Prosodic Boundary Marking in Ch'ol:

Acoustic Indicators and Their Applications

An Undergraduate Honors Thesis by Cora Lesure

Supervised by:

Prof. Jessica Coon (McGill)

Prof. Lauren Clemens (SUNY Albany)

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Abbreviations

A	Set A (ergative, possessive)
ABST	Abstract suffix
AFFR	Affirmative clitic
B	Set B (absolutive)
CL	Noun classifier
DET	Determiner
EP	Epenthetic vowel
IMFV	Imperfective aspect
NF	Non-finite suffix
PART	Partitive suffix
PL	Plural suffix
PARTPL	Participant plural clitics, 1st person inclusive
PREP	Preposition
PROG	Progressive aspect
SP	Spanish borrowing
TV	Transitive verb suffix

Introduction: Outline of This Thesis

For many of the world's languages, the only option for in-depth study is entering into a very remote location, and listening critically through loud and uncontrollable noises. This poses problems for any theoretical or descriptive endeavor. However, the domain of prosody particularly suffers due to its reliance on acoustic data. Prosodic research requires a level of control that is most easily attained in a laboratory setting. For Ch'ol and many languages, that is simply not possible, and subsequently this domain remains relatively understudied.

The present study is designed to facilitate future efforts in the description of Ch'ol prosody, as well as demonstrate a possible application of foundational prosodic work. This is done by examining the morphology-phonology interface and using the relationship discovered therein to address an outstanding question about Ch'ol structure. Specifically I will be addressing the classification of Ch'ol affixes and clitics. The classifications of these morphemes have previously been motivated solely by morphological evidence. Moreover, certain morphemes exhibit conflicting morphological characteristics.

For example, Set B morphemes were historically cliticized pronouns but are now classified as suffixes in the Cholan branch (Vázquez Álavarez 2011). Still they exhibit mixed behavior morphologically in that they show a lower degree of selectivity compared to other Ch'ol affixes. By examining prosodic characteristics in this context we are able to examine the motivation behind the existing classification using different criteria.

This thesis will take the following form. First, section one situates the discussion within the Ch'ol ethnolinguistic context and provides pertinent background information related to Ch'ol phonology. The analysis begins in Section 2, where I draw on the work of Clemens and Coon (2015). Building off of their analysis of prosodic phrasing in Ch'ol, which used intonation and duration based data, I conduct an experiment in order to establish language specific acoustic correlates of prosodic phrasing. Based off of the existing literature and a preliminary investigation, the experiment centers on an analysis of voice quality. Statistical testing yields two significant decreases word finally, decreased intensity and decreased H1-H2. There was a significantly greater decrease in H1-H2 at word boundaries that occurred phrase finally. These I analyze as indicators of word and phrase final non-modal voicing which I will call creak.

In Section 3, I use this along with the theory of prosodic structure outlined in Nespor and Vogel (2007) to investigate potential morphology-phonology isomorphism in Ch'ol at the level of the phonological word. The level of the phonological word is the point in the prosodic hierarchy at which the phonological and morphological components of the grammar interact (Nespor and Vogel 2007). Moreover, the phonological word is never larger than the terminus of the syntactic component. Therefore clitics should always fall outside of the domain of the phonological word and affixes should always fall within this domain. I employ the established word boundary indicators to investigate morphologically complex constructions containing a subset of the Ch'ol inventory of affixes and clitics. By

determining the location of word boundaries with respect to these morphemes, I subsequently determine their status as affixes or clitics.

Finally, statistically significant decreases in intensity were observed before clitics and word finally. Decreases were not observed before affixes of any kind, including Set B morphemes. I argue that prosodic evidence is in support of the existing classifications of the affixes and clitics examined. Despite ambiguous morphological behavior, the Set B morphemes demonstrate unambiguous membership within the domain of the phonological word. There is clear isomorphism between the morphological and phonological component in Ch'ol in that affixes are consistently contained within the domain of the phonological word and clitics are consistently outside of this domain. Section 4 of this paper provides a summary of my overall findings, my final conclusions, and the implications of this research for future work on Ch'ol.

1: Introducing Ch'ol

'Ili kty'añ lejojax tyi alol,

Kty'añ kambäl ip'ätyälel,

Ty'äñ ka'bäl isujmlel

Che'mik chaleñ ty'añ mik k'äyiñ.'

Mi lenguaje es extraño,

Mi lenguaje es embrujo,

Mi lenguaje es policromado

Porque al hablar canto.

- *Soy,* from *Ipusik'al Matye'lum (Corazón de Selva)*

by Juana Karen.

1.1 Ch'ol: The Ethnolinguistic Context

Ch'ol or Chol, as it is also written,[1] is one of roughly 30 Mayan languages still spoken in Mesoamerica. Most speakers can be found in Chiapas, Mexico but there are scattered communities living in the states of Tabasco and Campeche as well. In Chiapas, most speakers reside in the municipalities of Palenque, Sabanilla, Salto de Agua, Tila, and Tumbalá. Census data demonstrates migration of some Ch'ol speakers, mainly bilingual teachers, to the larger cities of Tuxtla Gutiérrez and San Cristobal de Las Casas as well (Vázquez Álvarez 2011).

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[1] Ch'ol is the official name of the language used in government statistics and therefore I will use that name throughout this work.

[2] Whether or not Ch'ol roots are all underlying CVC or there is a process that merely requires them

According to census data from the Mexican National Institute of Statistics, Geography and Computing, in 2010 there were approximately 212,117 native Ch'ol speakers living in Mexico (INEGI 2015). This is an increase of about 14.5% from 2005, and if the population continued to increase at around that rate it follows that today there are approximately 243,000 Ch'ol speakers.

Ch'ol, within the Mayan language family, is a member of the Greater Tseltalan branch of languages. Within this branch it is a member of the Cholan group, specifically the Western Cholan subgroup which it shares with Chontal (Vázquez Álvarez 2011). Within the Ch'ol language there are two main dialects, Tila and Tumbalá (Vázquez Álvarez 2011).

1.2: Ch'ol Phonology at a Glance

In this section I outline the key phonological processes pertinent to the following investigations. First, the orthography used throughout this work to write Ch'ol, seen in (1) below, is the same alphabet employed in Vázquez Álvarez (2011). This is the system made official in 2010 by the Instituto Nacional de Lenguas Indígenas.

(1) "a, b, ch, ch', e, i, j, k, k', l, m, n, ñ, o, p, p', r, s, t, ts, ts', ty, ty', u, w, x, y, ä, -"

This practical orthography corresponds directly to the phoneme inventory and very closely to the IPA. The Ch'ol phoneme inventory includes 21 consonants and 6 vowels, summarized in the following tables from Vázquez Álvarez (2011).

Table (1): Ch'ol Consonant Inventory

	Bilabial	Alveolar	Palatal	Velar	Glottal
Occlusive	b p p'		ty [tʲ] ty' [tʲ']	k k'	' [ʔ]
Fricatives		s	x [ʃ]	j [x]	
Affricates		ts [ts] ts' [ts']	ch [tʃ] ch' [tʃ']		
Nasals	m		ñ [ɲ]		
Lateral		l			
Trill		r			
Glides	w		y [j]		

Table (2): Ch'ol Vowel Inventory

	Front	Central	Back
High	i	ä [ɨ]	u
	e		o
Low		a	

Where the International Phonetic Alphabet and orthography diverge, IPA symbols have been provided in brackets. Additionally, the IPA is still used in this work when describing specific phonetic realizations.

