Word-medial strengthening in Mixtecan languages

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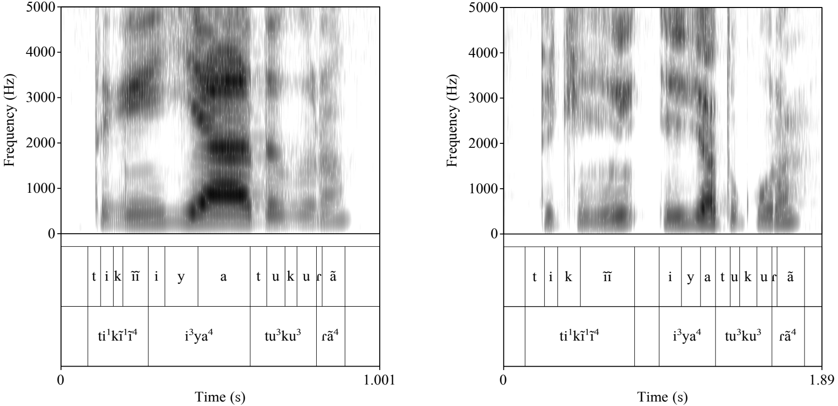
Motivation from fieldwork

Why are the obstruents pronounced so differently in these sentences?
[ti^{1}kĩ^{1}ĩ^4 i^{3}ja^4 tu^{3}ku^3 ɾã^4] (left) vs. [ti^{1}kĩ^{1}ĩ^4 i^{3}ja^4 tu^{3}ku^3 ɾã^4] (right)
'...*the sour tamale again, then.*'



Obstruent reduction

Relative to carefully-produced speech, an obstruent is produced with reduced spatial excursion of articulators and reduced constriction degree.

Such obstruents may be **shorter in duration** relative to carefully-produced variants (Lavoie, 2001; Parrell, 2014; Parrell and Narayanan, 2018)

Reduced voiceless obstruents may undergo a process of **passive voicing** or **voicing bleed** as well (Beckman et al., 2013; Davidson, 2018; DiCanio, 2012; Jansen, 2004; Schwarz et al., 2019; Stevens, 2000; Westbury, 1983; Westbury and Keating, 1986).

Goals

Language goal - to understand why and where reduction occurs

Intermediate goal - to understand how the observed patterns correspond with past work

Theoretical phonetic goal - to understand what structural properties lead to different patterns of reduction across languages; can we create a typology of reduction processes?

Where is reduction?

Speech reduction occurs most often in casual and running speech, but it is also found in carefully-produced speech contexts (Lavoie, 2001; Warner and Tucker, 2011; Warner, 2019).

Reduction frequently coincides with **weak prosodic positions** whereas obstruent fortition frequently coincides with **strong prosodic positions**. (Bouavichith and Davidson, 2013; Cho and Keating, 2001; Fougeron and Keating, 1997; Katz, 2016; Keating et al., 2004; Katz and Fricke, 2018)

Weak prosodic positions: unstressed syllables, word-internally, phrase-medially, and intervocalically

Strong prosodic positions: stressed syllables; word-initially, phrase-initially, and in phrase-final contexts contexts)

Why is reduction important?

Speech requires speakers to carefully control the timing of different articulatory gestures while simultaneously conveying information to listeners at a sufficient rate.

In running speech these constraints compete with each other and speakers may lenite certain phonological contrasts (cf. Lindblom, 1990).

Listeners are able use the degree of reduction for lexical parsing (Cho et al., 2007; Katz, 2016; Katz and Fricke, 2018) just as they are able to use more general prosodic cues for the purpose of lexical segmentation (Norris and McQueen, 2008; Saffran et al., 1996; White et al., 2015).

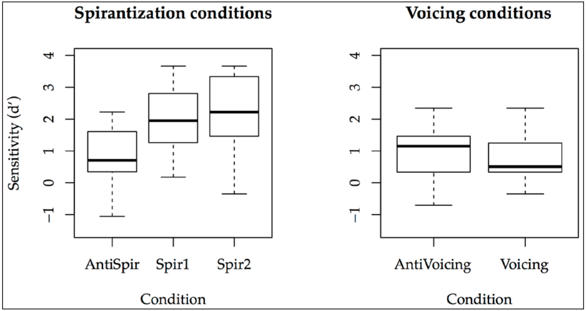


Figure 3: By-subject d' in the spirantization (left) and voicing (right) experiments by condition. Horizontal lines are median values; boxes are interquartile intervals; whiskers are ranges.

