Prosodic boundary marking in Ch'ol: Acoustic indicators and their applications

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Prosodic boundary marking in Ch'ol: Acoustic indicators and their applications*

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1. Introduction

The main aim of this paper is to examine word-level prosodic constituency in Ch'ol, both the acoustic manifestations of that constituency as well as their applications for research at the morphology-phonology interface. This work serves both to fascilitate future investigation into the prosody of Ch'ol and to explore the extent to which information regarding prosodic structure can inform our understanding of morphosyntactic structure.

As a first step, reliable acoustic correlates of prosodic structure must be determined on a language-specific basis. Vázquez Álvarez (2011) reports that Ch'ol sonorants are devoiced word-finally. This paper presents the results of an instrumental study of Ch'ol sonorants aiming to establish whether variation in voice quality is a reliable indicator of word-level boundaries in Ch'ol, and if so, whether the phenomenon exhibits differential behavior at the boundaries of different levels of the prosodic hierarchy and which acoustic parameters are used to signal this contrast. Next, we apply the acoustic correlates of word-level prosodic boundary to a study of the prosodic structure of morphologically complex verbs.

The bulk of this paper is organized around two instrumental studies. In Experiment 1, we use the acousitc measures of F0, intensity, and H1-H2 to argue that sonorants are glottalized via 'tense voice' in word-final position. In addition, we find preliminary evidence that word-final sonorants are especially creaky in phrase-final position, suggesting that this phenomenon is sensitive to the prosodic hierarchy.

In Experiment 2, the acoustic correlates of sonorant-final word boundaries in Ch'ol, which were established in Experiment 1, are used to investigate the prosodic structure of affixes and clitics in Ch'ol. We find no evidence of a prosodic word boundary separating affixes from the root, but we do find evidence that a prosodic word boundary separates clitics from the stem. Finally, we consider whether the plural marker *–ob* and the Set B

* Wolox awäläl to the Ch'ol speakers who made this study possible. Special thanks to Nicolás Arcos López and his family, Michael Becker, Ryan Bennett, Jessica Coon, Juan Jesús Vázquez Álvarez, Grace Kuo, Glyne Piggott, Lisa Travis, and Morelia Vázquez Martínez and her family. We would also like to acknowledge helpful feedback from the audiences at CILLA-VII, McGill Ling Tea, and SSILA 2016. This project was partially funded by SSHRC Insight Grant: "The mental representation of language variation: Macro- and micro-parameters", 2012–2015 awarded to Lisa Travis (PI) and Jessica Coon, as well as McGill's Arts Research Internship Award (ARIA), which was awarded to the first author.

markers *–oñ* and *–ety* behave more like affixes or clitics, prosodically speaking. This is of particular interest, because these morphemes exhibit mixed morphological behavior, which is to say that they pattern like affixes in some ways and like clitics in others. We find that prosodically they pattern like affixes.

Before turning to the specifics of Experiments 1 and 2 (Sections 3-4), we take a quick look at the claim that Ch'ol sonorants are devoiced word-finally (Section 2). We find no evidence of sonorant devoicing in the data we collected, although we share the impression reported in Vázquez Álvarez (2011) that sonorants in this position often sound devoiced. Of course, it is possible that the experimental setting effected participant speech, and now that some basic patterns have been established in a carefully controlled manner, a next step would be to verify our findings with naturally occuring speech.

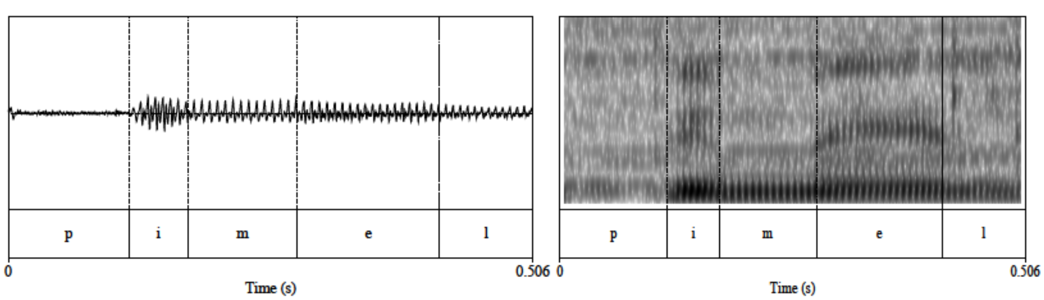
2. Sonorant devoicing

The literature describes three phonological processes that affect segments in word-final position: devoicing, deletion, and aspiration (Vázquez Álvarez 2011, Warkentin and Brend 1974, Bennett *to appear*). This section considers the first two of these processes, although we hope to consider word-final aspiration in future work.

Vázquez Álvarez (2011) reports that /b/ and /l/ can be deleted in word final position when the word is bi-syllabic. In these cases, /b/ is said to be replaced with a glottal stop /ʔ/. In our data, /b/ → /ʔ/ in some cases, and /b/ → Ø in other cases. We do not observe the deletion of /l/ in the data we collected, although we suspect that this is the result of the experimental setting.

Vázquez Álvarez (2011) also reports that /b/ and the sonorants /m, ñ, n/ and /l/ are devoiced in word-final position. Impressionistically, the nasals and the lateral consonant 'sound' devoiced in word-final position; however, no devoicing was observed instrumentally. Figure 1 provides the waveform and spectrogram of the same token of /l/ in word-final position.

Figure 1: *Waveform and spectrogram of pimel (name of plant)*



In Figure 1, the waveform remains periodic throughout the production of /l/ and the voicing bar is also visible for the entire duration of the segment.

To summarize, our preliminary investigation of phonological processes conditioned by the position of a segment in the phonological word confirms the existence of word-final /b/ deletion, but does not yield evidence of /b/ devoicing or devoicing of any word-final sonorant. As such, our preliminary investigation reveals a mismatch between impressionistic and instrumental findings. Experiment 1 seeks to determine the acoustic correlates associated with the perceived voicing contrast and place this phenomenon more precisely on the voice quality spectrum.

3. Experiment 1: Acoustic correlates of prosodic word boundaries

This experiment investigates the voice quality of word-medial, word-final phrase-medial, as well as word-final, phrase-final sonorants. We analyzed F0, intensity, and H1-H2 in order to elucidate the previously observed word-final process that was described as devoicing and instrumentally determine acoustic indicators of prosodic constituency. The experiment yielded evidence of word-final creaky voice that we suggest is most accurately classified as "tense voice" and preliminary evidence that this phenomenon is sensitive to prosodic structure above the level of the word.

3.1. Methodology

The data analyzed in Experiment 1 were collected for an earlier, unrelated study that investigated the prosodic structure of VSO and VOS clauses in Ch'ol (Clemens and Coon 2015). All participants of that study were native speakers of the Tila variety of Ch'ol and were recorded in Chiapas, Mexico. Participants were Ch'ol-Spanish bilingual and biliterate. Four participants completed the experiment, although, on account of apparent difficulty with the task, data from one participant was not analyzed.

Clemens and Coon (2015) recorded 44 target sentences: 22 VSO sentences with and without modified arguments (1a) and 22 VOS sentences with and without modified arguments (1b). Target sentences were normed by a native speaker before recording. The sentences are comprised of modified and unmodified arguments, as well as bi- and tri-syllabic words in order to mitigate any potential eurhythmic effects. Additionally, the stimuli contained sentence final adverbial phrases to prevent utterance-final prosodic effects on the verbal arguments.

(1) a.

Tyi	i-bä'ñ-ä	jiñi	(jujp'embä)	ñeñe'	ili	(chämeñ)	lukum	tyi	abälel.[1]
PRFV	A3-fear-TV	DET	fat	baby	DEM	dead	snake	PREP	night

"The (fat) baby feared the (dead) snake at night."

b.

Tyi	i-bä'ñ-ä	(chämeñ)	lukum	jiñi	(jujp'embä)	ñeñe'	tyi	abälel.
PRFV	A3-fear-TV	dead	snake	DET	fat	baby	PREP	night

"The (fat) baby feared the (dead) snake at night."

