

Laryngeal Complexity in Santiago Laxopa Zapotec

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1 Introduction

- Most work on tonal languages has been based on descriptions of Southeast and Far East Asian languages.
- This has lead to strong claims being made about what is possible for languages that contain tone and phonation (Masica 1976, Thurgood 2002, Yip 2002, Enfield 2005, Michaud 2012, Brunelle & Kirby 2016).
- The main claim from many of these authors is that tone and phonation are codependent.
- An example for this type of co-occurrence between tone and phonation is Mandarin's Tone 3 which is frequently associated with creaky voice (Hockett 1947).
- This claim has also been made in the reverse.
 - Breathy voice stereotypically appears with high pitch and creaky voice stereotypically appears with low pitch (Esling et al. 2019).
- Research into Mesoamerican languages, however, shows that these claims are too strong or exaggerated (Suárez 1983, Campbell, Kaufman & Smith-Stark 1986, Silverman 1997, Di-Canio 2008, Esposito 2010, Campbell 2017a,b).
- Most languages of the Oto-Manguean language family exhibits independent tone and phonation (Silverman 1997, Blankenship 1997, 2002, Ariza-García 2018).
- This has lead some researchers to propose that tone and phonation is phased/ordered with respect to each other in what is termed the Laryngeal Complexity Hypothesis (Silverman 1997, Blankenship 1997, 2002).
- A summary of this proposal is discussed in Section 2.
- Using Santiago Laxopa Zapotec, an Otomanguean language spoken in Santiago Laxopa, Ixtlán, Oaxaca, Mexico, I show that:
 - There are clear ordering effects between the different phonation types.
 - * Laryngealized vowels have a modal phonation in the middle of the vowel
 - * Checked and breathy vowels have non-modal phonation at the end of the vowel
 - Using a Generalized Additive Mixed Model (Hastie & Tibshirani 1986, Wood 2017), I show that the Laryngeal Complexity Hypothesis correctly characterizes the interaction between tone and phonation in Santiago Laxopa Zapotec.

2 Laryngeal Complexity Hypothesis

- The Laryngeal Complexity Hypothesis (LCH) has its origin in work from Silverman (1997) and Blankenship (1997, 2002).
- The LCH claims that languages that have both tone and phonation need them to be phased/or-dered with respect to each other.
- This is required because it is assumed that the same mechanism for tone is also responsible for phonation.
 - Tone is the rate of vocal fold vibration.
 - Ladefoged (1971) and Gordon & Ladefoged (2001) argued that phonation exists on a single dimension ranging from opened vocal folds to closed vocal folds.
- The variation in how open or closed the vocal folds are correspond to whether or not the sound produced is breathy or creaky.
- Ladefoged (1971) and Gordon & Ladefoged (2001) summarized this assumption in the dia-gram found in Figure 1.

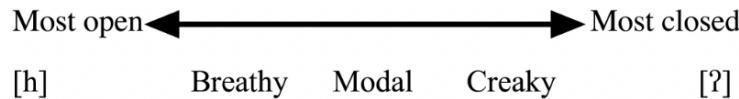


Figure 1: Simplified one-deminsional model for phonation. Based on Ladefoged (1971) and Gor-don & Ladefoged (2001)

- Because the same organ is responsible for these two different phenomena there is a mis-match in trying to produce both at the same time.
- The LCH assumes that there needs to be a strict ordering in the glottal gestures.
- If the gestures were overlapped there will be a perturbation of the tone and the listeners will not be able to reliably differentiate what the tone is.
- The LCH assumes that there is a close link between production and perception.
- This assumption places the responsibility on making sure the acoustic cues are the most perceptually salient on the speaker.
- In Figure 2, which is taken from DiCanio (2012), the cue for tone is represented by the Pitch Target and the Glottal Gesture represents the gestures needed to produce phonation.