(Katz and Fricke, 2018)

Katz and Fricke (2018) found that English listeners were more likely to parse words correctly when lenited segments appear word-medially than word-initially.

White et al. (2020) found that English, Italian, and Hungarian listeners were better able to learn words in an artificial language learning task when initial consonants were lengthened.

Stress matters too

In English, voiced stops were produced as approximants between 10-21% of the time in the onset of stressed syllables but 47-75% of the time in the onset of unstressed syllables (Bouavichith and Davidson, 2013).

In Spanish and French, incomplete closure of voiceless stops (/p, t, k/) was found to be more common in unstressed syllables than in stressed syllables (Torreira and Ernestus, 2011).

In both studies, stops in stressed syllables were longer than those in unstressed syllables.

Questions

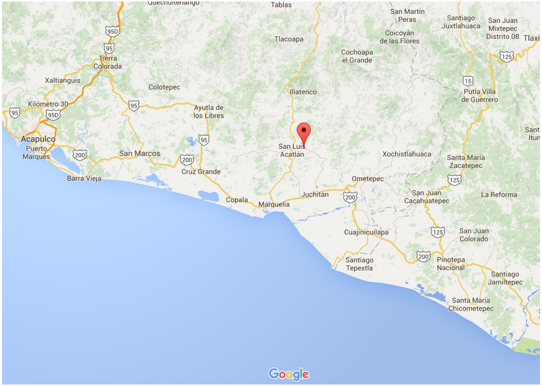
- Is reduction in Mixtecan languages mediated by word boundaries?
- Is reduction in Mixtecan languages mediated by stress?
- How might other linguistic factors contribute to the patterning?

Roadmap

1. Corpus phonetic study of reduction in Yoloxóchitl Mixtec using documentation corpora.
2. Corpus phonetic study of reduction in Itunyoso Triqui using documentation corpora (and somewhat different methods).
3. General discussion

Yoloxóchitl Mixtec

Mixtec (Otomanguean) is a family of languages spoken in Southern Mexico. Yoloxóchitl Mixtec (YM) is spoken in Yoloxóchitl, Guerrero by 2,500 speakers.



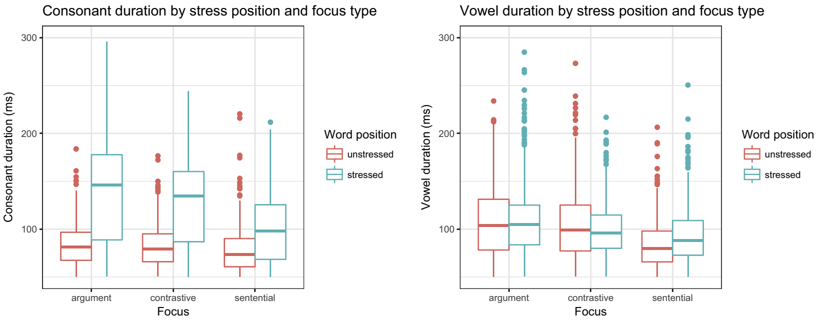
There is no voicing contrast among Yoloxóchitl Mixtec obstruents (Castillo García, 2007; DiCanio et al., 2020) and there are no discrete patterns of obstruent allophony.

	Bilabial	Dental	Alveolar	Post-alv	Palatal	Velar	Lab.velar
Plosive	(p)	t				k	k^w
Nasal	m		n				
P-s nasal	m^b		n^d			$ŋ^g$	
Tap			ɾ				
Affr.				tʃ			
Fric.		s		ʃ			
Approx.	β		l		j		

There is a very complex tonal system in the language, which has been the topic of past work (DiCanio et al., 2014, 2018, 2021), but this is not discussed here.

Word structure

Most roots are composed of bimoraic feet in YM, e.g. CVV or CVCV, with optional aspectual prefixes on verbs. There is fixed final stress realized via distributional asymmetries in the phonology and **consonant** lengthening (DiCanio et al., 2018).



Past experimental work using controlled experimental contexts shows greater duration in onsets of **final** syllables of the foot.