Sentences from Clemens and Coon (2015) were as sonorant rich as Ch'ol phonotactics allow with the hope of creating smooth pitch tracks that would aid in the interpretation of the tonal pattern of the sentences. While these data were not originally intended for the

[1] The abbreviations used in this paper include A—set A (ergative, possessive); AFFR—affirmative clitic; B—Set B (absolutive); CAUS—causative; CL—noun classifier; DET—determiner; DEM—demonstrative; DT—derived transitive; EP—epenthetic vowel; EXT—existential; IMFV—Imperfective aspect; ITV—intransitive verb suffix; NML—nominal suffix; PART—partitive suffix; PL—plural suffix; PARTPL—participant plural clitics, 1st person inclusive; PASV—passive; PREP—preposition; PRFV—perfective PROG—progressive aspect; RP—reportative; TV—Transitive verb suffix.

purposes of this experiment, they lent themselves well to the task at hand: to investigate the voice quality of sonorants in different prosodic positions.

In the original study, participants were asked to read the sentences as naturally as possible and without placing particular emphasis on any part of the sentence. Participants were told that they could repeat each sentence until they were satisfied with the result.

3.2. Data set

Although it has been reported that sonorants undergo a change in voice quality in word-final position in Ch'ol (Vázquez Álvarez 2011; Warkentin and Brend 1974), the acoustic parameters implicated in this process were hereto unknown. In this experiment, we investigate three indicators of nonmodal phonation: change in fundamental frequency (F0), change in intensity or amplitude, and change in the difference between the first and second harmonics (H1-H2) (Gordon and Ladefoged 2001, Ladefoged 2003). Because the recordings were made in the field and not the laboratory, they were not of high enough quality to facilitate the investigation of other useful measures, such as jitter.

We examined those sonorants described in Vázquez Álvarez (2011) as being devoiced word-finally, specifically the liquid /l/ and the nasals /m, ñ, n/.[2] The voiced stop /b/ was not included due to the tendency of /b/ to be deleted in this position (see Section 2). The glide /w/ was not examined due to its scarcity in the available data.

The segments of interest were examined in three prosodic environments:

(2) a. Word-medially (V_V)
    b. Word-finally, phrase-medially (V_#)
    c. Word-finally, phrase-finally (V_%)

Each word-final sonorant was coded as either (i) "phrase-medial," because it was in the final position of the word, but not the final position of the XP/φ-phrase or (ii) "phrase-final," because it occurred at the right edge of XP/φ-phrase in addition to being word-final. The way we coded the data reflects our assumption that syntactic and prosodic constituents align, at least to a large extent. However, adjective-final sonorants were coded as phrase-medial, because Clemens and Coon (2015) showed that they are produced in the same phonological phrase as the noun they modify. In contrast, noun-final sonorants were coded as phrase-final, because the subjects and objects in these sentences were produced in distinct prosodic constituents (Clemens and Coon 2015).[3] Example (3) illustrates how the data was coded: word-medial sonorants are shown underlined; word-final, phrase-medial sonorants shown in bold; word-final, phrase-final sonorants are shown in bold and precede %; utterance final sonorants were not considered.

[2] [n] is found in loan words and is an allophone of [ñ]

[3] More precisely, Clemens and Coon (2015) show that the subject and object in VSO clauses are produced in their own prosodic constituent, but objects in VOS clauses form a prosodic constituent with the verb. This is not an important distinction for the present study, because none of the verbs end in sonorants and the object is always in the right-most position of its phrase. In other words, the object is phrase final whether or not it is pronounced in the same prosodic phrase as the verb or alone.

(3) Tyi ich'ili k'umbä bu'u**l%** jiñi p'ump'u**ñ** uma' tyi k'iñijel.
PRFV A3-fry-TV soft beans DET poor mute PREP party
"The poor mute fried soft beans at the party."

As example (3) makes clear, different sonorants in the same prosodic environment do not necessarily occur in the same local phonological environment. For example, /m/ surfaces before a voiced stop (vd) in *k'umbä* 'soft' and before a vowel in *uma'* 'mute.' For each prosodic position, the range of local phonological environments – including pre-glottal stop [ʔ] and pre-voiceless consonants (vls) – is summarized in Table 1.

Table 1: *Local phonological environment*

Word-medial	Word-final, Phrase-medial	Word-final, Phrase-final
V_V	V_# ʔV	V_% ʔV
V_vd	V_# vd	V_% vd
	V_# vls	V_% vls

We did not maintain these divisions in our statistical analysis, because it became clear that any coarticulatory effects (especially in the case of phrase-medial stops) were not going to interfere with the emergence of overarching prosodic patterns.

Table 2 summarizes the makeup of our data set. Certain issues arose which resulted in the removal of some data points. Mainly these included recordings that happened to be compromised during the relevant timeframe, for instance by an animal noise.

Table 2: *Data set*

Segment	Word-medial	Word-final, phrase-medial	Word-final, phrase-final
/l/	77	11	32
/m/	47	5	46
/ñ/	36	20	0
/n/	0	0	11
Total	*n*=160	*n*=36	*n*=89

The data were first annotated via the Prosodylab-Aligner (Gorman et al 2011) and later fine-tuned by hand using Praat (Boersma and Weenink 2015). The relevant segments were then analyzed with VoiceSauce (Shue 2010). For this study, of the possible algorithms available in VoiceSauce, STRAIGHT was used to determine F0, the Snack Package was used to determine the formants, and the corrected harmonic values were used to determine H1-H2. H1-H2 is the measure in decibels of the first harmonic minus the second harmonic.

Voice quality does not manifest as a single universal acoustic parameter, but involves a bundle of acoustic information, which varies across languages. However, we chose to look for a decrease in F0, intensity, and H1-H2, because they are cross-linguistically reliable indicators of nonmodal phonation (Gordon and Ladefoged 2001).

3.3. Results

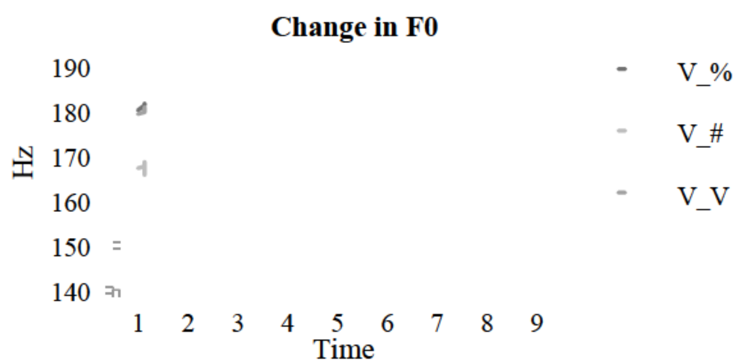
The examination of sonorant voice quality yielded evidence of non-modal phonation word-finally, but not word-medially. There was an observable decrease in F0 for the word-final, phrase medial condition. Additionally, there was a significant decrease in intensity observed for both word-final conditions. A three-way contrast was observed in H1-H2. For this parameter, word-medial sonorants did not exhibit a change, while a decrease was observed for both word final conditions: Word-final, phrase-final H1-H2 decreased significantly more than word-final, phrase-medial H1-H2.

3.3.1. F0

Sonorants in word-final, phrase-medial condition (V_#) were produced at 165.1 Hz on average, as compared to 180.48 Hz for sonorants in word-medial position (V_V) and 190.04 Hz for sonorants in word-final, phrase-final position (V_%). The difference in F0 for these conditions was trending, but did not reach significance.

In Figure 2 below, the change in Hz is time normalized for each condition: the *x*-axis shows nine equidistant points in time for each segment. For the word-final phrase-final sonorants, there is a slight rise in F0 towards the end of the segment. This is also the case for word internal segments. However, the word-final, phrase-medial segments exhibit a slight decrease in F0 over time.

Figure 2: *Time normalized change in F0 (Hz) across segment*



Instead of patterning like the other word-final sonorants, the word-final, phrase-final sonorants behave more like word-medial sonorants for this measure. We believe that this somewhat surprising finding is due to the fact that phrase level prosodic constituents are realized with a final high boundary tone (H%) that would affect the Hz on phrase-final sonorants, as well as the rest of the phrase-final word (see Clemens and Coon 2015). We will discuss this result in more detail in Section 3.4.

