechanism for the tonal change?

Processes of speech reduction may lead to sound change (Lin et al., 2014; Parrell and Narayanan, 2018).

Previous work on reduction has shown that, while it is mostly attributable to prosodic factors influencing duration, some reduced forms also occur in durationally-long contexts (Parrell, 2014; Parrell and Narayanan, 2018).

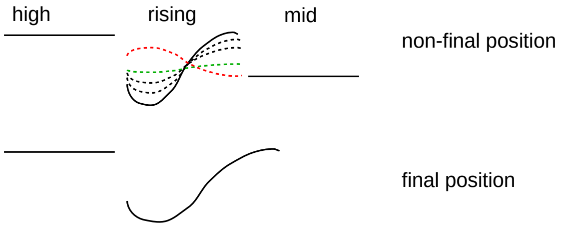
"*Prosodically-conditioned undershoot can lead to sound change if learners misattribute conditioned variability to phonological control instead of prosodic influence.*" (Parrell, 2014, 97).

–> Prosodically-conditioned *tonal* undershoot can lead to sound change.

Why do we get *this* change?

F_0 rises require more time than level or falling trajectories, thus we might expect that they be limited to contexts with longer phonetic duration, e.g. phrase-final position (Sundberg, 1979; Zhang, 2004).

Allotony results from durationally-induced F_0 levelling. Levelling is induced via articulatory undershoot (Parrell, 2014; Mücke and Grice, 2014).



Experiment II: Cliticization and tone

Personal clitics condition tonal changes on roots in many Otomanguean languages (Palancar and Léonard, 2016). Often only changes in tone or phonation indicate person.

Table: 1s marking in Itunyoso Triqui (DiCanio, 2016)

	Root	1s form
‘hand’	ɾa³ʔa³	ɾa³ʔaɦ⁵
‘be.afraid’	tʃu³ʔβiʔ³	tʃu³ʔβiɦ⁵
‘back’	tʃi³ɾaɦ⁵	tʃi³ɾa⁴³
‘to.ask’	a³tʃĩɦ⁵	a³tʃĩ⁴³

What is the process by which tonal changes on roots become the *primary* exponent for the person morpheme?

Tone and morphological change

Stability is a characteristic of tones as autosegments. Tones persist despite the loss of an original segmental anchor (Goldsmith, 1990).

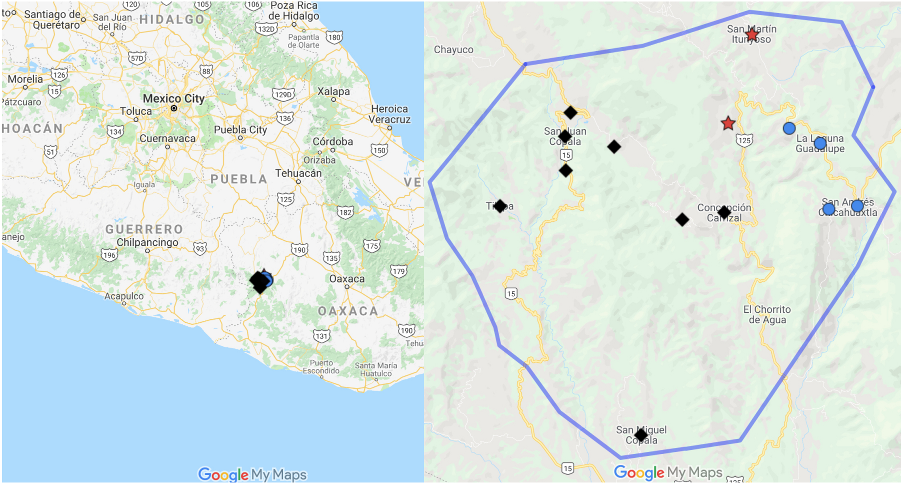
But what conditions the segmental deletion that gives rise to tonal morphemes?

Redundancy predicts durational compression in spontaneous speech.
(Aylett and Turk, 2004, 2006; Clopper et al., 2018; Gahl et al., 2012; Tang and Bennett, 2018)

Are certain types of tonal changes more redundant than others? How does segmental reduction interact with more redundant and less redundant tonal changes?