If duration correlates with patterns of lenition (as past research shows), we expect to find greater lenition in word-initial (often stem-initial) position than in word-medial position.

Is final stress a stronger predictor of patterns of lenition in YM than word-position is?

Methods

- Corpus of 6 speakers (3 male, 3 female) producing spontaneous narratives in YM, totalling 86 minutes.
- Analysis of duration, spirantization, and percentage of voicing during constriction/closure for /t, k, kʷ, s, ʃ, tʃ/.
- A total of 7923 segments were analyzed.
- Hand-labelling of corpus was done in a previous study (DiCanio et al., 2015), but words here were coded by stem position (initial, medial, final syllable), and word size (monosyllabic, disyllabic, polysyllabic).

- Duration was extracted with an existing Praat script.
- Voicing was extracted with a script written for Matlab (Chen, W-R). Percentage of voicing during constriction was calculated using a normalized low frequency energy ratio (Kasi and Zahorian, 2002; Zahorian and Hu, 2008).
- YAAPT outperforms Praat's (Boersma and Weenink, 2016) autocorrelation method for pitch-tracking across a variety of SNR conditions (Zahorian and Hu, 2008).
- Bayesian hierarchical linear models with two fixed effects (syllable position and consonant) and their two-way interaction using the Stan modeling language (Carpenter et al., 2017) and the package brms (Buerkner, 2016).
- For the voicing data, a zero-one inflated beta regression was set as the response distribution (Liu and Kong, 2015).

Examination of spirantization of stops by visual categorization

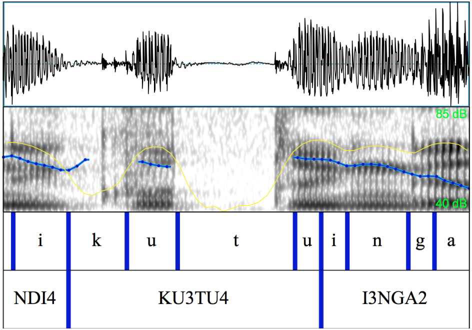
We used a qualitative, discrete measure of lenition where the two most-common stop consonants (/t, k/) were individually coded as: (1) voiceless stop, (2) partially voiced stop, (3) voiced stop, (4) voiced fricative, (5) voiced approximant, (6) nasal stop, (7) Tap, (8) Deletion.

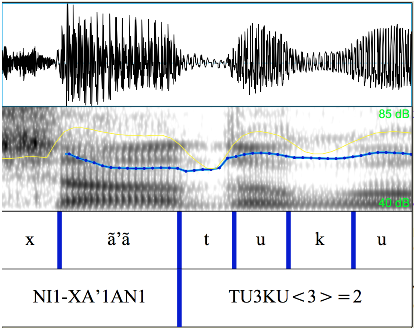
Stops were identified by the presence of a visible burst release and voicing was identified by the presence of a visible periodicity in the waveform.

A Praat script was used to automate these decisions and track the patterns of lenition.

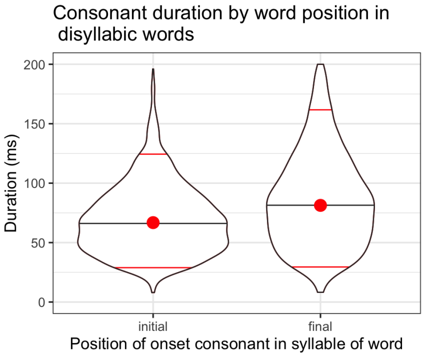
Examples

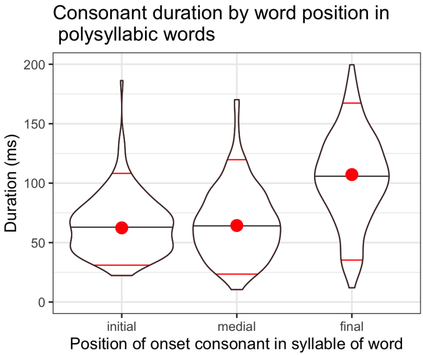
Reduction of stops in /ku^{3}tu^4/ ‘to fill up’ and /tu^{3}ku^3=^{2}/ ‘again=1s.’