Relevant to this work are three processes of epenthesis. Epenthesis is used to remedy vowel hiatus across morpheme and word boundaries (Vázquez Álvarez

2011) as well as fulfill the minimum word requirement of CVC (Coon 2010b).[2] In the first case, a glide is epenthesized as in (2) below.

(2) Tyi wäy-i-**y**-oñ (Coon 2010b)

PRFV sleep-ITV-**EP**-B1

'I slept.'

When vowels occur in hiatus across boundaries involving clitics, a different process is used that employs both epenthesis and deletion. In this process, the second vowel is deleted and a glottal stop is inserted. As can be seen in (3) it is ungrammatical to epenthesize a glide in this context.

(3) *la'pi'äl* 'your (plural) friends' (Vázquez Álvarez 2011)

/laapiʔɨl/ → [laʔpiʔɨl]

→ *[lawapiʔɨl]

The final epenthetic process assures that no root surfaces as VC through the insertion of an initial glottal stop.

(4) *ich* 'chili' (Vázquez Álvarez 2011)

/itʃ/ → [ʔitʃ]

This process is pervasive throughout Mayan and is said to interact with prosodic structure though research in this area is limited (Bennett *to appear).*

Moving on to stress, little research has been conducted in regards to stress in Ch'ol though phrasal conditioning on stress for the Greater Tseltalan branch has

[2] Whether or not Ch'ol roots are all underlying CVC or there is a process that merely requires them all to be realized as CVC is not agreed upon. Please see Coon *to appear,* Vázquez Álvarez 2011, and Coon 2010a for more information regarding this topic in Ch'ol, as well as Bennett (*to appear)* for Mayan more generally.

been attested (Bennett *to appear)*. The acoustic correlates of stress have not been determined for this language and are under-documented for much of Mayan more generally (Bennett *to appear).*

Ch'ol has been described as having word final lexical stress (Vázquez Álvarez 2011) as well as secondary stress. In words containing clitics as well as affixes, Vázquez Álvarez describes the presence of stem final secondary stress and main stress on the final clitic as in (5). Secondary stress is represented in bold while primary is indicated by way of an accent.

(5) buch-**ul**-ø-kú (Vázquez Álvarez 2011)

seated-STAT-B3-AFFR

'Yes, s/he is seated'

Still, no in depth analysis of Ch'ol stress has been conducted to my knowledge and it is unclear how the data used in the existing analysis was collected. If these data were gained from words in isolation it is possible that the pattern described is indicative of phrasal stress, pitch accent, lexical stress, or some combination there of (Gordon 2014). A high right boundary tone, H%, is attested in Ch'ol (Clemens and Coon 2015). In addition, what is identified as secondary stress may in fact be caused by phrase-level stress, intonation, or stress in compound prosodic words (Bennett *to appear).* Overall, there are a lot of factors that could be influencing existing stress judgments and a thorough investigation of stress using acoustic analysis is necessary to affirm the current description.

Finally, there are three word final processes that have been reported for Ch'ol. Werkentin and Brend (1974) as well as Vázquez Álvarez (2011) have

reported word final aspiration of voiceless consonants and affricates. Devoicing and deletion of sonorants has also been attested word finally. Devoicing is said to affect the consonants /b, l, m, ñ, n, w/ in word final position (Vázquez Álvarez 2011), though this process is examined more closely in Section 2.2.

(6) *alob* 'boy'

/alob/ → [aloḇ]

Deletion is said to only affect /b/ and /l/ in bi-syllabic words. In cases where /b/ is deleted it is necessarily replaced with a glottal stop (Vázquez Álvarez 2011) as in (7).

(7) *alob* 'boy'

/alob/ →[aloʔ]

2: Ch'ol-Specific Boundary Marking

The following sections detail the theoretical motivations as well as results of the first investigation I conducted. This study was designed to determine language specific acoustic correlates of prosodic phrasing. The need for language-specific prosodic cues is described in section 2.1. This is followed in 2.2 by a preliminary investigation motivated by the existing literature. This in effect narrows the focus of the investigation to an analysis of voice quality.

Section 2.3 outlines the details of the experiment, which yields two significant results. Word-final decreases in intensity and H1-H2 lead to the analysis, described in 2.4, that the perceived voicing contrast is due to non-modal phonation similar to glottalization, though the suitability of this term to explain the

phenomenon is debatable. In section 2.5 I discuss the conclusions made in regards to this experiment as well as their implications for future research.

2.1 Background and Antecedents

The present study builds off of the work conducted in Clemens and Coon (2015). That study used the acoustic properties of F0 and segment duration to analyze prosodic phrasing in Ch'ol. Though their investigation proved fruitful in regards to their research aims, it also highlighted the difficulties of using intonation to analyze Ch'ol prosody.

The source of this difficulty stems from the Ch'ol phoneme inventory and certain phonological processes. As was described in section 1.2 Ch'ol contains 21 consonants. Of these, there is no voiced stop series and the only voiced plosive is often deleted or realized with glottalization. There is also a series of phonemic ejective consonants p', ts', ty', ch', and k' as well as a phonemic glottal stop. In addition, glottal stops appear in situations of vowel hiatus and are often epenthesized in order to assure that no root violates the minimum word requirement of CVC (Coon 2010b). Glottalization affects typical keystones of prosodic analysis such as F0 and intensity (Ladefoged 2003). Moreover, voiceless consonants do not carry F0 at all.

In sum, Ch'ol phonology does not lend itself well to studies of intonation. Duration remains a reputable acoustic correlate, but alone it does not provide enough information to accurately analyze prosodic structure. It is only when converging evidence is available that the function of a specific acoustic correlate can

be understood. This means that in order to study prosodic structure in Ch'ol, more known acoustic indicators of that structure are necessary. Still, it is not a given by which other means Ch'ol conveys prosodic information. This is why language specific cues of prosodic constituency are key.

2.2 A Preliminary Investigation

As described in section 1.2, the existing literature describes three main word-final processes in Ch'ol, devoicing, deletion, and aspiration (Vázquez Álvarez 2011, Werkentin and Brend 1974, Bennett *to appear*). This study centers on the first two of these processes because these are most applicable to the data available.[3] Aspiration is still a worthy avenue of investigation and I leave it to future research.

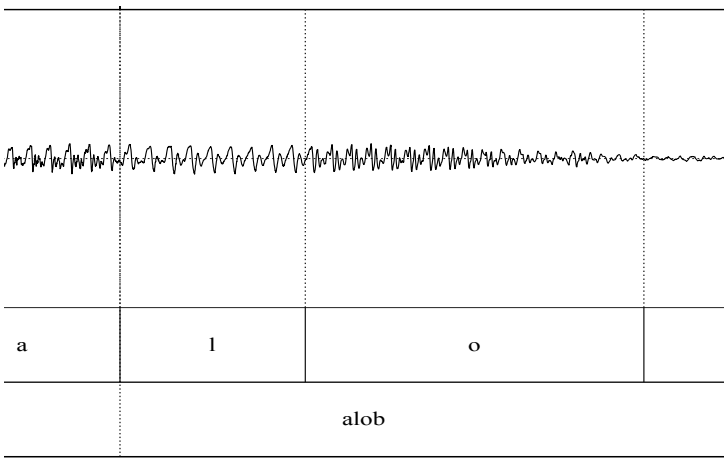
Turning to devoicing and deletion, I have summarized the descriptions given in 1.2 for convenience. Vázquez Álvarez (2011) states that /b/, /l/, the nasal stop series /m, ñ, n/, and glide /w/ can be devoiced in word final position. He also states that /b/ and /l/ can be elided in word final position when the word is bi-syllabic. /b/ in these cases is said to be necessarily replaced with a glottal stop /ʔ/.