A Likelihood Ratio Test was used to test the statistical significance of this pattern. A linear regression mixed model was created with the *lme4* package (Bates, Maechler & Bolker, 2012) in R (R Core Team 2015) to compare the main effect of F0 with the main effect of position. It contained one random intercept, speaker, and two random slopes, position and segment (/l,m,ñ, n/), as in (4).

(4) pitch ~ position + (1+position+segment|speaker)

The resulting model was compared to a null model using an ANOVA. The pattern did not reach significance ($p > 0.05$). These results were not separated by gender due to the limited number of speakers available for this study.

3.3.2. Intensity

Moving to intensity, we see a decrease in the two word-final conditions, as is illustrated in Figure 3. Sonorants in word-final, phrase-medial condition (V_#) were produced at 0.81 dB on average, as compared to 1.49 dB for sonorants in word-medial position (V_V) and 0.79 dB for sonorants in word-final, phrase-final position (V_%). We also see a decrease in intensity over time across the two word-final conditions, but not the word-medial condition.

As in Figure 2, Figure 3 shows the time-normalized change in dB for each condition: the *x*-axis shows intensity of the segment at nine equidistant points in time.

Figure 3: *Time normalized change in Intensity (dB) across segment*

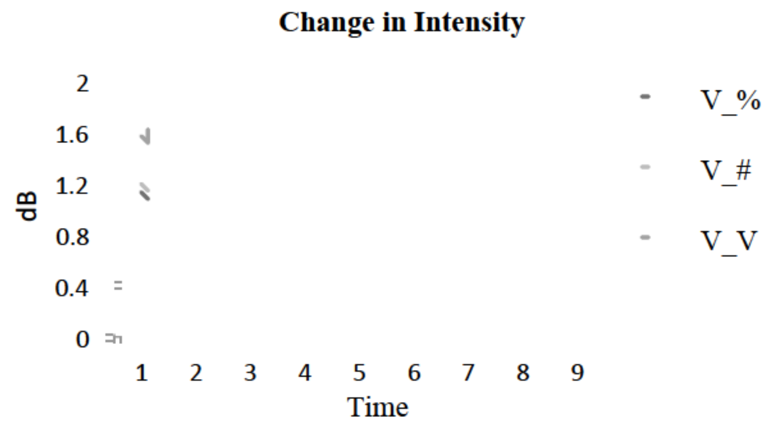
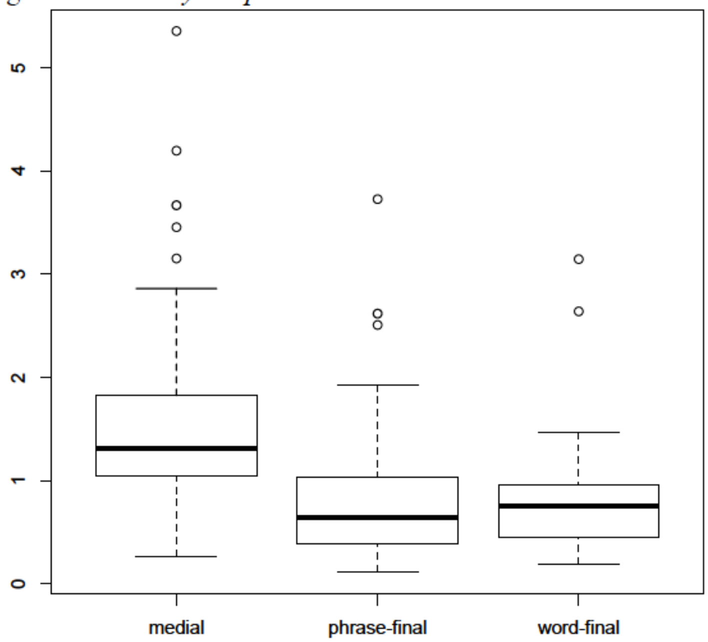


Figure 4 shows a boxplot that was generated using the mean dB value for each segment. Between the two word-final positions, there is nearly complete overlap for this measure. However, there is no overlap between the word-medial and word-final positions.

Figure 4: *Intensity boxplot*



This difference was statistically significant ($p < 0.001$) according to a Likelihood Ratio Test which compared the following model (5) and null model using an ANOVA

(5) intensity ~ position + (1+position+segment|speaker)

3.3.2. H1-H2

Next, we see a three-way contrast in harmonic structure as measured by H1-H2. The graph below illustrates change in H1-H2 over time. Sonorants in word-medial position (V_V) were produced with a steady H1-H2 of 8.02 dB, on average. Sonorants in word-final, phrase-medial position (V_#) were produced with an average H1-H2 of 5.66 dB, that showed a decrease of 1.64 dB over time. For sonorants in word-final, phrase-final position (V_%), we also see a decrease of 2.34 dB over time, but a lower average H1-H2 value of 4.09 dB

Figure 5: *Time normalized change in H1-H2 (dB)* across segment

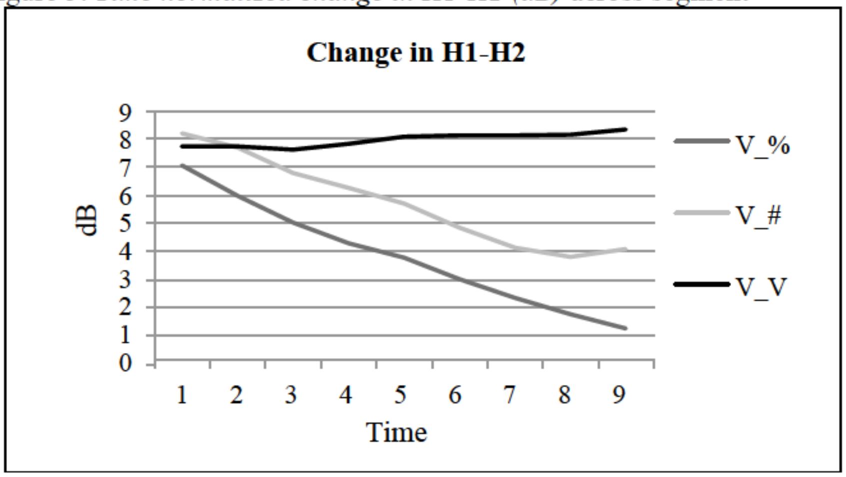
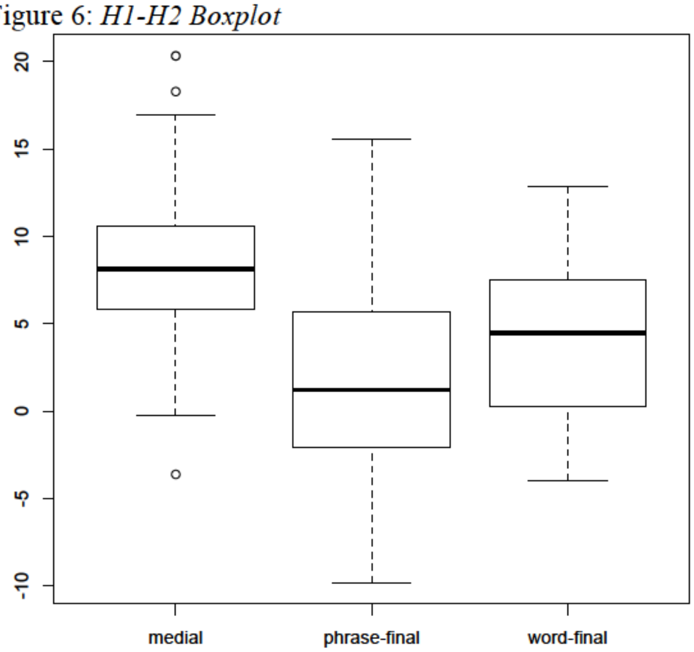


Figure 6 shows a boxplot representing the mean H1-H2 from the final portion of the segment, where the contrast is most apparent.