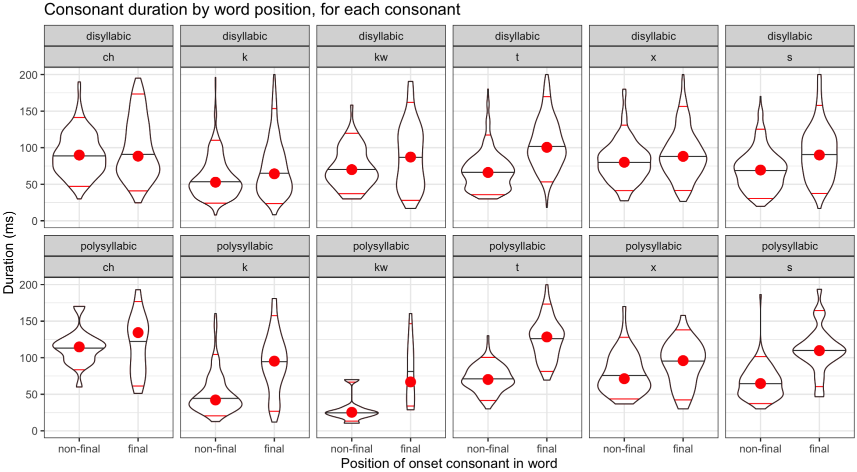


Results: Duration - longer in final syllables

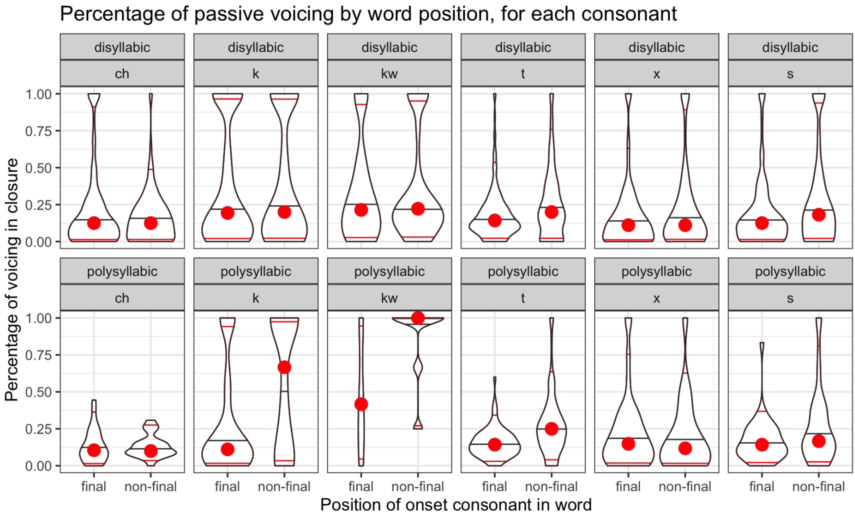




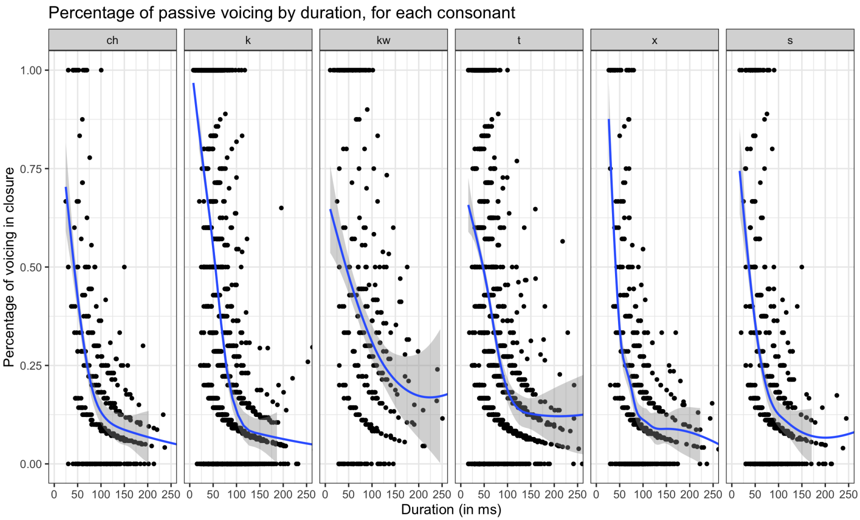
The pattern is consistent for all obstruents but not for /tʃ/.