Test case: variation in segmental deletion in the 2s clitic in Itunyoso Triqui within a corpus of spontaneous speech.

Triqui region



Word-level prosodic phonology

- Most morphemes (73% of roots) are polysyllabic.
- Nine lexical tones contrast on final syllables. Tone in non-final syllables is often redundant (e.g. [ɾu^{4}ne^{43}] 'avocado') but may be contrastive (/2/ vs. /3/, /3/ vs. /4/) (DiCanio, 2008, 2016).

	Open syllable		Coda /h/		Coda /ʔ/	
Tone	**Word**	**Gloss**	**Word**	**Gloss**	**Word**	**Gloss**
/4/	yũ^{4}	'earthquake'	yãh^{4}	'dirt'	niʔ^{4}	'see.1DU'
/3/	yũ^{3}	'palm leaf'	yãh^{3}	'paper'	tsiʔ^{3}	'pulque'
/2/	ũ^{2}	'nine'	tah^{2}	'delicious'	ttʃiʔ^{2}	'ten'
/1/	yũ^{1}	'loose'	kãh^{1}	'naked'	tsiʔ^{1}	'sweet'
/45/			toh^{45}	'forehead'		
/13/	yo^{13}	'fast (adj.)'	toh^{13}	'a little'		
/43/	ɾa^{43}	'want'	nnãh^{43}	'mother!'		
/32/	ɾã^{32}	'durable'	nnãh^{32}	'cigarette'		
/31/	ɾã^{31}	'lightning'				

Triqui grammar/phonology

- Final syllables are bimoraic, consisting of the shapes /CVh, CVʔ, CVː/, and prominent. Most of the phonological contrasts occur on them (DiCanio, 2008).
- Tone has a high morphological load in the language, marking person, verbal aspect, and a few other distinctions (DiCanio, 2016).

tʃa^{43}	'to eat (PERF)'	tʃa^{2}	'to eat (POT)'
tʃah^{4}	'I ate'	tʃah^{1}	'I will eat'
tʃa^{41} = ɾeʔ^{1}	'You ate'		
tʃah^{3}	'(aforementioned) ate'	tʃah^{23}	'(aforementioned) will eat'
tʃoʔ^{4}	'We ate'	tʃoʔ^{2}	'We will eat'

Variation in 2^{nd} person marking

The 2S clitic may be realized with varying degrees of reduction.

1. A full clitic pronoun may be produced, i.e. ɾeʔ¹
2. The rime may be omitted, i.e. ɾ∼ɾ̥∼ɾ̥
3. The entire clitic may be omitted.

Tonal effects on the root

The 2S clitic has three possible effects on Triqui roots (DiCanio, 2016):

1. Roots with final tone /4, 43, 3, 32/ undergo low tone spreading which replaces the preceding syllable's tone:
   a^{4}tʃĩ^{43} 'to pass' > a^{4}tʃĩ^{1}=ɾeʔ^{1}
2. Certain roots (a couple hundred) with final tone /3/ raise the preceding syllable's tone to /4/:
   a^{3}tʃi^{3} 'to peel' > a^{3}tʃi^{4}=ɾeʔ^{1}
3. Roots with final tones /2, 1, 31, 45/ involve no change on the preceding syllable's tone:
   ka^{2}tʃĩ^{2} 'POT.pass' > ka^{2}tʃĩ^{2}=ɾeʔ^{1}

Does redundant, tonal information on the root predict observed patterns of clitic reduction?