This description formed the starting point of my investigation of prosodic boundary marking, deletion and devoicing both being candidates for language specific boundary cues. I examined a variety of word final segments in Praat to see if the data available illustrated either process. Overall, some deletion was found but devoicing was not observed.

[3] The data used for this preliminary investigation as well as the first experiment was the same data used for the investigation described in Clemens and Coon (2015). For further information about this data see §2.3.1 of this paper.

In the domain of elision, /b/'s were found to be deleted. The following image illustrates a word final /b/ that has been deleted as well as possible compensatory lengthening of the proceeding vowel:

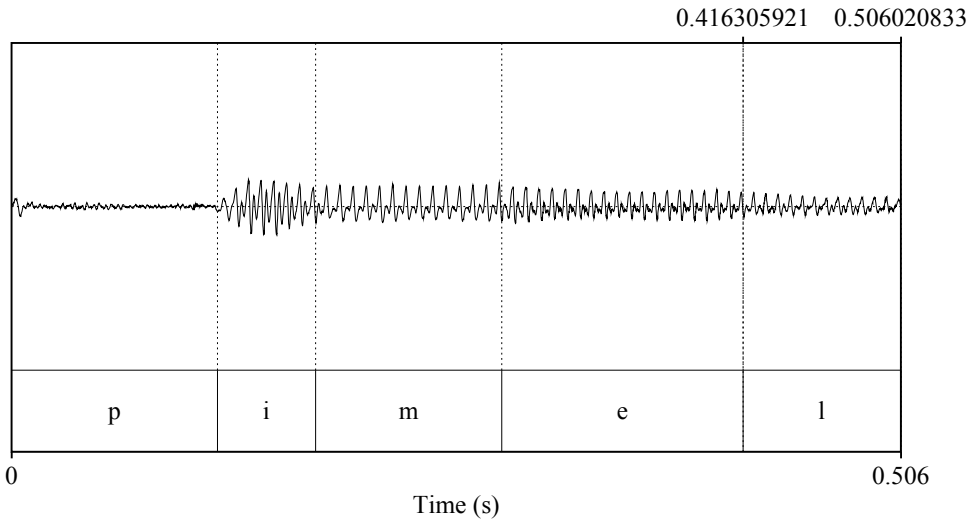
Figure (1) : *alob* 'boy'



In this case glottal stop epenthesis was not found, though in some cases, not pictured, glottal stop insertion was observed. At this point, no /l/ deletion was observed.

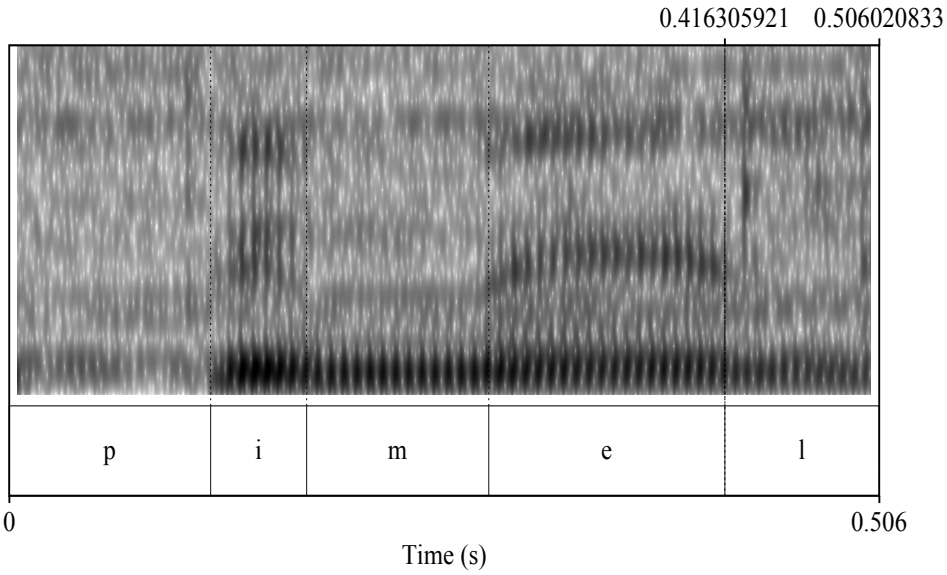
In regards to devoicing, it became clear that though in listening, segments do at times sound devoiced, this was not evident in the waveform or spectrogram. The following example illustrates such a case:

Figure (2): *pimel* (the name of a plant)



As can be seen above, the waveform remains periodic throughout the production of the /l/. As can be seen below in Figure (3), the voicing bar is visible for the full duration of the segment.

Figure (3): *pimel* (the name of a plant)



To summarize, my preliminary findings yielded evidence of word-final /b/ deletion as well as compensatory lengthening on the preceding vowel and glottal

stop substitution. It did not yield evidence of /b/ devoicing or devoicing of any word-final sonorant.

2.3 The Experiment:

The preliminary investigation illustrated a mismatch between auditory evidence and the information presented by the acoustic signal. Based off of native speaker perceptions, there is a word-final process occurring involving sonorants. This process lends itself to the interpretation of a voicing contrast. However, the previous analysis of devoicing is not compatible with the information gleaned from the acoustic signal. The following experiment seeks to determine the acoustic correlates associated with the perceived voicing contrast and place this phenomenon on the vocal quality spectrum.

Beyond pin pointing the acoustic parameters involved, the investigation is designed to explore possible phonological conditioning at work in the realization of any change in voicing. This is for the ultimate purpose of determining language specific cues of prosodic boundary marking, which as emphasized by prior work done in Ch'ol prosody, is particularly beneficial for languages like Ch'ol (that are difficult to analyze by other means).

2.3.1 A Note about Data

The data used for this experiment was collected by Jessica Coon and Lauren Clemens in the summer of 2014 for the sake of their investigation of prosodic phrasing mentioned previously. This experiment utilizes data from three speakers

recorded for that experiment. All speakers are between 20 and 40 years of age. They are all speakers of the Tila dialect and were recorded in Chiapas.

The data was obtained via a reading task and all target sentences are as sonorant rich as possible due to the intentions of the original experiment. Additionally they contain adverbial material sentence finally and all head nouns and modifiers are bi- and tri-syllabic. The following is an example of one of the target sentences used:

(8) 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."

The strange nature of these sentences is due to the effort to create sentences that conform to the aforementioned specifications. Such qualities are necessary for prosodic investigations. Voiceless sounds are aperiodoc and do not carry pitch and are subsequently unsuitable for investigations of prosody. The sentence final adverbial material gives a buffer between the material being examined and the end of the utterance so that general utterance final processes are not misconstrued as language specific prosodic evidence. In short, this data though not originally intended for the purposes of this experiment, lends itself well to the task at hand.

2.3.2 The Experimental Design

The design of this investigation is exploratory in nature. Though previous evidence indicates a voicing contrast, the exact parameters being employed are unknown. This study investigates three indicators of non-modal phonation: change

in F0, change in intensity, and change in H1-H2 (Gordon and Ladefoged 2001). F0 is a measure of the fundamental frequency of the sound wave while intensity pertains to the amplitude. These refer to the auditory phenomenon of pitch and loudness respectively. H1-H2 is a measure of the difference between the first harmonic and second harmonic in decibels (Ladefoged 2003).