Results: Voicing lenition

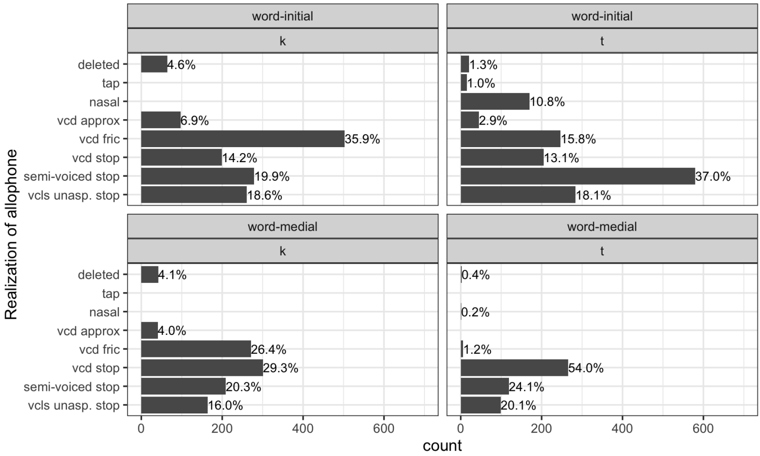


As duration increased, a smaller proportion of the obstruent was voiced.

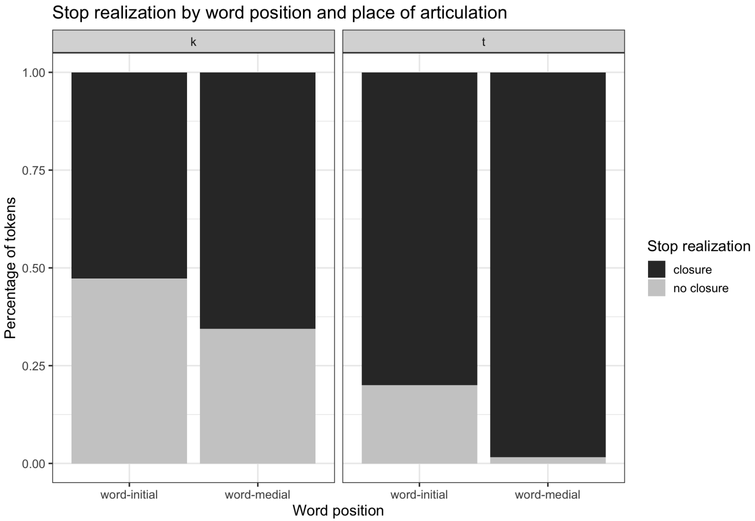


Results: Closure/spirantization

Stops /t, k/ were fully voiced 48% and 63% of the time, respectively.



Stop realizations were more frequent *in tonic syllables* than in non-tonic syllables.



Interim discussion

- Obstruents in YM are frequently lenited.
- Voicing lenition and spirantization realizations were more frequent in word-medial (stressed syllables) than in non-final syllables.
- Patterns of lenition largely follow durational differences within the word.

Itunyoso Triqui

Triqui (Otomanguean) is a family of 3 languages spoken in Southern Mexico. Itunyoso Triqui is spoken in San Martín Itunyoso, Oaxaca by 2,600 speakers.

A more complex consonant inventory with a length contrast which only appears in onsets of monosyllabic words.

	Bilabial	Dental	Alveolar	Post-alveolar	Retroflex	Palatal	Velar	Labialized velar	Glottal
Plosive	p*	t tː					k kː	kʷ kʷː	ʔ
Pre-nasalized plosive			nd				ŋg	ŋgʷ	
Affricate		ts		tʃ tʃː	ʈʂ ʈʂː				
Nasal	m mː		n nː						
Pre-stopped nasal						cn			
Tap			ɾ						
Fricative	β βː	s		ʃ					h
Approximant						j jː			
Lateral approximant			l lː**						