Figure 6: *H1-H2 Boxplot*



For this measure, partial overlap between both word-final positions is observed. The above variation was statistically significant ($p < 0.001$) according to a Likelihood Ratio Test that used the model in (6) and the null model:

(6) H1H2 ~ position + (1+position+segment|speaker)

Further Likelihood Ratio Tests were used with the existing models to compare the variation on a position by position basis. This yielded a significant difference ($p < 0.001$) between both word-final positions when compared separate from the word-medial position data, despite partial overlap. This also yielded a significant difference ($p < 0.005$) between the word-final, phrase-final position and the word-medial position, when compared separately from the word-final, phrase-medial data. When comparing word-medial and word-final, phrase-medial positions, the null model failed to converge and the following reduced models were used:

(7) H1H2 ~ position + (1+position|speaker)

This comparison also generated a significant result ($p < 0.001$). The only difference between the original and reduced model is that the reduced version lacks a random slope for type of segment.

3.3.4. Summary of results

In word-medial position, no decrease in F0, intensity, or H1-H2 was found. In word-final-position, phrase-final position we found (i) a trending but non-significant decrease in F0, (ii) a significant decrease in intensity and (iii) a significant decrease in H1-H2. In word-final phrase-final position we found (i) no decrease in F0, presumably because of a competing high boundary tone, (ii) a significant decrease in intensity, and (iii) a significant decrease in H1-H2. While there was no meaningful difference in the decrease in intensity between the two word-final conditions, there was a significant difference in decrease of H1-H2: H1-H2 values were lower at the edge of the higher-level prosodic constituent, i.e. in phrase-final position.

Table 3 provides a summary of the results. An ✗ indicates no evidence of the given measure at the specified position where a ✔ indicates evidence. The ✔✔ indicates that word-final, phrase-final sonorants displayed particularly low H1-H2 values.

Table 3: *Summary of results*

Cue	Word-medial	Word-final, phrase-medial	Word-final, phrase-final
Decreased F0	✗	✔ ($p > 0.05$)	✗
Decreased intensity	✗	✔ ($p < 0.001$)	✔ ($p < 0.001$)
Decreased H1-H2	✗	✔ ($p < 0.001$)	✔✔ ($p < 0.001$)

3.4. Discussion

Our data demonstrate that F0, intensity and H1-H2 decrease during the production of sonorants at word-boundaries, but not word-internally. We take this fact to indicate that sonorants are realized with a type of nonmodal phonation in word-final position. We believe that this particular nonmodal phonation is best characterized as "tense voice," which is a type of creaky voice (Keating and Garallek 2015; Keating, Garellek, and Kreiman 2015). This section considers this classification in greater depth, as well as the effect of position in the phonological phrase.

3.4.1. Classification of the phenomenon

Decreases in F0, intensity, and H1-H2 are all indicative of nonmodal phonation (Gordon and Ladefoged 2001). Modal phonation is the most efficient mode of voicing, so intensity and F0 decrease in nonmodal phonation as efficiency is lost (Ladefoged 2003). Beyond indicating nonmodal phonation, H1-H2 is specifically indicative of glottalization or 'creak,' because the glottal pulses during creaky phonation are very short and the glottis closes very quickly contributing greater energy to the higher frequencies (Ladefoged 2003).

Although low H1-H2 has been cited by many as an indicator of creaky voice (e.g., see Gordon and Ladefoged 2001 and Keating and Esposito 2006), the presence of decreased H1-H2 in our data probably does not independently constitute sufficient evidence to classify this phenomenon as creak. Furthermore, the fact that F0 increases in places where H1-H2 decreases, as is the case for the word-final, phrase-final condition, is indicative of a phonation unlike the most prototypical creaky voice. Thus, additional research is necessary before we can confidently place this phenomenon on the spectrum of nonmodal phonation.

Nonetheless, we strongly suspect that this phenomenon is best classified as a type of creaky voice known as "tense voice" (Keating and Garallek 2015; Keating, Garellek, and Kreiman 2015). Attributes of tense voice are shown in (8):

(8) a. Varied F0
    b. Possible decrease in intensity
    c. Low H1-H2
    d. No visible glottal pulses

F0 is not the most useful indicator of tense voice, because as (a) suggests, it is found with a variety of F0 patterns. With respect to (b) and (c), our data are clearly consistent with a decrease in intensity and (relatively) low H1-H2. It is interesting to note that glottalization in Yucatec Maya is most consistently indicated by a decrease in intensity (Frazier 2009). Finally, as exemplified by Figure 1, there are no visible glottal pulses in the vast majority of word-final sonorants in our data. Thus, we believe that sonorants in Ch'ol are produced with tense voice in word-final position.

3.4.2. Prosodic hierarchy

Part of the initial motivation for undertaking this study was to determine whether the change in voice quality in word-final position would vary according to position in the phonological phrase. In other words, we wanted to know whether the phenomenon was sensitive to the prosodic hierarchy, which minimally includes the positions above the level of the word as shown in Figure 7.

Figure 7: *Prosodic hierarchy*

Intonational phrase (ι-phrase*)*

|

Phonological phrase (φ-phrase)

|

Prosodic word (prosodic-ω)

While we believe that we have provided clear evidence the right edge of the prosodic-ω conditions nonmodal phonation in Ch'ol sonorants, it is less clear whether there is a substantive difference between the nonmodal phonation found at the prosodic-ω boundary as compared to the φ-phrase boundary.

In terms of intensity, we found no difference between the word-final, phrase-medial and word-final, phrase-final conditions. However, in terms of H1-H2, which is arguably the most reliable acoustic correlate of creaky voice, we found a significant difference between the two word-final conditions. Recall that sonorants in word-final, phrase-medial position were realized with an average H1-H2 of 5.66 dB and showed a decrease of 1.64 dB over the course of the segment, while sonorants in word-final, phrase-final position were realized with a lower average H1-H2 value of 4.09 dB and a greater decrease of 2.34 dB over time.

Taken at face value, the overall lower H1-H2 value of prosodic-ω boundaries that coincide with φ-phrase boundaries suggests that this process displays gradient sensitivity to different levels of the prosodic hierarchy. However, as shown in Figure 6, there is a good deal of overlap between the two word-final conditions. As such, we would like to be careful about overinterpreting this result. On one hand, it could be the case that relative creakiness is a genuine indicator of prosodic structure above the level of the word. It is also possible that the difference between word-final, phrase-medial and word-final, phrase-final position is instead the result of an independent phonetic factor that we have not controlled for, such as consonant duration.

So, while we have found preliminary evidence suggesting that creaky voice in Ch'ol sonorants at prosodic-ω boundaries is sensitive to higher levels of prosodic constituency, we acknowledge that future work ought to explore this question in more depth. Similarly, while our data suggest that the nonmodal phonation of Ch'ol sonorants in word-final position is best categorized as creaky voice, and more specifically, tense voice, additional acoustic and articulatory work would be undertaken. What is clear is that there exists a word-final phonological process in Ch'ol affecting sonorants, in which F0, intensity, and H1-H2 decrease in predictable ways. Having established these language specific acoustic correlates of word-level prosodic constituency, we turn to the prosodic status of affixes and clitics in Ch'ol in Experiment 2.

4. Experiment 2: Prosodic structure of affixes and clitics

Experiment 2 uses the acoustic measures for word boundaries established in Experiment 1 to investigate the prosodic structure of affixes and clitics in Ch'ol, as well as to determine whether certain morphemes with mixed morphological behavior pattern more like affixes or like clitics, prosodically speaking. The complete data set has yet to be analyzed, and as such, the results reported in this proceedings paper are preliminary. Still, clear patterns emerge: based primarily on the results from intensity, the root and its affixes are realized as a single prosodic-ω, whereas clitics are separated from the stem by a prosodic-ω boundary. The dependent morphemes of mixed morphological status behave prosodically like affixes, which is to say there is no evidence of a prosodic-ω separating them from the root.

4.1. Ch'ol Affixes and Clitics

Ch'ol is a language with a rich morphological system that includes many more affixes and clitics than we are going to discuss here. This section provides a brief introduction to the affixes and clitics that are the focus of Experiment 2.

4.1.1 Affixes

Of the morphemes we investigated, the stative suffix *–Vl* and the nominal suffix *–el* fit squarely into the affix category. This section provides an overview of the phonological and morphological reasons for classifying these morphemes as affixes.