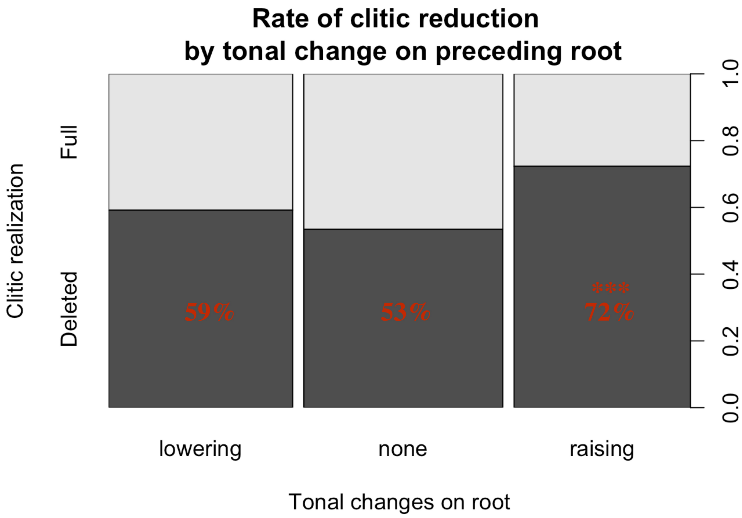
How does this relate to tonal change?

Methods

- Corpus of 104 Triqui texts, transcribed in ELAN (Wittenburg et al., 2006), totalling 9 hours (DiCanio (AILLA), no date).
- 21 different speakers producing spontaneous speech on a range of topics (conversational, local history, ethnobotany, etc.)
- Extracted all cases of 2S marking - 479 examples.
- All 2S variants were transcribed in texts in terms of two degrees of reduction (Deleted or Full vowel).
- All examples were coded for whether the clitic conditioned lowering, raising, or no change.
- Results evaluated with a generalized logistic model in R (R Development Core Team, 2017).

Do reduced forms occur more often in contexts where the clitic conditions tonal changes on the root?

Reduced clitics occur 61% of the time overall, but significantly more often when tonal raising co-occurs on the preceding root ($z = -3.3$, $p < .001$).



Why might deletion be more frequent with tonal raising than tonal lowering?

- Tonal raising is the most restricted context – it *only* occurs on roots which carry tone /3/. On the other hand, tonal lowering is conditioned by roots possessing tones /4, 43, 3, 32/.
- But is this tonal change in progress?
- The same clitic is reduced to /=t/ in Chicahuaxtla Triqui (the closest neighbor), where the process seems to have evolved further (Hernández Mendoza, 2017). There is no concomitant tonal lowering process in Chicahuaxtla - only raising.

The evolution of tonally-conditioned segmental allomorphy

Table: 1s clitic allomorphy in Yoloxóchitl Mixtec (Castillo García, 2007)

	Root	1S		Verb	1S
'plate'	$\text{ko}^{1}\text{ʔo}^{4}$	$\text{ko}^{1}\text{ʔo}^{42}$	'bed'	$\text{i}^{1}\text{sto}^{3}$	$\text{i}^{1}\text{sto}^{32}$
'pineapple'	$\text{ʃu}^{4}\text{jũ}^{4}$	$\text{ʃu}^{4}\text{jũ}^{42}$	'to peel'	$\text{k}^{w}\text{i}^{3}\text{i}^{4}$	$\text{k}^{w}\text{i}^{3}\text{i}^{42}$
'beard'	$\text{ʃa}^{3}\text{a}^{2}$	$\mathbf{ʃa^{3}a^{2}{=}ju^{1}}$	'to sleep'	$\text{ku}^{1}\text{sũ}^{1}$	$\mathbf{ku^{1}sũ^{1}{=}ju^{1}}$

The clitic $/{=}\text{ju}^{1}/$ is the source of the original tone /2/, though when the root already ends in a low tone (/2, 1/), an overt clitic pronoun must apply.

The Triqui clitic variation appears to be a change heading in the same direction. In conditions where contextual cues are not as common, reduction is less frequent.

Data summary

- For Yoloxóchitl Mixtec, utterance position conditions durational changes in words in Yoloxóchitl Mixtec, which causes tonal hyper- and hypo-articulation.
- Compression of rising tones causes tonal levelling, some of which persists for speakers in durationally-long contexts. This type of levelling is attested in a neighboring dialect.
- For Itunyoso Triqui, the degree of segmental reduction of the 2s clitic varies by the type of tonal changes it conditions on the preceding root.
- More segmentally-reduced clitics co-occur with root tone raising.