*Rare in native words **Occurs in only a few words

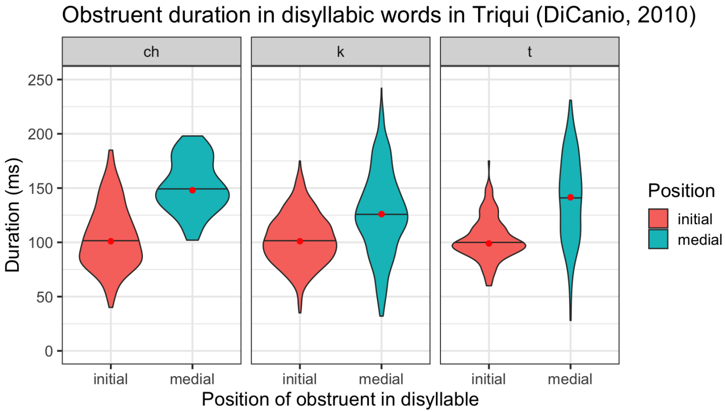
(DiCanio, 2010)

Word-level prosodic phonology

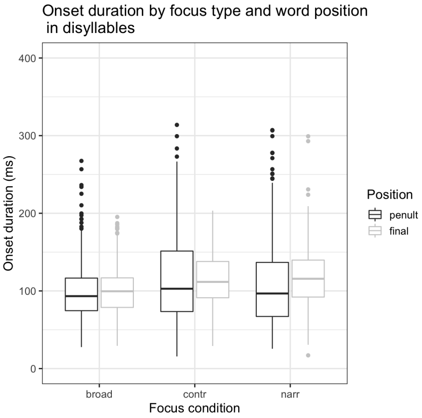
- Most morphemes (73% of roots) are polysyllabic. All verbal roots may take one or more aspectual prefixes.
- Nine lexical tones contrast on final syllables. Tone in non-final syllables is often redundant (e.g. [ɾu^{4}ne^{43}] 'avocado') but may be contrastive (/2/ vs. /3/, /3/ vs. /4/) (DiCanio, 2008, 2016).
- Final syllables are bimoraic, consisting of the shapes /CVh, CVʔ, CVː/, and prominent. Most phonological contrasts occur only in final syllables, including contour tones, prenasalization, glottalization, and vowel nasalization (DiCanio, 2008).

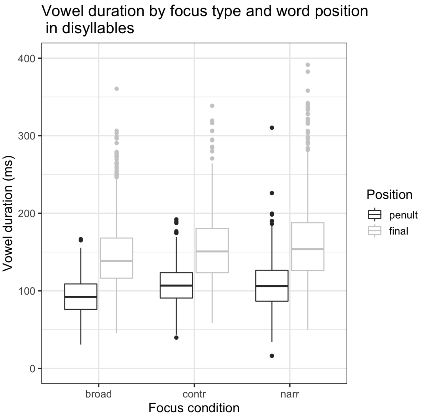
Past experimental work

Like in Yoloxóchitl Mixtec, past experimental work shows a pattern where onsets of final, stressed syllables are lengthened (DiCanio, 2010).



The locus of lengthening in Triqui appears to be more on the vowel, unlike Yoloxóchitl Mixtec. More recent work shows onset lengthening, but it is less prevalent outside of focus contexts (DiCanio & Hatcher 2018, in progress).





Predictions

Based on the experimental work, we predict consonant strengthening in word-medial onsets of stressed syllables and reduction in pre-tonic syllables, including in word-initial position.

Methods

- Corpus of 11 speakers (7 male, 4 female) producing spontaneous narratives, totalling 81.4 minutes (about 40 minutes/sex).
- Analysis of duration, spirantization, and percentage of voicing during constriction/closure for /t, k, kʷ, s, ts, tʃ/.
- A total of 6081 segments were analyzed.
- Hand-correction of corpus following forced alignment using the Montreal Forced Aligner (McAuliffe et al., 2017). All words were coded by stem position (initial, medial, final syllable), and word size (monosyllabic, disyllabic, polysyllabic).

- Duration values extracted via a custom script written for Praat (Boersma and Weenink, 2016)
- Δ-intensity values extracted via a custom script adapted to Praat, following methods from Kingston (2008) and Hualde and Nadeu (2011).
- An intensity contour for a 0-400 Hz band pass filtered signal was extracted over a window consisting of the segmented target and 50 ms adjacent offset windows.
- Δ-i values reflect the maximum intensity difference over this window.
- The expectation is that a greater intensity "dip" corresponds to a less lenited segment since unreduced voiceless obstruents have lower amplitude in the lower spectrum.

Script extracts a number of inflection points in acoustic signal. Unlike Ennever et al. (2017); Katz and Pitzanti (2019), we used a maximum intensity difference from time-points 1-8.