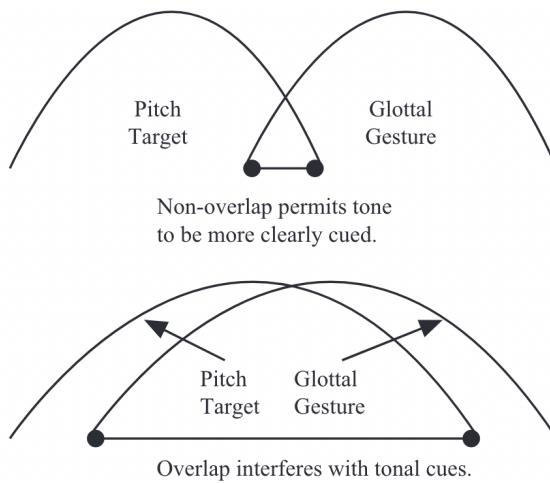


Figure 2: Representation taken from DiCanio (2012).

- DiCanio (2012) found that when the magnitude of coarticulation for glottal consonants occurs on the vowels there is a strong correlation between the magnitude of overlap and the amount of perturbation in the f0 signal. If, however, the degree of overlap was minor then the acoustic signal had little to no perturbation.
- Jalapa Mazatec is a language with both contrastive tone and phonation and Garellek & Keating (2011) validated the claims made by the LCH, in that tone and phonation seemed to be ordered with each other when it comes to at least one of the phonation types.

3 Santiago Laxopa Zapotec

- Santiago Laxopa Zapotec (SLZ), endonym *Dille’xhun Laxup*, is a Northern Zapotec language spoken by approximately 1000 people in the municipality of Santiago Laxopa, Ixtlán, Oaxaca, Mexico and in diaspora communities in Mexico and the United States (Adler & Morimoto 2016, Adler et al. 2018, Foley, Kalivoda & Toosarvandani 2018, Foley & Toosarvandani 2020).
- Closely related to San Bartolomé Zoogocho Zapotec (Long & Cruz 2005, Sonnenschein 2005) and shares a high level of mutual intelligibility with it.
- SLZ is similar to other Zapotecan languages in distinguishing lenis and fortis consonants (e.g., Nellis & Hollenbach 1980, Jaeger 1983, Uchihara & Pérez Báez 2016).
- SLZ has a standard five vowel inventory.
- These five vowels, additionally, appear with one of four different phonation types which will be discussed in greater detail in Section 3.2.

Table 1: Consonant inventory for Santiago Laxopa Zapotec

		bilabial	alveolar	post-alveolar	retroflex	palatal	velar	labio-velar	uvular
stop	lenis	b	d				g	g^w	
	fortis	p	t				k	k^w	
fricative	lenis		z	ʒ		ʐ			
	fortis		s	ʃ		ʂ	ç		
affricate	lenis		ðz						
	fortis		ts			tʃ			
nasal	lenis		n						
	fortis	m:	n:						
lateral	lenis		l						
	fortis		l:						
trill			r						
approximate								w	

Table 2: Vowel qualities in Santiago Laxopa Zapotec.

	front	central	back
high	i		u
mid	e		o
low		a	

3.1 Tone in Santiago Laxopa Zapotec

- Similar to other Otomanguean languages, SLZ is tonal (Suárez 1983, Campbell, Kaufman & Smith-Stark 1986, Silverman 1997, Campbell 2017a,b).
- SLZ has five distinct tonal patterns that appear on the syllables of nouns, see Table 3.

Table 3: Examples of the five tonal patterns observed in the Santiago Laxopa Zapotec words.

High	a ^H	xha	[zə ^H]	'clothing.POSS'
Mid	a ^M	lhill	[liz ^M]	'house.POSS'
Low	a ^L	yu'	[çu ^L]	'earth'
Rising	a ^{MH}	yu'u	[çu ^L u ^{MH}]	'quickslime (Sp. cal)'
Falling	a ^{HL}	yu'u	[çu ^L u ^{HL}]	'house'

- These five tonal patterns are illustrated in Figures 3 for one SLZ speakers.

- Figures 3 shows the five tonal contrasts averaged for each tonal contrast from the onset to ending of the vowel.
- The first 20-25% of Figures 3 can be ignored due to the influence of consonantal transitions.