Some of the other measures such as jitter were not possible due to the quality of the recordings.[4] This is just one reality of collecting prosodic data in the field. Such measures could prove fruitful in future research when better conditions are available.

This experiment examines those sonorants described in Vázquez Álvarez (2011) as being devoiced word-finally, specifically the liquid /l/ and the nasals /m, ñ, n/ are examined.[5] The voiced stop /b/ is not examined due to the tendency of /b/ to be deleted in this position, as was observed in the preliminary investigation. The glide /w/ is not examined due to its relative scarcity in the available data.

These segments were examined in three phonological environments:

- Word-medially
- Word-finally, phrase-medially
- Word-finally, phrase-finally

[4] Jitter measures the duration of fundamental frequency cycles in order to quantify aperiodicity at the glottal source (Gordon and Ladefoged 2001).
[5] [n] is found in loan words and is an allophone of [ñ]

For example:

(9) Tyi ich'i**l**i k'u**m**bä bu'u**l** ji**ñ**i p'u**m**p'u**ñ** u**m**a' tyi

PRFV A3-fry-TV soft beans DET poor mute PREP

k'iñijel

party

"The poor mute fried soft beans at the party."

Above, the segments in bold are all examples of analyzed sonorants. The /l/ in *ich'ili* demonstrates a word-medial segment, /l/ in *bu'ul* is a word-final phrase-final segment, and the /ñ/ of *p'ump'uñ,* is an example of a word-final phrase-medial segment. As can be seen in this example, some word-medial segments are vowel internal and some come before voiced segments. The full range of phonetic environments is summarized in the table below:

Table (3): Possible Phonetic Environments[6]

Phonological Position: word-medial	word-final, phrase-medial	word-final, phrase-final
V_V	V_# 'V	V_% 'V
Vd_V	V_# Vd	V_% Vd
	V_# Vls	V_% Vls

These divisions were maintained throughout the analysis to safeguard against misconstruing co-articulation with a boundary process. However, they were not maintained in the statistical analysis as at that point overarching patterns had emerged, despite differences in phonetic environment, and these were most

[6] Here V means 'vowel', Vd means 'voiced', Vls means 'voiceless', and # and % mean 'word boundary' and 'phonological phrase boundary' respectively.

relevant to the task at hand. See Appendix A for a table containing all analyzed segments and their positions.

There is an additional assumption that should be noted here. The decisions pertaining to the classification of words as phrase-medial versus phrase-final were made in accordance with the analysis made in Clemens and Coon (2015). In that experiment, VSO and VOS clauses were examined and the authors provided prosodic arguments for (V)(S)(O) and (VO)(S) phrasing. The criteria used in that study to demarcate prosodic boundaries were intonation and duration. It is assumed here, at least for the sake of a starting point, that the boundaries demarcated in that work are correct.

Additionally, all of the phrase-final words investigated in this experiment occurred at the end of the subject DP or object NP. All of the phrase-medial words examined were modifiers inside of the DP/NP. Therefore some basic aspects of the analysis found in Clemens and Coon (2015) do affect my study. However, their arguments regarding the differences between VSO/VOS clauses do not.

2.3.3 Methodology

The data, which was first annotated via the Prosodylab-Aligner (Gorman et al 2011), was fine-tuned by hand using Praat (Boersma and Weenink 2015), and then the segments in question were analyzed in VoiceSauce (Shue 2010). VoiceSauce is particularly compatible with investigations like this one because of its ability to analyze large swaths of data relatively quickly. 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.

Certain issues arose which resulted in the removal of some data points. Mainly these included those recordings that happened to be compromised at the point of the segments of importance, for instance by a page turn or animal noise.

2.3.4: The Results

The analysis yielded three major results, two of which were statistically significant. These involved the acoustic parameters of F0, Intensity, and H1-H2 respectively. I will move through each of these in turn presenting a line graph illustrating the relevant pattern over the course of each segment as well as box plots illustrating the statistical findings.

First turning to F0 or pitch, there was a non-significant decrease in F0 for sonorants in the position word-final, phrase-medial. Below is a graph showing the change in Hz for each position over time. For the word-final phrase-final sonorants, V_% (n=89), there is a slight rise in F0 towards the end of the segment. This is also the case for word internal segments, V_V/Vd_V (n=160). However, it is clear that word-final phrase-medial segments, V_# (n=28) exhibit a decrease in F0 over time. VoiceSauce for each parameter can provide the mean measure at nine equidistant points in time over the course of the segment being analyzed. These means were averaged for all segments for each point in time at each position to produce the plot below.

Figure (4): Change in F0

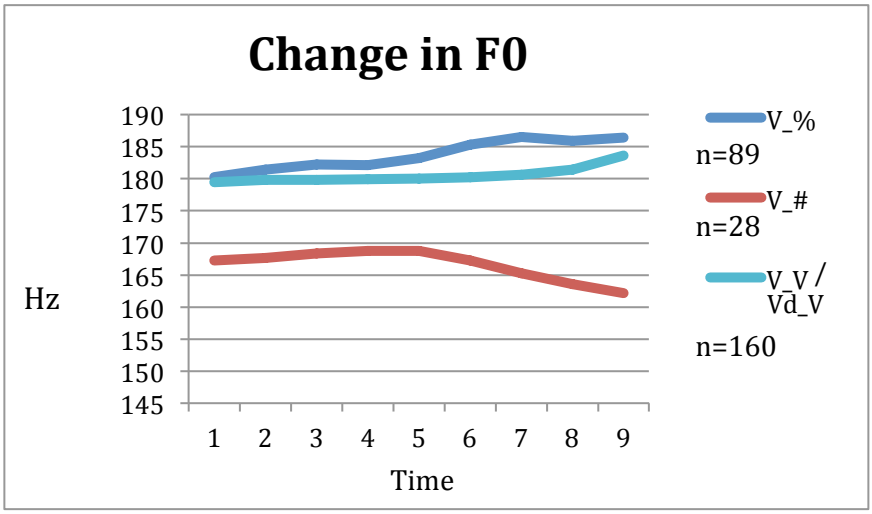
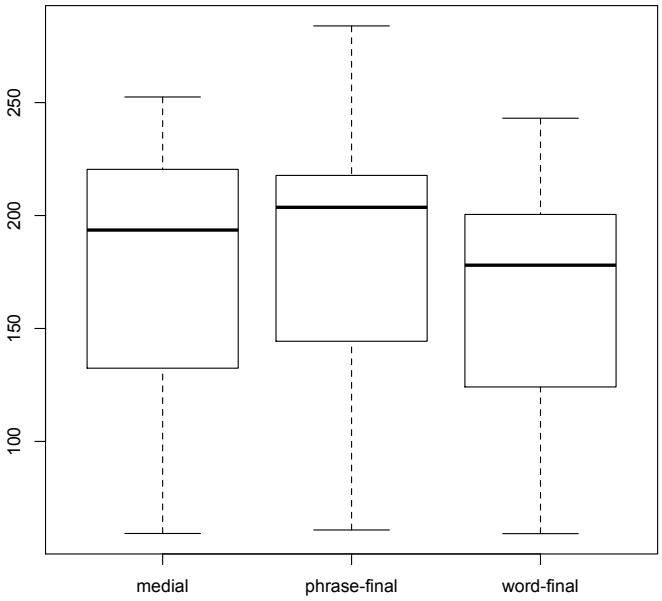


Figure (5): Change in F0, Boxplot



The above boxplot was generated using the mean F0 for the entirety of each segment. It is apparent that the word-final phrase-final sonorants are patterning with the word-medial sonorants for this measure, if not slightly increasing in F0. This is expected due to the presence of a high right boundary tone, H%, as was

observed in Clemens and Coon (2015). This pattern was not significant for the sonorants I investigated (p>.05).