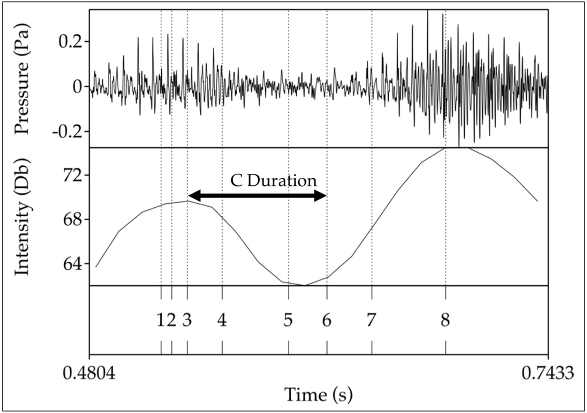


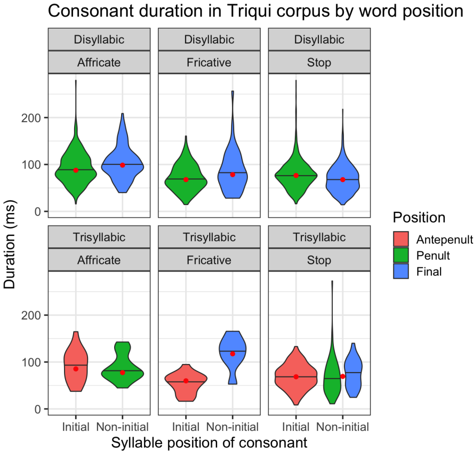
Figure from Katz and Pitzanti (2019)

Methods: Stats

- For both duration and intensity results, we constructed linear mixed effects models with fixed effects of Finality (non-final/final) and Manner of articulation (affricate-fricative-stop). A random slope for Finality was specified along with random intercepts for Speaker and Word.
- Sum contrast coding and standardization used for all factors.
- For all models, we maximized the random effects structure; more complex random effects structure did not converge.

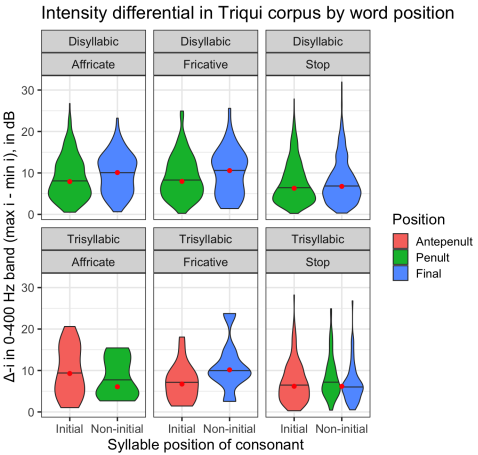
Results: duration

Consonants are longer in stressed syllables in word-medial position than in unstressed syllables word-initially - but only for fricatives and affricates.



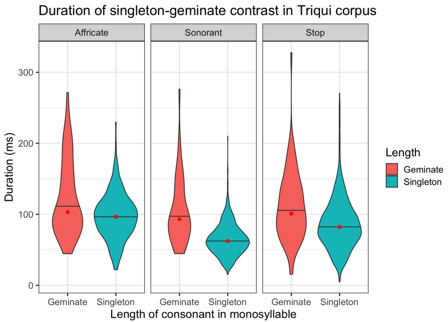
Results: Δ-intensity

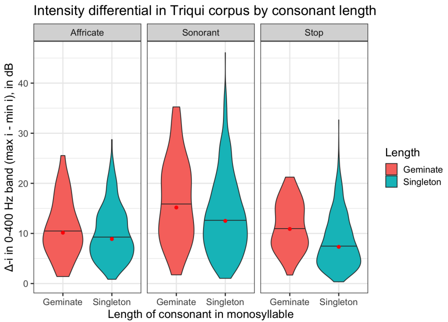
Differences in duration did **not** result in significant changes in intensity.



Tangential results

Durational changes **did** correspond with intensity changes in the singleton-geminate consonant contrast.





Summary

- Obstruents in Itunyoso Triqui show less evidence of lenition conditioned by word position or stress in polysyllabic words.
- No pattern of word-initial strengthening.
- Durational differences by word position are not sufficiently large enough in polysyllables to condition consistent patterns of lenition.
- Patterns of lenition are more likely in monosyllabic words with singleton obstruent onsets. Is lenition conditioned by contrast?