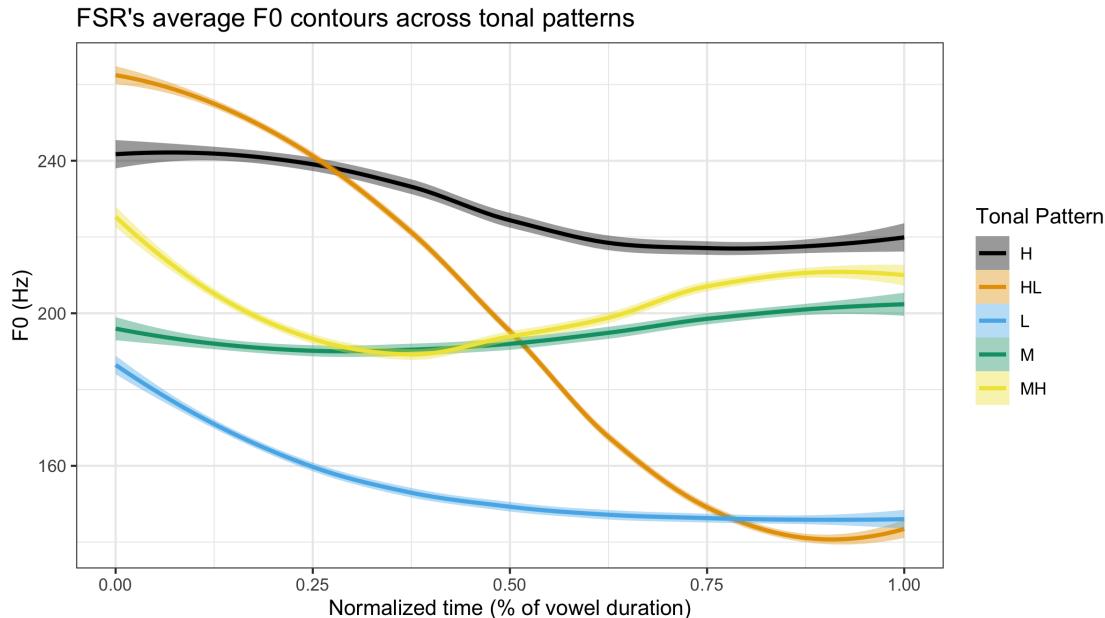


Figure 3: Tonal contrasts for FSR averaged and time normalized. Each line in this graph represents the average of approximately 10 syllables for each tonal pattern.

3.2 Phonation in Santiago Laxopa Zapotec

- Zapotecan languages commonly make use of contrastive phonation on vowels (e.g., Avelino 2004, Long & Cruz 2005, Avelino 2010, López Nicolás 2016, Chávez-Péon 2010).
 - SLZ is no different and has four contrastive phonation types: modal /a/, breathy /ã/, checked /a'/, and laryngealized /a''a/.
- (1) Four-way near minimal phonation contrast
 - a. *yag* [çag^L] ‘tree; wood; almúd (unit of measurement approximately 4kg)’
 - b. *yah* [çə^L] ‘metal; rifle; bell’
 - c. *cha'* [tʃa'^L] ‘a cooking pot’
 - d. *ya'a* [ça'a^L] ‘market’
 - Breathy phonation on vowels is characterized by a raspy quality throughout the whole vowel or a portion toward the end of the vowel, see Figure 4.

