Interactions of Tone and Phonation in Santiago Laxopa Zapotec

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Questions

- How does phonology interact with phonetics?
- How does tone and phonation interact at the phonetics-phonology interface?
- How does tone and phonation interact in Santiago Laxopa Zapotec?

1 Introduction

- The interaction of tone and phonation in the languages of the Americas is a relatively understudied topic.
- There are some studies such as
- This paper investigates how tone and phonation interact with each other and with the phonetics-phonology interface.
- This investigation uses Santiago Laxopa Zapotec to answer these questions.
- Santiago Laxopa Zapotec (SLZ) is a variety of Sierra Norte Zapotec, an Oto-Manguean language (Adler et al. 2018, Sichel & Toosarvandani 2020).
- SLZ is spoken by ~1200 people in the municipality of Santiago Laxopa, Oaxaca, Mexico with a small number of speakers in Oaxaca City, Mexico and Santa Cruz, CA.
- Similar to other Oto-Manguean languages, SLZ has both tone and phonation (Campbell, Kaufman & Smith-Stark 1986, Stolz & Stolz 2001, E. Campbell 2017, E. W. Campbell 2017).
- Data is drawn from elicitations conducted 2020-2021 with two native speakers of SLZ that live in the Santa Cruz, CA area.

2 Phonetics-Phonology Interface

- Kingston (2007) explains that there are three ways in which phonetics can interface with the phonology.
    1. Phonetics *defines* distinctive features
    2. Phonetics *explains* many phonological patterns
    3. Phonetics *implements* phonological representations.
- Using these three ways in which the phonetics interacts with the phonology, we can account for the ways that tone and phonation interact.

- We can *define* what the tones and phonation types are in SLZ.
  - This can be accomplished through frameworks such as Articulatory Phonology (Browman & Goldstein 1992) and Auditorism (Kingston & Randy L. Diehl 1994, 1995).
- We can *explain* what the tones and phonation types are in SLZ.
  - This can be done through discussing the physical, physiological, and/or psychological properties of speaking and listening.
  - For tones, this means discussing the f0 measures and perceived pitch
  - For phonation, this means discussing relevant acoustic measurements like spectral tilt and CPP (Garellek 2019).
- We can *implement* the phonological representations of tone and phonation types in SLZ.
  - This would be accomplished by discussing what the abstract abstract phonological categories are and what factors control how those categories are actually implemented within the phonetics.
- This paper will tackle the way *explaining* what the tones and phonation types are and how those phonological representations are *implemented.*
  - This will be accomplished by describing the acoustic measurements that correlate with the different phonation types.
  - Additionally, I will explain the different f0 measurements and how they correlate to the different tonemes of the language.

3 Phonemic Inventory

- This section lays out what is currently known about the vowel and tone inventories of Santiago Laxopa Zapotec based on fieldwork conducted by myself and other researchers at UCSC.

3.1 Vowels

- SLZ follows the majority of languages in exhibiting a basic five vowel inventory.

Table 1: SLZ Vowels

	front	central	back
high	i		u
mid	e		o
low		a	

- Like other Oto-Manguean langauages, SLZ can manipulate these five vowel categories by making them laryngeally-complex (Silverman 1997).
- This is accomplished through the addition of three different laryngeally-complex phonations, which are all contrastive as seen in the the near-minimal triple (1)
  - Breathy: [a̤] <*ah*>
  - Checked: [aˀ] <*a'*>
  - Laryngealized: [aˀa] <*a'a*>[1]

(1) Near-minimal triple
  a. *yah* [ja̤³] 'iron; rifle'
  b. *yu'* [çuˀ³] 'earth'
  c. *yu'u* [juˀu¹³] 'house'

- Each of these phonation types are associated with different configurations of the larynx (Esling et al. 2019).
- Breathy phonation is produced with an open supraglottic tube during the production of the vowel
- Checked phonation consists of modal phonation which is abruptly stopped which is associated with a glottal stop.[2]
- Laryngealized vowels in SLZ and other closely related varieties (Yalálag Zapotec) show a variable pronunciation ranging from a vowel that has a glottal stop interrupting the vowel to the use of creaky voice throughout the vowel or a portion.
- Table 2 shows the variable pronunciation of laryngealized vowels in Yalálag Zapotec, taken from Avelino (2010).