As shown in (9), the stative suffix *–Vl* (in bold) surfaces directly next to the root:

(9)	Buch-**ul**-ety	tyi	k-tyaj-a-y-ety	(Coon *to appear b*)
	Seated-STAT-B2	PRFV	A1-find-TV-EP-B2	
	'I found you (while you were) seated'			

The stative suffix, which is used to form an intransitive stative stem behaves like an affix in many ways. First, its vowel (V) is harmonic with the root vowel, which provides initial evidence of its place within the domain of the same phonological word as the root, as we assume, following Nespor and Vogel (2007), that harmonic phenomena does not cross phonological word boundaries.

Moving from phonology to morphology, the stative suffix shows a high level of selectivity in regard to its host: it only attaches to transitive and positional roots. Selectivity is one of the primary ways to distinguish affixes and clitics (Zwicky and Pullum 1983), as affixes are more selective than clitics. Finally, the stative suffix cannot attach to a stem that already contains a clitic, which is another important diagnostic established by Zwicky and Pullum (1983).

The suffix *–el* is involved in nominalizations in Ch'ol. The suffix *-el* is found on a wide range of nominal forms in Ch'ol, as well as on intransitive stems in the non-perfective aspects. We follow Coon (2010a, 2013) in considering the form of these instransitive stems to involve nominalizations and gloss the suffix consistently as -NML, though nothing critical hinges on this decision.[4] In (10a), *–el* (shown in bold) attaches to intransitive verb roots to form a nonfinite/nominalized verb. When *–el* attaches to adjective or nominal roots the result is often an alienable or abstract noun, as in (10b).

(10) a. Yariuj=ix mi i-sajty-**el** kixtyañuj.
every.day-already IMFV A3-die-NML people
'Every day people die.'

b. y-i'ik'-**el** (Vázquez Álvarez 2011)
A3-soft-NML
'Its blackness'

Nominalizing suffixes of this sort are common throughout the Mayan family. Although nominalizing *–el* is arguably less selective than stative *–Vl*, we confidently classify *–el* as an affix, because it is clearly derivational, can attach directly to the root, and cannot attach to a stem containing a clitic (see also Bricker 1981).

4.1.2 Clitics

Of the morphemes we investigated, participant plural *la* (inclusive) and *lo(jo)ñ* (exclusive) and the aspectual and modal/evidential second position clitics fit squarely into the clitic category. This section explains that classification.

The participant plural clitic *la* is used to pluralize second person and first person inclusive. First person exclusive is denoted by *lo(jo)ñ*. As shown in (11), these clitics can attach to the right or left of the stem.[5]

(11) a. K-lumal-Ø=tyo=**la**
A1-town-B3-still-PARTPL
'It is still our (inclusive) town'

b. **La**=k-lumal-Ø=tyo (Vázquez Álvarez 2011)
PARTPL- A1-town-B3-still
'It is still our (inclusive) town'

The participant plural clitics must attach to the predicate stem, but they can attach to predicates from any lexical category. In (11), *la* attaches to a nominal predicate and example (12) gives an example with a verbal predicate.

[4] Other authors distinguish between *–el* the nominal suffix that gives a certain abstract quality to the nouns and adjectives it attaches to and *–el* the nonfinite marker that attaches to certain intransitive verb roots (e.g., see Gutiérrez Sanchez 2004, Vázquez Álvarez 2011, 2014).

[5] The longer form *–lojoñ* cannot act as a proclitic but the shorter form can (Vázquez Álvarez 2011).

(12) Mu=ch=bi i-tyä'l-añ-oñ=**la** (Vázquez Álvarez 2011)
IMPRFV=AFFR=REP A3-bother-DT-B1=PARTPL
'Yes, it is said that it bothers us.'

Unlike the affixes discussed in the previous section, the participant plural markers attach to stems that already include other clitics, like the second position *=tyo* 'still' in (11a). Following Zwicky and Pullum (1983), we assume that clitics, but not affixes, can attach to other clitics.

The second position clitics are less selective than the participant plural clitics in that they attach to whatever element comes first within the TP/IP domain – usually an aspectual auxiliary or predicate (13a). These clitics cannot attach to fronted constituents such as *wh*-words or topicalized constituents, which are presumably in the domain of CP, which is why it is important to specify that they surface in the second position of the TP/IP, and not necessarily the second position of the utterance (Coon *to appear b*). In (13b) the aspectual clitic *=ix* attaches to the imperfective aspectual auxiliary *muk',* which is subsequently realized as *mux,* instead of the first element in the CP domain, which is topicalized *jiñi wiñik.*

(13) a. Añ=äch=**ix** juñ-kojty wa'li
EXT=AFF=already one-CL now
'Now there's already one (animal).'

b. Jiñi wiñik mu=**x** i-majl-el tyi cholel (Coon *to appear b*)
DET man IMFV=already A3-go-NOM PREP field
'He's going to the field already.'

All of the second position clitics can attach to a stem that already includes another clitic, as exemplified by *=ix,* which attaches to the affirmative second position clitic *=äch* in (13a). However, there are restrictions on the order in which certain second position clitics can combine. For example, the aspectual clitics *=ix* 'already' and *=tyo* 'still', can only attach to the affirmative second position clitic *=äch*. The modal/evidential second position clitics stack more freely (Vázquez Álvarez 2011).

4.1.3 Mixed-status morphemes

Finally, we would like to point out that a few bound morphemes in Ch'ol exhibit mixed morphological behavior, which we will refer to as mixed-status morphemes, that makes them difficult to categorize as either a clitic or an affix.

First, the plural *–ob* is traditionally included among Ch'ol suffixes (e.g., see Vázquez Álvarez 2011). However, it is not quite as selective as the affixes discussed in Section 4.1.1. Plural *–ob* can attach to either the plural argument or its selecting predicate, or it can simultaneously appear on both the argument and the predicate, as shown in (14):

(14) Tyi k-il-ä-y-**ob** jiñi wiñik-**ob** (Vázquez Álvarez 2011)
PRFV A1-see-TV-PL DET man-PL
'I saw the men.'

The plural suffix *–ob* can also appear before or after the partitive *–tyak*, as shown in (15):

(15) a. aläl-**ob**-tyak
child-PL-PART
'Some of the children'

b. aläl-tyak-**ob** (Coon *to appear b*)
child-PART-PL
'Some of the children'

We take the fact that *-ob* can occur in either order to further indicate a somewhat lessened degree of selectivity.

Next, we turn to Ch'ol's Set B markers, *–oñ* (1st person) and *–ety* (2nd person), which are considered to be affixes by most researchers (cf. Coon *to appear b*). However, like *–ob,* Set B markers exhibit mixed morphophonological behavior with respect to the affix-clitic continuum. On one hand, they comply with affix criterion that states that affixes do not attach to clitics. On the other hand, their distribution is reminiscent of the =la/=loñ participant plural clitics discussed in the previous section: Set B markers attach to aspectual auxiliaries as in (16a), verb stems as in (16b), and nominal predicates (16c).

(16) a. Muk'-**oñ** tyi wäy-el
IMFV-B1 PREP sleep-NOM
'I sleep.'

b. Tyi wäy-i-y-**oñ** (Coon 2010)
PRFV sleep-ITV-EP-B1
'I slept.'

c. X-'ixik-**oñ** (Coon *to appear b*)
CL-woman-B1
'I am a woman'

Based on the transcriptions of Vázquez Álvarez (2011), the Set B markers pattern with affixes with respect to stress assignment. Lexical stress falls on the final syllable of Ch'ol words, as shown in (17):

(17) a. Buch-ˈul
seat-STAT
'S/he is seated'

b. Buch-ul-ˈoñ
seat-STAT-B2
'We are seated'

When clitics are added to the stem, Vázquez Álvarez (2011) reports that primary stress falls on the final clitic, but secondary stress is retained on the last syllable of the stem, as shown in (18).

(18) a. Buch-ˌul=tyo=ˈku
seat-STAT=still=AFFR
'yes, s/he is still seated'

b. buch-ul-ˌoñ=tyo=ku=ˈla
seat-STAT-B2=still=AFFR=PLINC
'yes, we are still seated'

Section 4.5 recasts this description of stress slightly, but what is crucial for the present discussion is that the Set B markers behave like affixes with respect to stress and not like clitics.