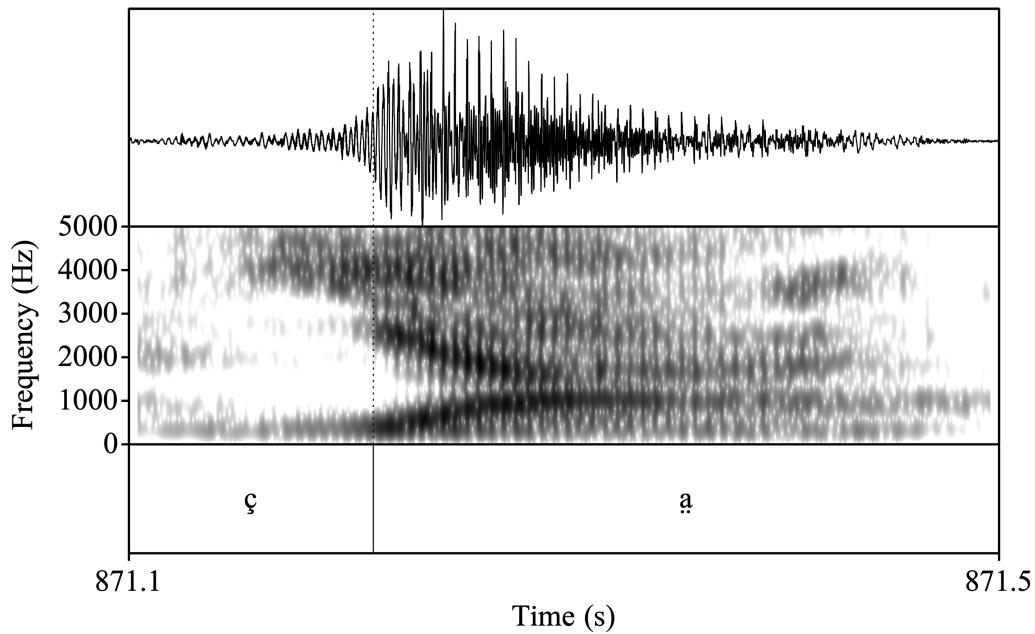


Figure 4: FSR's breathy vowel in the word *yah* 'metal; rifle'

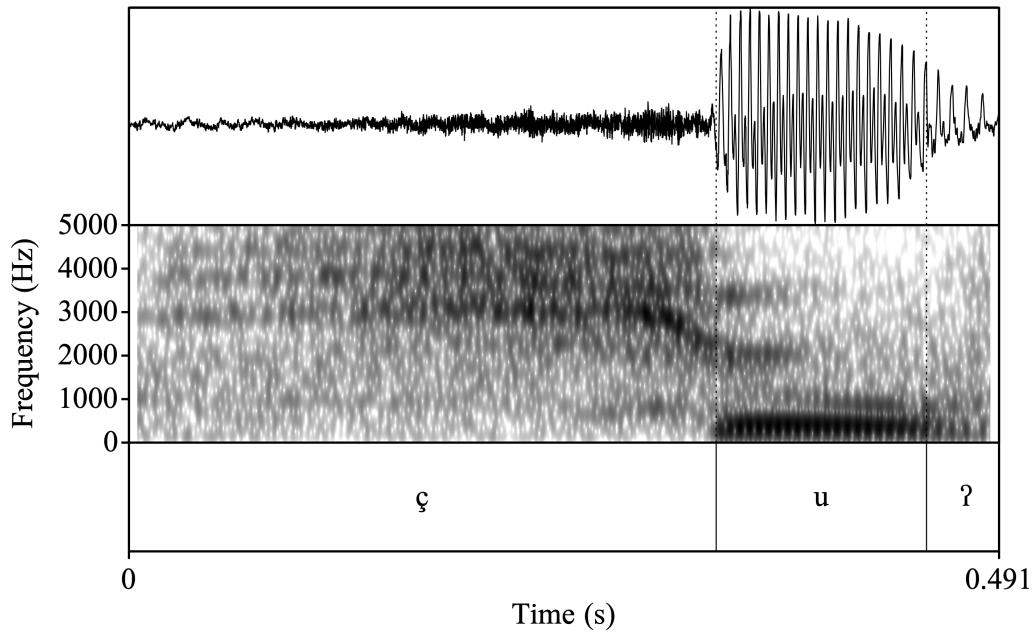


Figure 5: RD's checked vowel in the word *yu* 'earth'

- Checked vowels on the other hand are characterized by an abrupt glottal closure which cuts the vowel short. This phonation is sometimes only realized as a very short period of

creakiness at the end of the vowel, see Figure 5.