To statistically test this finding, a Likelihood Ratio Test was used. A linear regression mixed model was created in R (R Core Team 2015). The model used the *lme4* package (Bates, Maechler & Bolker, 2012) 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 type of segment (/l,m,ñ, n/):

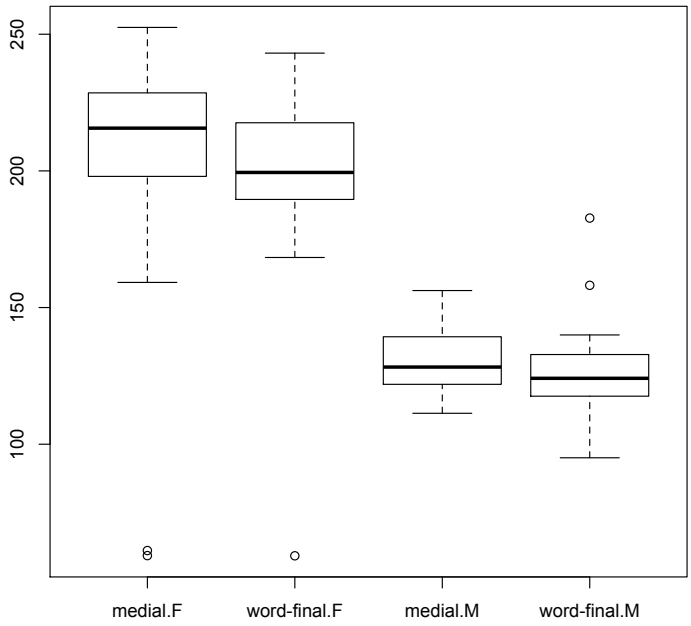
(10) pitch.model = lmer(pitch ~ position + (1+position+type|speaker), data=pitch)

This was then compared to the following null model using an ANOVA.

(11) pitch.null = lmer(pitch ~ position + (1+position+type|speaker), data=pitch)

These results were not separated by gender due to the limited number of speakers available for this study. However they do represent a general trend in the data despite a lack of significance and the effect of gender. For the sake of completeness and to further illustrate the trend, the following boxplot illustrates the change in F0 separated by gender for word-medial sonorants and word-final phrase-medial sonorants. Again mean F0 values used represent the mean for the entire duration of each segment.

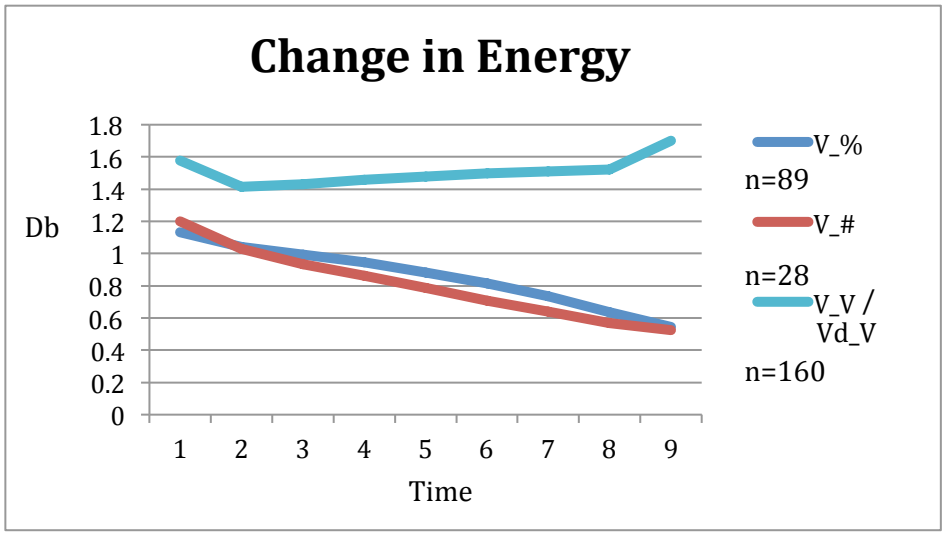
Figure (6): F0 by gender, word-medial vs. word-final phrase-medial.



As can be seen above, there is a larger decrease in female speakers as opposed to male speakers. Again these findings were not significant but demonstrate a potentially interesting avenue for future research.

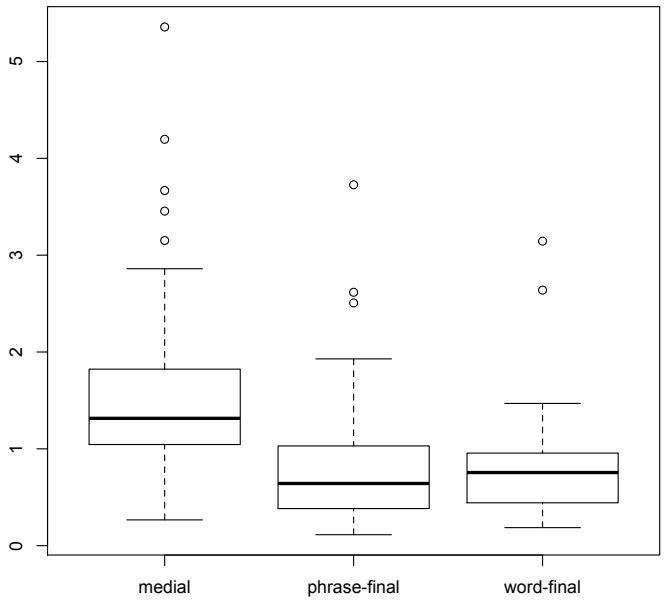
Moving to intensity, which I will refer to as energy, as it is called in VoiceSauce. For this measure we again see a decrease as is illustrated by figure (7). This graph was generated in the same way as the graph above, though now we see change in decibels over time.

Figure (7): Change in Energy



Here there is a decrease in both word-final positions, V_% (n=89)and V_# (n=28), as compared to the word-medial segments, V_V/Vd_V (n=160). Word internal positions display a slight decrease, a leveling and a slight increase.

Figure (8): Change in Energy, Boxplot



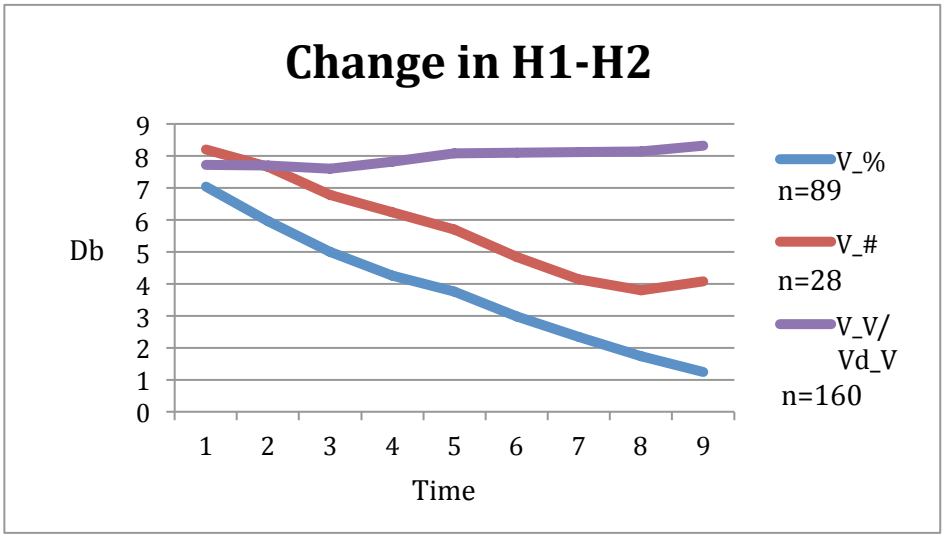
This boxplot was also generated using the mean value for the entirety of the segment. Between both word-final positions there is almost complete overlap for this measure. However, there is no visible overlap between word-medial and word-final positions. This difference was significant (p<.001) according to a Likelihood Ratio Test which compared the following model (12) and null model (13) using an ANOVA.