Discussion: Tonal hypo-articulation

The Yoloxóchitl Mixtec data suggests that processes of speech reduction condition the initial stages of tonal contour levelling.

Certain speakers appear to over-generalize from reduced variants. The average pitch of the rising tone becomes the new "target."

This may arise due to general constraints on perceiving dynamic pitch trajectories (House, 2004). Given a shorter time domain, larger pitch distances are required for listeners to perceive a contour. Speakers may only hear a static target in compressed contexts.

Incidentally, this may explain why the /24/ rise (involving a larger span) does not undergo the same levelling.

Discussion: Redundancy of morphophonetic cues

The Itunyoso Triqui data suggest a relationship between the tonal information carried on the root and the degree of reduction in a clitic.

Clitic-conditioned tonal processes in Otomanguean languages result in multiple exponence in morphology (Harris, 2017).

Redundant segmental cues in morphophonology undergo reduction and tonal cues (occurring earlier in time) persist.

The findings here suggest a diachronic pathway for the evolution of tonally-conditioned allomorphy.

Conclusions

- Even elaborate tonal systems (Otomanguean: Mixtecan) continue to undergo diachronic change.
- Examining low-level sychronic variation alongside descriptive work on closely-related language varieties can elucidate the mechanisms for tonal change.
- Both experimental and documentation/corpus-based methods are useful.
- The usual suspects are causal - speech reduction and gradual changes in cue weighting.

Acknowledgements

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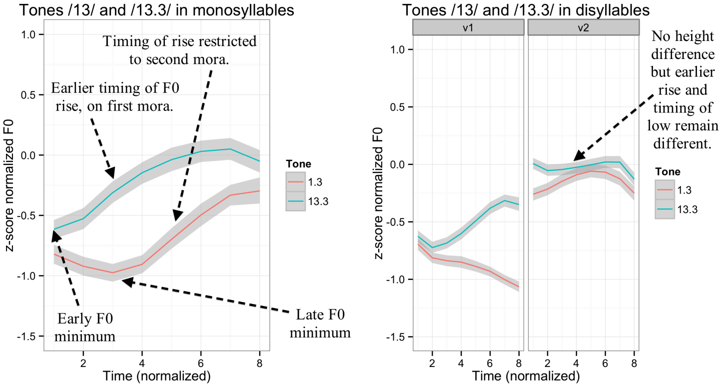
- Collaborators: Richard Hatcher, Basileo Martínez Cruz, Wilberto Martínez Cruz, Jonathan Amith, Rey Castillo García, Joshua Benn, Jason Lilley, Tim Bunnell

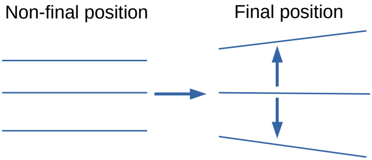
Appendix I - position of /13/

Though this tone is not in the same position (the penultimate mora) as observed in the current study, there is some evidence that /13/ is raised in penults too.



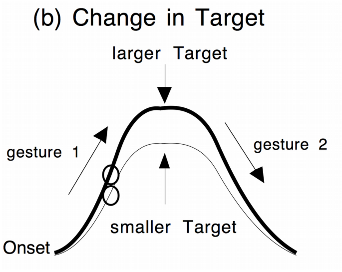
Appendix II: Processes affecting final tones

- Final raising of highest tone and lowering of lowest tone reflect distinct processes from utterance-level effects.
- Utterance-level declination occurs with non-high tones but not with the highest tone (/4/).
- Are these boundary tones? No. If they were to exist, we would have to stipulate that they be extensions of the same preceding tones, i.e. H% only after /4/.

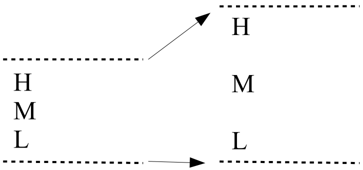


Appendix III: mechanisms of hyperarticulation

Prosody in YM is marked primarily by adjustments to F_0 range and hyper/hypoarticulation (de Jong, 1995; de Jong and Zawaydeh, 2002).



Change in range = postural target adjustment?



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