- In order to explain and define these vowels, I elicited tokens in carrier sentences and will conduct acoustic measurements on them. See §6 for more information.

[1]Previous descriptions of the the vowel system of closely related languages have used various different terms for this vowel including broken, rearticulated, interrupted, and creaky (Long & Cruz 2005, Avelino 2010, Avelino Becerra 2004, Sonnenschein 2005, Adler & Morimoto 2016). In order to avoid confusion, I will use the term laryngealized following Avelino (2010).

[2]There are two ways in which this vowel can be analyzed. One is the traditional way where the glottal stop is considered inseparable from the vowel. The other is to treat this as a consonant which is restricted to only reside in codas (similar to how the sound /ŋ/ is restricted to codas in English). This second approach is the one taken by Avelino Becerra (2004). I will follow the traditional way of analyzing these vowels through this paper.

Table 2: Layngealized Vowels in Yalálag Zapotec

/Vˀ V/	[VʔV]
	[VV̰V]
	[VV̰:V̆]
	[VV̰V̰]

3.2 Tone

- SLZ exhibits five different surface tonal patterns as shown in Table 3
  - Three level tones: H, M, and L (represented using Pike's numbers with 1 being the highest tone)
  - Two contours: MH and HL
- The number of tones were discovered doing a tonal analysis following the methods laid out in Pike (1948) and Snider (2018) by Maya Wax Cavallaro, Jack Duff, and myself from 2020-2021.

Table 3: SLZ tones

High	a^{1}	*xha*	[ʐ̩a^{1}]	'clothing.POSS'
Mid	a^{2}	*lhill*	[ɾi$ʒ^{2}$]	'house.POSS'
Low	a^{3}	*yu'*	[ɕu^{ʔ3}]	'earth'
Rising	a^{21}	*yu'u*	[juˀu^{21}]	'quicklime (sp. cal)'
Falling	a^{13}	*yu'u*	[juˀu^{13}]	'house'

- The exact nature of these tones will be one of the focuses of this paper.
- Additionally, I will be focusing on what the tone bearing unit is in SLZ.

4 Interaction of Tone and phonation

- The interaction of tone and phonation is a well-established fact and has been heavily studied in Asian tonal languages (see references in Yip 2002, Michaud 2012, Brunelle & Kirby 2016).
- In these languages it is common for certain phonation types to co-occur with certain tones.
  - Mandarian Tone 3 always co-occur with creaky voice (**duanmuPhonologyStandardChinese2007**).
- The interaction between tone and phonation in the languages of the America's has been studied but to a lesser extant than Asian languages (Adler & Morimoto 2016, Chávez-Peón 2010, DiCanio 2012).

- Chávez-Peón (2010) showed that the similar restrictions in tone and phonation co-occurrence appear in Quiaviní Zapotec but are at the same time much more free, see Table 4.

Table 4: SLQZ tone and phonation

	High	Low	Falling	Rising
Modal	✓	✓	✓	✓
Breathy	X	✓	✓	X
Creaky	✓	✓	✓	X
Interrupted	✓	✓	✓	X

- One of the unique aspects found here is the co-occurrance of creaky voice with a H-tone.
  - Creaky voice is frequently a by-product of low pitch but according to Esling et al. (2019) can also sometimes co-occur with high pitch.
- I am trying to determine to what extent tone and phonation interact in SLZ and based on that distribution make a hypothesis as to why certain tones and phonation types are allowed or disallowed from co-occurring.
- I will also hope to test Silverman's (1997) claim that tone and phonation are ordered during the production of the vowels.
  - Tone is found on the modal portion of the vowel.
  - Phonation occurs only in a portion of the vowel.

5 Methodology

- Two native speakers of SLZ (1 male and 1 female) were asked to perform two tasks:
  1. Word lists elicitation
  2. A narrative elicitation
- Word list elicitation consisted of approximately 200 words repeated three times each in a carrier sentence, 2.
- Consultants where recorded using a Zoom H4n audio recorder (44.1kHz and 16bit) and Zencastr, a professional podcasting service website.