(12) energy.model = lmer(energy ~ position + (1+position+type|speaker), data=energy)

(13) energy.null = lmer(energy ~ position + (1+position+type|speaker), data=energy, REML=FALSE)

A similar difference was seen for the measure of H1-H2. Though here we see a three-way contrast. The graph below illustrates change in decibels over time.

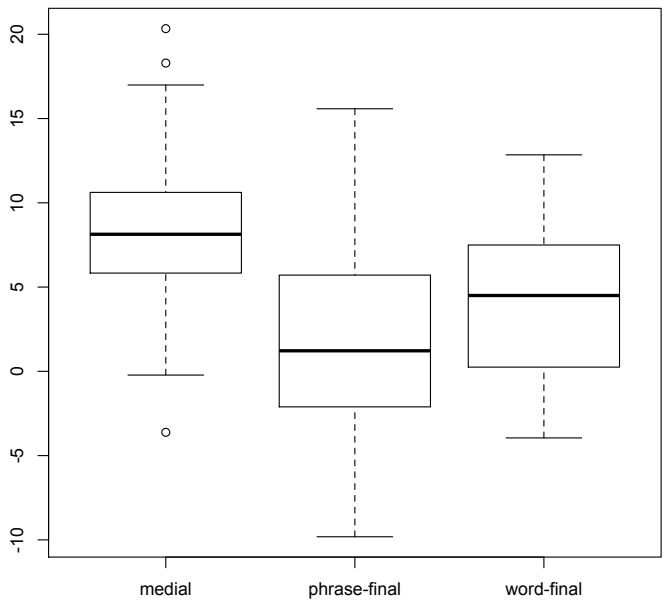
Figure (9): Change in H1-H2



Here we see the greatest decrease in H1-H2 occurring for word-final phrase-final segments, V_% (n=89). We also see an additional decrease for word-final phrase-

medial segments, V_# (n=28). Again, like with energy, a similar decrease is not observed for word-medial segments, V_V/ Vd_V (n=160).

Figure (10): Change in H1-H2, Boxplot



The boxplot above was generated using the mean H1-H2 from the final portion of the segment, where the contrast is most apparent. For this measure, partial overlap between both word-final positions is observed. The above variation was statistically significant (p<.001) according to a Likelihood Ratio Test that used the following model and null model:

(14) H1H2.model = lmer(H1H2 ~ position + (1+position+type|speaker), data=H1H2)

(15) H1H2.null = lmer(H1H2 ~ position + (1+position+type|speaker), data=H1H2, REML=FALSE)

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<.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<.005) between the word-final phrase-final position and the word-medial position, when compared separate 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:

(16) H1H2.model = lmer(H1H2 ~ position + (1+position|speaker), data=H1H2)

(17) H1H2.null =lmer(H1H2 ~ position + (1+position|speaker), data=H1H2, REML=FALSE)

This comparison did generate a significant result (p<.001). The only difference between the original and reduced model is that the reduced version lacks a random slope for type of segment.

Below I have provided a table summarizing the results. An ✗ indicates no evidence of the given measure at the specified position where a ✔ indicates evidence. The ✔✔ distinguishes the amount of decrease in H1-H2 observed for word-final sonorants in that phrase-final segments exhibited a larger decrease.

Table (4): Summary of Results

Position	Decreased F0 (p>.05)	Decreased Energy (p<.001)	Decreased H1-H2 (p<.001)
word-medial	✗	✗	✗
word-final, phrase-medial	✔	✔	✔
word-final, phrase-final	✗	✔	✔✔

2.4 Analysis

Voice quality like prosodic constituency does not manifest itself via a single universal acoustic parameter; it involves a bundle of acoustic information. This bundle can vary across languages with individual acoustic correlates ultimately indicating different processes case by case. The measures of F0, energy, and H1-H2 in and of themselves can manifest a variety of different qualities and thus I will analyze them, where applicable, as a bundle.

That being said, the changes observed indicate decreases of these measures (save F0 at phrase boundaries) at word boundaries which occur both at the edge of phonological phrases and internal to phonological phrases. Such decreases do not appear to occur word internally.

Decreases of this nature are all indicative of non-modal phonation (Gordon and Ladefoged 2001). Phonation, as described in that work, exists on a spectrum from most open (voiceless) to most closed (glottal closure). Modal phonation is in the middle of this spectrum with non-modal representing deviations from this center towards a greater level of openness or closure. Due to the status of modal phonation as the most efficient mode of voicing (Ladefoged 2003), it follows that when phonation deviates from modal, energy and F0 decrease as efficiency is lost.

H1-H2 is the measure in decibels of the first harmonic minus the second harmonic. This measure, if it is decreased, represents a greater level of energy centered in the domain of the second harmonic relative to the first harmonic. This beyond indicating non-modal phonation, is specifically indicative of 'creak'. This is due to the fact that when creaky phonation is produced the glottal pulses are very

short and the glottis closes very quickly contributing greater energy to the higher frequencies (Ladefoged 2003).

This phonation type falls between modal voicing and a full glottal closure on the aforementioned spectrum. There are theoretically countless points between these two options and many different types of creak, or glottalization as it is also called, have been attested (Keating and Esposito 2006). For the sake of this analysis I will use the term glottalization to indicate some level of glottal constriction and will discuss this issue further in the following section.

Glottalization has been found to indicate prosodic constituency in a variety of languages. 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. Moreover in that study the author references a large body of literature describing the boundary-marking role of glottalized phonation. As cited in that work it has been found to indicate phrase boundaries in Swedish (Fant and Kruckenburg 1989) as well as Serbian, Finish, and Croatian (Lehiste 1965). Glottalization is also found utterance and sentence finally in a variety of other languages (Markó 2012).

In sum, decreased energy and F0 (where found), are motivation to place these sonorants in the domain of non-modal phonation. Decreased H1-H2 gives the additional motivation to classify this specific phenomenon as creak. I posit that a process of final glottalization is occurring for the sonorants /l,m,ñ,n/ in Ch'ol. Due to significant changes observed between phrase-medial and phrase-final positions,[7] I also posit that this process is sensitive to higher order prosodic structure. These

[7] The fact that a significant difference was seen between the two word-final positions also supports the demarcation of phrase boundaries established in Clemens and Coon 2015.

analyses are further supported by crosslinguistic evidence that cites glottalization as a method to indicate prosodic constituency.

2.5 Discussion

Overall the research aims of this experiment were met. Language specific boundary cues were obtained. The question as to what acoustic phenomenon was occurring that lent itself to the description of devoicing, was answered. Furthermore, now that language specific acoustic correlates of prosodic constituency have been established for Ch'ol, these can be used as diagnostics in questions of isomorphism between the phonological and morpho-syntactic components of the grammar. Such a question is the focus of my second experiment.