Historically, the Set B markers were clitics (Kaufman and Norman 1984), but today the morphological status of Set B markers varies across the family (see Coon *to appear a* and references therein for an overview of the status of Set B markers for individual Mayan languages). Further complicating the issue, for some languages, including Ch'ol, Set B markers are analyzed as affixes by some (Kaufman and Norman 1984; Vázquez Álvarez 2011) and as clitics by others (Coon *to appear b*).

Set B markers bare a close resemblance to the language's free standing pronouns, which Coon (*to appear b*) takes to support an analysis where Set B markers are D^0 elements that move out of the DP in order to cliticize to the verb. However, the Set B markers and the free-standing pronouns might also be similar if the former were historically clitics that were eventually reanalyzed as affixes (Kaufman and Norman 1984; Kaufman 1990).

Perhaps the strongest evidence in support of Coon's (*to appear b)* D^0-clitic analysis comes from the fact that a phonological word boundary separates the Set B markers from its host. The argument is based on allophonic variation in the status suffix for derived transitives, which surfaces as –äñ word-internally (19a), and as –añ word-finally (16b).

(19) a. Tyi wäy-is-**äñ**-ty-i
PRFV sleep-CAUS-DT-PASV-ITV
'He was made to sleep.'

b. Mi k-wäy-is-**añ** ñeñe' (Coon *to appear b*)
IMPF 1ERG-sleep-CAUS-DT baby
'I made the baby sleep.'

Notably, this status suffix surfaces as *–añ*, its word-final form, before second position clitics, such as *=ix* 'already' (20a) and before the Set B marker, as shown in (20b):

(20) a. Wäy-is-**añ**=ix
sleep-CAUS-DT=already
'Make him sleep already!"

b. Mi k-wäy-is-**añ**=ety (Coon *to appear b*)
IMPF 1ERG-sleep-CAUS-DT=2ABS
'Make him sleep already!"

In this case, the Set B marker clearly patterns with clitics as opposed to affixes. The fact that the Set B markers trigger the 'word-final' allomorph of the status suffix for derived transitives provides morphophonological evidence that there is a prosodic word boundary between the Set B marker and its host, which we would not expect if the Set B markers were affixes. Thus, Coon (*to appear b*) raises serious doubt about the viability of earlier analyses, which treated Ch'ol's Set B markers as affixes.

In sum, the morphemes classified here as mixed-status – the Set B markers and the plural marker *–ob* – simultaneously exhibit characteristics of canonical affixes and clitics. These morphemes show a lower level of selectivity compared to other affixes in Ch'ol, but cannot attach to material containing clitics. In the case of the Set B markers, the phonological evidence also points in different directions: on one hand, they behave like affixes with respect to lexical stress; on the other hand, they behave like clitics with respect to conditioning the *–añ* allomorph of the derived transitive status suffix.

Our hope is that Experiment 2 will provide prosodic evidence to aid in the classification of these mixed-status morphemes, with the understanding that it is often – but not necessarily – true that we can expect a perfect correlation between the prosodic and syntactic behavior of individual morphemes with respect to the distinction between affixes and clitics (see Bennett and Henderson 2014; Bennett et al. 2015 for a syntax-prosody mismatch of this sort in Kaqchikel). We return to this issue in Section 5.

4.2. Methodology

Six participants completed the experiment, three men and three women between the ages of 18 and 40. Five participants speak the Tila variety of Ch'ol and one speaks the Tumbalá variety. All participants are Ch'ol-Spanish bilingual and biliterate. Participants were recorded in Chiapas.

We constructed a list with 56 target words and phrases, 27 of which are discussed in this paper. Of those 27, 9 target words are bare *l*-final roots (21), 7 target words are *l*-final roots preceding an affix (22), 6 are *l*-final roots preceding a clitic (23), and 5 are *l*-final roots preceding a dependent morpheme of mixed morphological status (24).

(21) bare *l*-final roots
a. ch'**il**
'fry'

b. bu'u**l**
'beans'

(22) *l*-final roots preceding an affix

a. Stative suffix –*Vl*
mu**l**-ul
wet-ST

b. Nomanilizing suffix –*el*
kuñ**l**-el
soft-NML

(23) *l*-final roots preceding a clitic

a. 2nd position clitic –*ix* 'already'
choñko**l**=ix
PROG=already

b. 2nd position clitic –*tyo* 'still'
laja**l**=tyo
same=still

(24) *l*-final roots preceding a morpheme of mixed morphological behavior

a. Pl marker –*ob*
alä**l**-ob
child-PL

b. Set B marker –*oñ*
tso**l**-oñ
put.in.line-B1

This study focused on /l/, because of the relatively high frequency of /l/ in word-final position. Target words were normed by a native speaker before recording.

The data used for this experiment was collected by way of a reading task. Each target item was recorded in isolation and in the carrier phrase *tyi kälä* ____ *ak'bi* or 'I said ____ yesterday'. Participants were told that they could repeat each word and sentence until they were satisfied with the result.

4.3. Acoustic analysis

The results presented here represent the target words that were prodcued in a carrier phrase. Moreover, disfluent sentences were removed before analysis along with all tokens that were otherwise unusable due to animal noises or other background interference.

The previous experiment found decreases in pitch, intensity, and H1-H2 at word boundaries both phrase-medially and phrase-finally. For experiment 1, the results pertaining to intensity and H1-H2 were particularly robust, so these acoustic measures are the focus of experiment 2.

The acoustic analysis undertaken in Experiment 2 closely resembles that of Experiment 1. The segments were annotated in Praat and then analyzed using VoiceSauce according to the same specifications. The Straight algorithm was used to determine F0, Snack Package was used to determine the formants, and the corrected harmonic values were used for H1-H2.

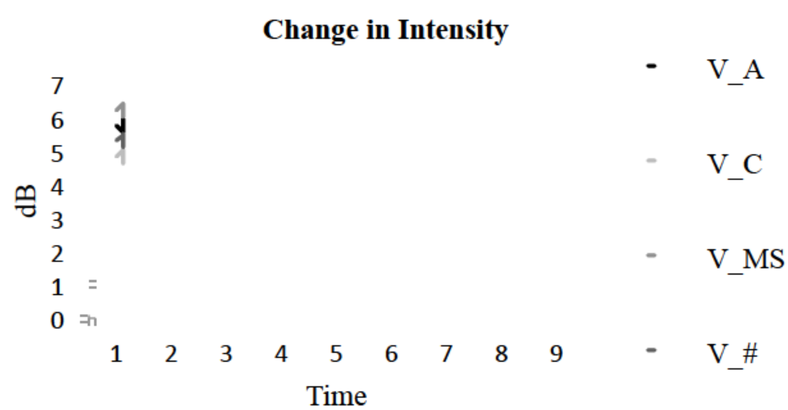
4.4. Results

4.4.1. Intensity

Beginning with intensity, we see a decrease in word-final condition and the clitic condition, as is illustrated in Figure 8. In word-final position (V_#, *n*=51), /l/ was produced at 4.7 dB on average, as compared to 4.62 dB when /l/ preceded a clitic (V_C, *n*=50). In contrast, /l/ was produced at an average of 5.77 dB when it preceded an affix (V_A, *n*=47) and 6.24 dB when it preceded a mixed-status morpheme (V_MS, *n*=42). Figure 8 also shows a 34.46% decrease in intensity over time when /l/ is word final and a 33.30% decrease over time when /l/ precedes a clitic. In comparison, the intensity of /l/ stays relatively steady in the other two conditions: it increases by 4.42% when it precedes an affix, and it increases by 1% when it precedes a mixed-status morpheme.

Figure 8 shows the time-normalized change in dB for each condition: the *x*-axis shows intensity of the segment at nine equidistant points in time.