- Laryngealized vowels are quite common in Zapotecan languages and have received a wide number of different names.
- Previous descriptions have used terms such as broken, rearticulated, interrupted, and creaky (Long & Cruz 2005, Avelino 2004, 2010, Sonnenschein 2005, Adler & Morimoto 2016, Ariza-García 2018).
- In addition to a wide number of different names these vowels also exhibit a wide range of allophones.
- Avelino (2010) found in the closely related Yalálag Zapotec that among his consultants there were at least four different pronunciations as seen in Table 4.

Table 4: Laryngealized Vowels in Yalálag Zapotec

/V'V/	[V?V]
	[VV̚V]
	[VV̚:V̚]
	[VV̚V̚]

- In SLZ, this vowel is also highly variable.
- One consultant does rearticulation, where there is a full glottal stop in the middle of the vowel, or creaky voice.
- This alternation seemed to be in free variation but there was a greater tendency to creak in words with a L tone, such as *xa'ag* [ʂq:x] ‘topil’¹, see Figure 6 for a comparison between this consultant’s pronunciation of the laryngealized vowels.
- Another consultant only ever produces creaky voice for these vowels regardless of the tone with the word.

3.3 Interaction of tone and phonation in Santiago Laxopa Zapotec

4 Methodology

- 18 native language speakers of SLZ who live in Santiago Laxopa, Ixtlán, Oaxaca, Mexico took part in this study (7 male).

¹A topil is a type of government office in traditional Oaxacan communities somewhat akin to a sheriff.

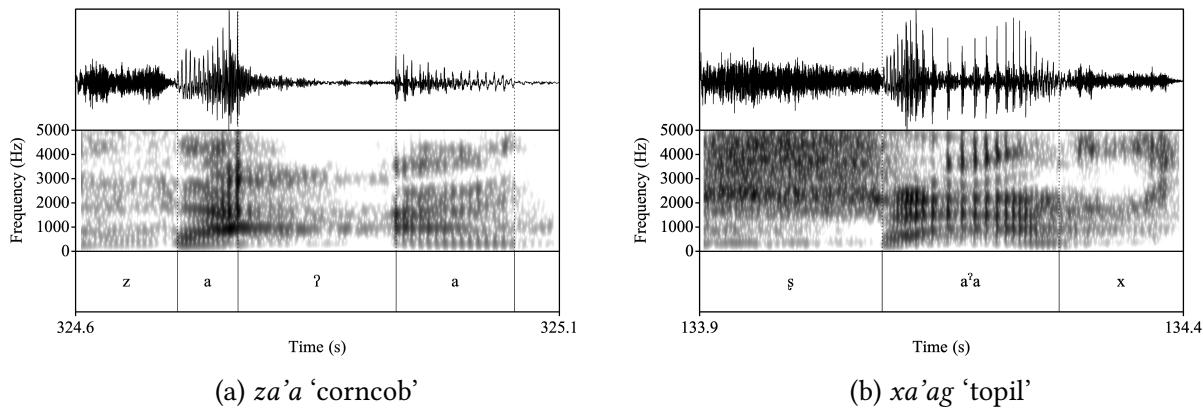


Figure 6: Comparison of FSR's laryngealized vowels in *za'a* 'corncob' and *xa'ag* 'topil'

Table 5: SLQZ tone and phonation interactions (Chávez-Péón 2010).

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

Table 6: Number of unique syllables for each interaction of tone and phonation in the data.

	Modal	Breathy	Checked	Laryngealized
High	✓	–	✓	✓
Mid	✓	✓	✓	✓
Low	✓	✓	✓	✓
High-Low	✓	✓	✓	✓
Mid-High	✓	✓	–	✓

- Because of the COVID-19 pandemic data collection was conducted remotely using Zencastr², a professional podcasting website, (44.1kHz, 16-bit) or in-person outside in a well ventilated location, using a Zoom H4n handheld recorder (44.1kHz, 16-bit).
- The speakers were asked to say 80 words that varied for phonation and tone three times in isolation and three times in the carrier phrase shnia' X chone las.

²<https://zencastr.com/>

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