Pragmatically speaking, the results and the subsequent analysis given filled a practical need. Now I have a tool with which to explore further the morphology-phonology interface. However, there are still some remaining issues as to what to call this phenomenon. The realization of a phonation contrast is at its core a difference in articulatory movements, the variety of these movements is vast and our ability to find acoustic correlates of these movements, limited. In addition, the three-way contrast of breathy, modal, creaky is evidently not enough because as Markó (2012) points out, many more types of irregular phonation have been attested. For example (as cited in Markó), Dilly et al (1996) described four different realizations of irregular phonation when listening to radio broadcast data and Batliner et al (1993) described six in thirty minutes of spontaneous speech.

H1-H2 has been cited by many as an indicator of creaky voice (Gordon and Ladefoged 2001, Keating and Esposito 2006) but it is not in and of itself a knock down argument. Additionally, the fact that F0 could increase in places where decreased H1-H2 also occurred is indicative of phonation unlike true creaky voice. Though it is evident that the voicing is non-modal and is most likely more closed as opposed to more open, more research is necessary to establish the exact details and place this type of voicing accurately on the spectrum. What is clear is that there is a statistically significant word-final process in Ch'ol in which energy, F0, and H1-H2 decrease in predictable positions.

3: Where Phonology Meets Morphology

Clemens and Coon (2015) delimited the edge of the phonological phrase in Ch'ol using intonation and duration. My first experiment found language-specific acoustic correlates used in Ch'ol to signal phonological phrase as well as phonological word boundaries, namely decreased energy and H1-H2. This experiment goes one step further in that it uses these cues to investigate the location of certain morphemes in relation to the domain of the phonological word. This domain can never extend beyond the terminus of a syntactic node. Therefore, clitics are never found within the same phonological word as affixes. I use this relationship to address the status of Ch'ol morphemes. Specifically, morphemes which have been previously classified as affixes and clitics but exhibit morphologically mixed behavior.

The following section, 3.1, first situates the investigation within the theoretical prosodic framework outlined by Nespor and Vogel (2007). Then in 3.2 I outline the experiment, its design, methodology and ultimately its results. This is followed by my analysis in 3.3 and finally a discussion in 3.4.

3.1Background and Antecedents

The phonological word has been described as the level of the prosodic hierarchy that represents "the interaction between the phonological and morphological components of the grammar" (Nespor and Vogel 2007). Additionally, though non-isomorphism between prosody and morpho-syntax is a crucial motivation for having two separate systems, there are possible points at which these systems can be isomorphic. One of these points is at the level of the phonological word (Nespor and Vogel 2007).

3.1.1 The Domain of the Phonological Word : ω

Nespor and Vogel argue for two possible domains of the phonological word, 'ω'. This paper assumes that this is correct, and that there are indeed two possibilities as opposed to three, which has been argued as well (as cited in Nespor and Vogel: Booij 1983, among others). First ω can be equal to the terminal element of the syntax, in which case it is isomorphic with the morphological element. It is isomorphic in that it regroups the terminal elements of the morphology in such a way that they form a constituent identical to a morphological constituent. In terms of affixes these would all be included along with the stem in one phonological word.

Second, the domain of ω can be smaller than the terminal element of the syntax and subsequently regrouping renders no isomorphism between the phonology and a morphological constituent at this level.

The distinction between these two possibilities is discussed in Nespor and Vogel within the context of compounding. In the former case, both stems involved with the compound along with any affixes belong to one ω. In the later the stems of each component stem in the compound would belong to distinct phonological words.

In this work, compounds are not analyzed.[8] Instead, I examine what have been previously classified as affixes and clitics. In words containing only one stem, isomorphism should be observed. This means that affixes should fall within the domain of the phonological word containing the stem, and clitics should not. If the prosodic data is in line with the predictions made by isomorphism, the current classification of Ch'ol affixes and clitics is supported.

In addition, clitics demonstrate qualities of both affixes and independent words (Zwicky 1977, Zwicky and Pullum 1983, among others). Due to their inability to fit comfortably in all cases in either category, Nespor and Vogel take after Hayes (1989) in positing an additional constituency layer in the prosodic hierarchy just for clitics, "The Clitic Group". Such a constituent is smaller than a phonological phrase and bigger than a phonological word.

By design, the Clitic Group is non-isomorphic with the morphology because no such constituent layer exists in the morphology. However, if the data indicates

[8] Compounding does occur in Ch'ol and though it is beyond the scope of this research, it would be an interesting avenue for future prosodic work.

the presence of clitics within the domain of the phonological word this would present evidence contrary to their classification as clitics nonetheless. If the data demonstrates that the clitics are outside of the domain of the phonological word this would still not technically be isomorphism but it would support their status as clitics.

3.1.2 Ch'ol Affixes:

Ch'ol being agglutinative, has a vast variety of both affixes and clitics. Here is a discussion of the relevant affixes, and clitics will be discussed in section 3.1.3. The affixes examined here are a subset of the full system for two main reasons. First, it would have been impractical to analyze the full range of affixes in Ch'ol. Second, suffixes were used for the sake of correspondence to the previous experiment. The morphemes included were chosen because they illustrate the wide range of morphological behavior exhibited by affixes in Ch'ol. That being said, the Set A person markers which either cliticize (Arcos López 2009) or prefix to the verbal complex (Vázquez Álvarez 2011, Coon *to appear*), would be an interesting avenue for future research of this nature.[9]

Moving on to the affixes examined presently, these belong to four major categories of suffix. I will discuss each in turn highlighting the morphological and existing phonological motivations behind classifying them as affixes. I will move

[9] Set A and Set B refer to ergative and absolutive respectively in Mayan linguistics. For an overview of this alignment in Ch'ol please see Coon *to appear,* and for an in-depth discussion of the ergative split in Ch'ol please see Coon 2010b

from most affix-like to least affix-like according to available criteria. The functions and names of the affixes used as well as information regarding their distributions come from Vázquez Álvarez (2011) unless otherwise noted, though the spectrum presented here is my own.

First, the stative suffix –*Vl* attaches to both transitive and positional roots to form an intransitive stative stem, and is most affix-like according to the following criteria. This suffix contains a vowel that is harmonic with the root vowel which at the start provides evidence of its place within the domain of the phonological word (Nespor and Vogel 2007). It also appears as in (18) below, before all other affixes, directly to the right of the verb root.

(18) Buch-**ul**-ety tyi k-tyaj-a-y-ety (Coon *to appear*)

Seated-STAT-B2 PRFV A1-find-TV-EP-B2

'I found you (while you were) seated'

Additionally this suffix shows a high level of selectivity in regard to its host and it does not attach to material already containing clitics. These were criteria A and F respectively in Zwicky and Pullum (1983), and I will use these titles for simplicity as I describe the other affixes.

(A) "Clitics can exhibit a low degree of selection with respect to their hosts, while affixes exhibit a high degree of selection with respect to their stems."

(F) "Clitics can attach to material already containing clitics, but affixes cannot."

Second, the non-finite suffix or –*el*. This suffix attaches to intransitive verb roots as in (19). It is one of several nominalizing suffixes in Ch'ol.

(19) Yariuj=ix mi i-sajty-el kixtyañuj (Vázquez Álvarez 2011)

SP:every.day-already IMFV A3-die-NF SP:people

'Every day people die.'

This suffix does not exhibit vowel harmony but it does demonstrate selectivity (criterion A) in only attaching to intransitive roots, and it cannot attach to material containing clitics (criterion F).