(2) Carrier Sentence
sh-ni=a'^{13} _____ cho^{2}ne^{2} las^{2}
CONT-speak=1SG _____ three times
'I say _____ three times'

- Because carrier sentence elicitation is rather artificial an additional task was chosen to produce a more natural context.
- This was done by having consultants tell the story presented in a picture book called "Where are you, Frog?" (**mayerFrogWhereAre1969**).
  - Consultants were asked to tell the story in a textless picture book.
  - This allowed for a somewhat controlled vocabulary which will aid in analyzing the vowels for both tone and phonation.
- This task was also chosen in order to test the claims made by Garellek & Esposito (2021) that in narrative contexts the only acoustic measures that indicates different phonation types is CPP, a type of sound-to-noise ratio.

6 Next Steps

- Finish extracting tokens from word list elicitations
- Process audio for "Frog, Where are you?" from speaker f1 and m1
- Continue reading Esling et al. (2019) on Voice Quality
- Do more readings on the phonetic-phonology interface (Keating 1996, Zsiga 2020)

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Appendix

Consonant Inventory

- SLZ has approximately 27 consonants as shown in Table 5
- Like other Zapotecan languages consonants are divided between fortis and lenis (Nellis & Hollenbach 1980, Jaeger & Van Valin 1982, Uchihara & Pérez Báez 2016).
- Following Jaeger & Van Valin (1982) there are four reasons that we use fortis/lenis instead of voiceless/voiced in Zapotecan languages.
    1. Fortis obstruents are always voiceless, while lenis can be voiced, partially devoiced, or voiceless.
    2. Fortis stops and affricates aalways retain their stop closure, whereas lenis stops and affricates are often realized as fricatives.
    3. Fortis obstruents are usually of longer duration than lenis obstruents.
    4. Fortis and lenis sonorants are primarily distinguished by length, with fortis having a longer duration than lenis.
- The behavior that Jaeger & Van Valin (1982) described is illustrated in Table 6.
- This same behavior has been observed to some extent in SLZ and in other Sierra Norte varieties (Sonnenschein 2005).
    - It is quite common that lenis stops become their voiceless fricative counterpart word finall, e.g. *yag* [jax^{3}] ‘wood; tree’
- One explanation for this behavior has to do with morae.
- According to many authors the reason for this difference in behavior is because fortis consonants are inherently moraic (e.g., Chávez-Peón 2010, Uchihara & Pérez Báez 2016).

Table 5: SLZ Consonants

		bilabial	alveolar	retroflex	alveo-palatal	palatal	velar	labio-velar	uvular
nasal	lenis		n						
	fortis	mː	nː						
stop	lenis	b	d				g	g^w	
	fortis	p	t				k	k^w	
fricative	lenis		z	ʐ~ɭ	ʒ	ç			ʁ~χ
	fortis		s	ʂ	ʃ				
affricate	lenis		d͡z						
	fortis		t͡s		t͡ʃ				
lateral	lenis		l~ɾ						
	fortis		lː						
trill			r						
approximate						j		w	

Table 6: Allophones of some fortis and lenis obstruents in Yateé Zapotec

			Fortis				Lenis	
/t/	→	tˑ	initially	/d/	→	d, ɖ, ð, ð̠	initially
		tː	medially			d, ð	medially
		t^h	finally			ð̠, θ	finally
/t͡ʃ/	→	t͡ʃˑ	initially	/d͡ʒ/	→	d͡ʒ, ɖ͡ʒ̠, ʒ, ʒ̠	initially
		t͡ʃː	medially			d͡ʒ, ʒ	medially
		$\widehat{t\mathrm{ʃ}^h}$	finally			ɖ͡ʒ̠, ʒ̠, ʃ	finally

- Additional evidence for this comes from the behavior of vowels before fortis and lenis consonants (Arellanes 2009, Chávez-Peón 2010, Uchihara & Pérez Báez 2016).
  - Before fortis consonants vowels are short.
  - Before lenis consonants vowels are long.

(3) Lenis and fortis codas in Quiaviní Zapotec

Lenis		Fortis	
láːd	‘side’	látː	‘tin can’
táːn	‘Cayetana’	tasː	‘cup’