Discussion: voicing and lenition

The relationship between duration and voicing observed for Yoloxóchitl Mixtec closely parallels findings in Kakadelis (2018) on Arapaho, Bardi, and Siera Norte del Puebla Nahuatl.

Each of these languages lacks a phonological voicing contrasts among obstruents, suggesting that voicing lenition might be prosodically-mediated here.

In languages with a voicing contrast, it seems that the degree of passive voicing is both less pervasive and less sensitive to prosodic position.

In English, Davidson (2018) finds that voiceless stops tend to undergo rather little passive voicing.

Discussion: lengthening and lenition

We observe similar effects of durational lengthening in onsets of stressed syllables in Yoloxóchitl Mixtec and in Itunyoso Triqui.

By contrast, non-final consonants are shorter.

Where durational differences are larger, we observe more robust patterns of obstruent lenition. Reduced (voiceless) obstruents are realized with incomplete closure (approximantization) and with more voicing throughout.

Initial weakening or prosodic strengthening?

Since stress is final in both languages and most words are disyllabic, word-medial, pre-final position is prosodically prominent.

Word prosodic patterns on consonant production may be stronger than patterns related just to word position.

Stem-*final* stress is fairly common in the world's languages. Among languages with phonologically-predictable stress, between 18% - 31% have stem-final stress (depending on the typological survey) (Gordon, 2016).

What about morphology? (speculation alert)

Word-initial strengthening has been found in English, Spanish, French, Italian, Hungarian, and Korean, all of which are primarily suffixing languages.

The other languages where word-initial strengthening has been observed are either isolating (Taiwanese) or primarily suffixing with some prefixation on verbs (Bardi) (Bowern, 2012).

Yoloxóchitl Mixtec has only prefixal inflectional morphology on verbs, historical derivational prefixes on nouns, and pronominal enclitics which can freely apply to most parts of speech (Castillo García, 2007).

This patterning is common among Otomanguean languages (Beam de Azcona, 2004; Campbell, 2014; DiCanio, 2020, 2016; Macaulay, 1996).

If the goal of word-initial strengthening is to ensure reliable cues to word segmentation (Katz and Fricke, 2018; White et al., 2020), ideally speakers should ensure clear acoustic or articulatory cues in the initial portion of words which happens to be co-extensive with a lexical stem.

Is strengthening structure-dependent?

In languages where the initial portion of the word does not immediately inform listeners of the stem's identity, it is less important for speakers to strengthen it in the natural context of speech communication. Only two types of patterns appear to be attested so far.

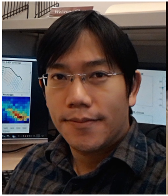
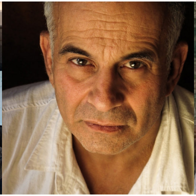
	Pfx-Pfx-**Root**	
→	CV-CV-**CVCV**	**Root/word-final strengthening**
	CV-CV-**CVCV**	**Root-initial strengthening**
	CV-CV-**CVCV**	**Word-initial strenghtening**
	Root-Sfx-Sfx	
→	**CVCV-**CV-CV	**Root/word-initial strengthening**
	CVCV-CV-CV	**Root-final strengthening**
	CVCV-CV-CV	**Word-final strengthening**

A future direction for research?

In languages with patterns of initial consonant mutation and/or processes of prefixation, knowing the initial consonant does not aid the listener in ascertaining lexical identity (Ussishkin et al., 2017).

This possibility has potential repercussions for models of speech recognition which rely primarily on word onset identification (Norris and McQueen, 2008).

Acknowledgements - diverse collaborative team

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Not pictured: Richard Hatcher (SUNY Buffalo), Rey Castillo García (Guerrero, Mexico).

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WHERE DISCOVERIES BEGIN

YM morphology

Though there are prononimal enclitics, many are vocalic and involve final vowel replacement, e.g. /ju^{3}βa^4/ 'father', /ju^{3}βa^{42}/ 'my father', /ju^{3}βõ^4/ 'your father', etc (Castillo García, 2007; Palancar et al., 2016).

The stem-final syllable is therefore often also the locus of additional morphological information.

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