Figure 8: *Time normalized change in Intensity (dB) across /l/*



As in the previous experiment, Likelihood Ratio Tests were conducted which compared a model with a null model using an ANOVA. The models were as follows:

(25) intensity ~ morpheme + (1+morpheme|speaker)

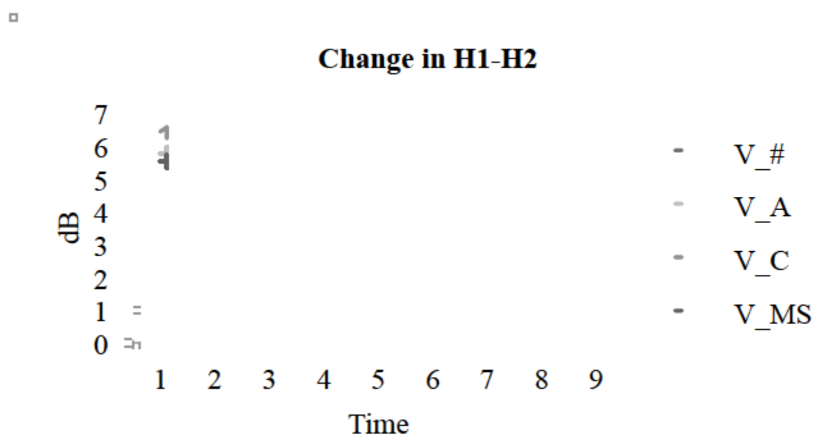
These models are linear regression mixed models which have a random intercept, speaker, and random slope, morpheme. Morpheme in this case refers to the type of morpheme following the /l/; affix, clitic, etc. The individual data points used were the means referring to the end portion of each segment, where the most divergence is seen.

There is no statistically significant difference in the intensity of /l/ in word-final as compared to stem-final position, i.e. before a clitic. In addition, the difference between the intensity of /l/ before an affix as compared to a mixed-status morpheme is also not significant. However, the intensity at which /l/ is produced in word- and stem-final position is significantly lower ($p < 0.001$) than it is in root-final position, i.e. before an affix.

4.4.2. H1-H2

The data we have analyzed from Experiment 2 has not yielded any meaningful patterns with respect to H1-H2, which is steady across all conditions, as shown below:

Figure 9: *Time normalized change in H1-H2 across /l/*



We think it is likely that the carrier phrase *tyi kälä* ____ *ak'bi* or 'I said ____ yesterday' prompted speakers to produce the target items emphatically. This could explain why the intensity of the target words in Experiment 2 are particularly high. High levels of intensity can obscure the relationship of high H2 relative to H1 (Ladefoged 2003). We are therefore suspicious that the design of Experiment 2 prevented us from observing any decrease in H1-H2 in (at least) word-final position, as we clearly saw in Experiment 1. It is also possible that the target items produced in isolation will shed light on this problem.

4.4.3 Summary of the results

The investigation into the prosodic structure of affixes and clitics in Ch'ol yielded evidence suggesting that a prosodic word boundary separates clitics from their host, but that affixes and mixed-status morphemes are part of the same phonological word as the root. A significant decrease in intensity was observed word-finally and before clitics, but there was no decrease for this measure before mixed status morphemes or affixes. Although no pattern in H1-H2 emerged within the data, we believe that this was an artifact of experimental design. The next section discusses these findings in greater depth.

4.5. Discussion

H1-H2 did not vary by condition in Experiment 2, but intensity decreased significantly word-finally and stem-finally before clitics, while it remained steady before affixes. Because intensity decreases at the right edge of the prosodic word and because we find no decrease in intensity at the edge of the root preceding an affix, we propose that together the root and the affix form a single prosodic word (*ω*). Evidence supporting this analysis comes from the fact that lexical stress in Ch'ol is word-final, and stress shifts as additional affixes are added (Vázquez Álvarez 2011).

In contrast to affixes, the decrease in intensity before clitics provides evidence that a prosodic-*ω* boundary delimits the stem from clitics. There are two questions to answer before we can provide an analysis for the prosodic structure of clitics. The first question pertains to the size of the clitic: is the clitic a prosodic-*ω* or something smaller, such as a syllable (σ)? Ch'ol, like many Mayan languages has a minimal word requirement of CVC. Whether all Ch'ol roots are underlyingly CVC or a glottal stop is epenthesized into initial position as a repair strategy is a matter of debate (e.g., see Bennett to appear, Coon to appear, and Vázquez Álvarez 2011). Either way, clitics do not meet this minimal word requirement, which suggests that they are smaller than a prosodic-*ω*.

The second question pertains to the status of the node that dominates the clitic and its host: does the clitic attach to a maximal prosodic-*ω*, as in (26a), or does it attach directly to the prosodic phrase (*φ*), as in (26b)?

(26) a. *ω* b. *φ*

ω′ σ *ω*′ σ
stem clitic stem clitic

Unfortunately it is not possible to offer a definitive answer at this time, because for all of the examples we have analyzed thus far, the clitic coincides with the right-edge of what we independently know to be a φ-phrase. Relatedly, the acoustic correlates of stress in Ch'ol have not been established, the domain(s) of stress assignment appear to be rather complicated, and the literature lacks a study dedicated to stress in Ch'ol.

Vázquez Álvarez (2011) reports that clitics in final position bare primary stress, while the final syllable of the host bares secondary stress, as shown in (27).

(27) Buch-ˌul=ˈku. (Vázquez Álvarez 2011: 16b)
seated-STAT-AFFR
'Yes, s/he is seated.'

Evidence that the primary stress on the affirmative clitic *ku* is actually assigned at the phrasal level comes from the fact that *ku* loses stress in yes-no questions, where its stress shifts to the initial syllable, as in (28). Because the 'stress' found on the clitic is sensitive to utterance type, its domain must be higher than the prosodic word.

(28) ˈBuch-ˌul=ku? (Vázquez Álvarez 2011: 17b)
seated-STAT-AFFR
'Is it true that s/he is seated?'

Therefore, we believe that what Vázquez Álvarez (2011) refers to as primary and secondary stress are two distinct phenomena targeting different levels of the prosodic hierarchy. The 'secondary stress' in (27-28) that is found on the clitic's host, is likely lexical stress. In contrast, the 'primary stress' in (27) is likely a phrase-level phenomenon, confirming what Vázquez Álvarez (2011) seems to suspect.

Based on Vázquez Álvarez's (2011) transcription of stress, it would seem as though the clitic attaches directly to a φ-phrase, as in (26b). We would also like to consider the possibility that what is represented as primary stress in (27) is actually an instantiation of the high boundary tone observed by Clemens and Coon (2015), which demarcated φ-phrases in their data as well many ι-phrases. The right edges of the relevant clitics coincide with the right edges of ι-phrases in all of the examples in Vázquez Álvarez (2011) and either φ-phrases or ι-phrases in Experiment 2.

In order to investigate the possibility that the primary 'stress' in (27) is actually a high boundary tone, we need to investigate the acoustic properites of these examples in phrase-medial postion, for example in VO clauses with bare objects (see Clemens and Coon 2015). If, in fact, the primary 'stress' in (27) is actually a H%, we predict that the only stressed syllable on verbs that host clitics in phrase-medial position would occur on the final syllable of the clitic's host. If this were true, it would indicate that the correct analysis of the prosodic structure of clitics and their hosts is actually the one shown in (26a), where the clitic attaches to a maximal prosodic-ω.

Turning to the mixed-status morphemes, there is no indication of prosodic-ω demarcating them from the stem. Because intensity decreases at the right edge of prosodic word and because we find no decrease in intensity at the edge of the root preceding the mixed-status morphemes, these dependent morphemes are internal to the stem's prosodic word (ω). For the prosodic boundary-ω diagnostic, the mixed-status morphemes – the plural marker and the Set B markers – pattern like affixes.

For now, it seems as though these dependent morphemes exhibit mixed prosodic as well as mixed morphological behavior, at least in the case of the Set B markers. On one hand, they behave like affixes with respect to prosodic boundary marking and stress assignment, suggesting that they are internal to the prosodic-ω. At the same time, they trigger the word-final allomorph of the derived transitive status suffix, suggesting that they are external to the prosodic-ω. We suspect that the answer lies in the timing of vocabulary insertion as compared to prosodic structure assignment, but will leave this question for future work.

5. Conclusions

Two instrumental experiments were conducted for the purpose of investigating Ch'ol prosodic constituency. In Experiment 1, sonorants were observed in three conditions: i) word-medially ii) word-finally, phrase medially iii) word-finally, phrase finally. The acoustic parameters of F0, intensity, and H1-H2 were analyzed in order to instrumentally examine the word-final process previously described as devoicing. All measures exhibited word-final decreases, with decreases in intensity and H1-H2 being statistically significant ($p<.001$).

We interpret these results as being indicative of word-final glottalization, and based on the typology of creaky voice found in Keating and Garallek (2015) and Keating, Garellek, and Kreiman (2015), we suggest that this phenomenon be further classified as 'tense voice'. Sonorants in word-final position were produced with 'tense voice' in both phrase-medial and phrase-final position with evidence from H1-H2 lending cursory support to the analysis that this process is sensitive to the prosodic hierarchy.

Thus, Ch'ol is one of the many languages that uses different kinds of glottalization to indicate prosodic constituency. Markó (2012) looks at its use in Hungarian in cases of vowel hiatus and found the level of glottalization to be most prevalent across word boundaries. As cited in that work, glottalization has been found to indicate phrase boundaries in Swedish (Fant and Kruckenburg 1989) as well as Serbian, Finish, and Croatian (Lehiste 1965).

More specialized research will confirm or challenge our initial classification of the glottalization we observed, but either way, Experiment 1 provides reliable and language-specific acoustic measures which help us identify prosodic boundaries and understand prosodic constituency in Ch'ol. This is expressly important in Experiment 2, but also to the endeavor of understanding Ch'ol prosody going forward. As is true across the Mayan family, Ch'ol has a consonant inventory that lacks voiced stops, affricates, and fricatives, but includes phonemic and epenthesized glottal stops and ejective stops and affricates. This renders intonation difficult to analyze for this language. Acoustic indicators of prosodic phrasing that do not rely on intonation, such as intensity and changes in harmonic structure are therefore valuable to the overall study of Ch'ol prosody.

Experiment 2 used intensity and H1-H2 to compare the sonorant /l/ in four positions: i) root finally before affixes ii) stem finally before clitics iii) before dependent morphemes of mixed status iv) word-finally. The Set B and plural markers were classified as 'mixed-status,' because morphologically speaking, they exhibit behavior prototypical of both Ch'ol affixes and clitics.

We found that intensity decreased before clitics and word-finally, but remained relatively constant before affixes and mixed-status morphemes. We interpreted a decrease in intensity before a dependent morpheme boundary to be indicative of a prosodic-ω boundary. As such, the lack of decrease in intensity before affixes in Ch'ol demonstrates that the root and its affix form a single prosodic word. In contrast, we found evidence for the existence of a prosodic-ω boundary between the clitic and its host. We also presented an independent argument that the clitic itself is smaller than a prosodic-ω. However, additional data must be gathered before we can firmly establish whether the clitic attaches to a maximal prosodic-ω or directly to the φ-phrase.

7. References

Bates, D., Maechler, M., Bolker, B., & Walker, S. 2015. _lmer4: Linear Mixed-Effects Models using Eigen and S4_. R package version 1.1-9,<URL: http://CRAN.R-project.org/package=lme4>.

Bennett, R. to appear. Mayan phonology. *Language and Linguistic Compass.*

Bennett, R., 2014. Mayan phonology. Ms. Yale University. ——, & Henderson R., 2014. The prosodic structure of inflection in Kaqchikel (Mayan). Paper presented at Workshop on the Sound Systems of Mexico and Central America.

Bennett, R., Harizanov B. & Henderson R. "Prosodic smothering in Macedonian and Kaqchikel". At Linguistic Inquiry.

Boersma, P. & Weenink, D. 2015. Praat: doing phonetics by computer [Computer program]. Version 5.3.63, retrieved 24 January 2014 from http://www.praat.org.

Clemens, L. & Coon, J. 2015. Deriving Mayan V1: A Fresh Look at Chol. Presented at the Society for the Study of the Indigenous Languages of the Americas (SSILA), Portland, Oregon.

Coon, J. 2010. Rethinking split ergativity in Chol. *International Journal of American Linguistics* 76:207–253.

Coon, J. 2013. *Aspects of split ergativity*. New York: Oxford University Press, Studies in Comparative Syntax.

Coon, J. to appear a. Little-v agreement and templatic morphology in Chol. *Syntax*.

Coon, J. to appear b. Ch'ol. *The Mayan Languages*, (eds.) Judith Aissen, Nora England, and Roberto Zavala. London: Routledge.

Fant, G. & Kruckenberg, A. 1989. Preliminaries to the study of Swedish prose reading and reading style. *Speech Transmission Laboratory Quarterly Progress and Status Report 30/2*. Stockholm: Royal Institute of Technology. 1–80.

Frazier, M. 2009. The production and perception of pitch and glottalization in Yucatec Maya: University of North Carolina at Chapel Hill dissertation.

Gordon, M. & Ladefoged, P. 2001. Phonation types: a cross-linguistic overview, *Journal of Phonetics,* 29,383-406.

Gorman, K., Howell, J., & Wagner, M. (2011). Prosodylab-Aligner: A tool for forced Alignment of Laboratory Speech. *Canadian Acoustics*. 39.3. 192-193.

Gutiérrez Sánchez, P. 2004. *Las clases de verbos intransitivos y el alineamiento agentivo en el chol de Tila, Chiapas.* Tesis de Maestría, Maestría en Lingüística Indoamericana. CIESAS, México.

Kaufman, T. & Norman W. M. 1984. An outline of proto-Cholan phonology, morphology, and vocabulary. In Phoneticism in Mayan hieroglyphic writing, ed. John S. Justeson and Lyle Campbell, 77–166. Albany, NY: Institute for Mesoamerican Studies, State University of New York

Kaufman, T. 1990. Algunos rasgos estructurales de los idiomas mayances con referencia especial al K'iche'. In Lecturas sobre la lingüística maya, ed. by Nora England & Stephen R. Elliot, 59–114. Antigua: CIRMA.

Keating, P. A. & Esposito, C.M. 2006. Linguistic Voice Quality. *Proc. 11th Australasion International Conference on Speech Science and Technology.*

Keating, P. & M. Garellek. (2015). Acoustic analysis of creaky voice. Poster, LSA, Portland, OR.

Keating, P., M. Garellek, & J. Kreiman. 2015. Acoustic properties of different kinds of creaky voice. In The Scottish Consortium for ICPhS 2015 (Ed.), *Proceedings of the 18th International Congress of Phonetic Sciences.* Glasgow, UK: the University of Glasgow.

Ladefoged, P. 2003. *Phonetic Analysis: An Introduction to Fieldwork and Instrumental Techniques.* Blackwell Publishing.

Lehiste, I. 1965. Juncture. In: Proceedings of the 5th International Congress of Phonetic Sciences, Münster 1964. New York: S. Karger. 172–200.

Markó, A. 2012. Boundary marking in Hungarian V(#)V clusters with special regard to the role of irregular phonation. The Phonetician 01/2012, 105-106(I-II):7-26.

Nespor, M. & Vogel, I. 2007. *Prosodic Phonology.* (eds.) Harry Van der Hulst, Jan Koster, Henk van Riemsdijk. Berlin. Mouton de Gruyter.

R Core Team. 2015. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL http://www.R-project.org/.

Vázquez Álvarez, J. J. 2011. A grammar of Chol, a Mayan language. Doctoral Dissertation, University of Texas Austin, Austin, TX.

Vázquez Álvarez, J. J. 2013. *Dos tipos de cláusulas no finitas en chol*. In Enrique

Palancar and Roberto Zavala (ed.), Estudios sintácticos en lenguas de Mesoamérica, pp. 305-338, México: CIESAS.

Warkentin, V. & Ruth B. 1974. Chol phonology. *Linguistis* 12(132). 87–102.

Y.-L. Shue. 2010. The voice source in speech production: Data, analysis and models. Doctoral Dissertation, University of California, Los Angeles.

Zwicky, A. and Pullum, G. 1983. Cliticization vs. Inflection: English N'T. *Language,* Vol. 59, No. 3 (Sep., 1983), 502-513.