Third, the abstract suffix –*el* was investigated. This affix changes the meaning of nouns or adjectives into an abstract quality.[10] For example:

(20) i-kuñl-**el** (Vázquez Álvarez 2011)

A3-soft-ABST

'Its softness'

This suffix lacks vowel harmony but it does comply with criteria A and F from Zwicky and Pullum (1983).

Fourth, the plural suffix –*ob* is investigated in this work. This is described as a suffix in Vázquez Álvarez (2011) and this classification is in line with the parameters A and F as well. Still this suffix is not as selective as the previously mentioned suffixes in that it can attach to plural nouns as well as their corresponding predicates, as in (21) (Coon *to appear*, Vázquez Álvarez 2011).

[10] -*Vl* suffixes are common throughout Mayan and this suffix is probably related to the –*Vl* suffix (Bennett *to appear*). Coon (2013) argues that non-finite intransitives are all nominalizations. However, an analysis of these morphemes is not needed for the current investigation.

(21) Tyi k-il-ä-y-ob jiñi wiñik-ob (Coon *to appear*, Vázquez Álvarez 2011)

PRFV A1-see-TV-PL DET man-PL

'I saw the men.'

This suffix can also co-occur with the partitive suffix –*tyak* (Coon *to appear*), appearing either after or before that suffix as in (22) and (23) below.

(22) aläl-ob-tyak

child-PL-PART

'Some of the children'

(23) aläl-tyak-ob

child-PART-PL

'Some of the children'

The fact that these can occur in either order demonstrates a somewhat lessened degree of selectivity. Still, -*ob* does not occur attached to material already containing clitics.

Also examined were the two audible set B markers –*oñ* and –*ety,* which mark first and second person respectively. In Ch'ol the third person set B marker is phonologically null. From a morphological standpoint these comply with criterion F, though they do not comply with A, regarding their selectivity. These suffixes attach to aspectual auxiliaries as in (24), transitive and intransitive verb stems as in (25), nominal predicates, as well as adjectival predicates as in (26) (Coon *to appear*).

(24) Muk'-**oñ** tyi wäy-el (Coon 2010b)

IMFV-B1 PREP sleep-NF

'I sleep.'

(25) Tyi wäy-i-y-**oñ** (Coon 2010b)

PRFV sleep-ITV-EP-B1

'I slept.'

(26) X-'ixik-**oñ** (Coon *to appear*)

CL-woman-B1

'I am a woman'

Phonologically speaking, these morphemes undergo glide epenthesis when vowel hiatus occurs between them and another affix, like in (25) above.

Below I have provided a table summarizing the described affixes and their behavior, both morphological and phonological.

Table (5): Summary of Affixes and Their Behavior

Affix	Function	Morphological Behavior	Selectivity	Phonological Behavior
-Vl	stative suffix	A, F	transitive and positional roots	vowel harmony
–el	non-finite suffix	A, F	intransitive roots	---
-el	abstract suffix	A, F	nouns, adjectives	---
-ob	plural suffix	A, F	plural human nouns, predicates	---
-oñ/-ety	Set B suffixes	F	aspect auxiliaries, transitive and intransitive stems, nominal and adjectival predicates	glide epenthesis

3.1.3 Ch'ol Clitics

Vázquez Álvarez (2011) describes Ch'ol clitics as falling into three categories. There are the participant plural clitics *–la* and *–lo(jo)ñ*. The clitic *-la* is used to pluralize 1st person inclusive as well as second person plural. First person exclusive is denoted by *lo(jo)ñ*. These are the least restricted of the clitics and able to attach to the right or left of the verbal complex.[11]

(26) K-lumal-ø=tyo=**la** (Vázquez Álvarez 2011)

A1-town-B3-still-PARTPL

'It is still our (inclusive) town'

(27) **La**=k-lumal-ø=tyo (Vázquez Álvarez 2011)

PARTPL-A1-town-B3-still

'It is still our (inclusive) town'

Subsequently these are the most clitic like in terms of criterion A from Zwicky and Pullum (1983) in that they show the least amount of selectivity regarding their host. These also can attach to material containing other clitics as in (26), in compliance with F.

Then there are the 'second position' clitics which are found in a more restricted distribution than the participant plural clitics. These attach to the first element within a specific domain, either an aspectual auxiliary or predicate. This is often the second position in an utterance, hence the name, though this is not always the case. For example, these clitics cannot attach to fronted constituents such as *wh*-words or topicalized constituents (Coon *to appear*), as can be seen in the following

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

example. In (28) the aspectual clitic –*ix* cannot attach to the topicalized *jiñi wiñik* and is therefore seen attached to the imperfective aspectual auxiliary *muk'* forming the allomorph *mux.*

(28) Jiñi wiñik mu**x** i-majl-el tyi cholel (Coon *to appear*)

DET man IMFV.**already** A3-go-NF PREP field

'He's going to the field already.'

The exact domain in which these clitics can be hosted is still not fully clear and would be an interesting avenue for further research. Importantly for this investigation they still demonstrate canonical clitic-like behavior.

Additionally not all second position clitics can attach to hosts already containing certain other second position clitics. For example the aspectual clitics =*ix* 'already' and =*tyo* 'still', cannot attach to a host already containing any of the other second position clitics accept =*äch* an affirmative second position clitic. The following second position clitics are examined in this work:

=*ix* 'already'

=*tyo* 'still'

=*äch* 'affirmative'

=*ku* 'affirmative'

=*ka* 'dubitative'

=*ba* 'interrogative'

=*me* 'predictive'

In terms of phonological motivation, all vowel initial clitics are of the form VC meaning that they do not meet the minimum word requirement for Ch'ol, CVC (Coon

2010b). They do not take an epenthesized glottal stop when they begin with a vowel, unlike vowel initial roots, which always surface as CVC due to this process.

There is a third type of clitic described in Vázquez Álvarez 2011, a phrase boundary marking enclitic, =*i.* However, due to the aims of this investigation being at the word level and not the phrase level, it is not examined in the present experiment. The forms of perfective and imperfective aspect markers *tyi* and *mi* respectively also demonstrate clitic like behavior in that they are VC and cannot host clitics (Coon 2010b), but these also fall outside the scope of this work due to their status as proclitics.

3.2 The Experiment

Overall there is evident variation in the distribution of the discussed morphemes. The present experiment uses the acoustic parameters of energy and H1-H2 to determine the location of phonological word boundaries in constructions containing what have been classified as affixes and clitics. This is for the purpose of determining whether or not the prosodic component of the grammar is in agreement with the morphological evidence outlined in 3.1.

3.2.1 The Data

The data used for this experiment was collected by way of a reading task. Six speakers were recorded, 3 male and 3 female, all between 18 and 40 years of age. Recording took place in Chiapas and all speakers use the Tila dialect except for one male speaker who uses the Tumbalá dialect. Dialectal variation predominantly

occurs among lexical items and the speaker in question was a very strong reader and therefore dialectal variation relating to the realization of prosodic constituency is not likely.

Data took the form of a word list of 56 words which were recorded both in isolation and in the carrier phrase *tyi kälä* ___ *ak'bi* or 'I said ___ yesterday'. The results presented here represent the carrier phrase-internal data only.

Literacy in Ch'ol is uncommon and subsequently not many speakers were found to participate in this study. Moreover, all tokens that were read without fluidity or confidence were removed along with all tokens that were otherwise unusable due to animal noises or other background interference.

3.2.2 Experimental Design

The previous experiment illustrated statistically significant decreases in energy and H1-H2 at word boundaries both phrase-medially and phrase-finally for the liquid /l/ as well as the nasal stop series /m, ñ, n/. This experiment uses those findings as a diagnostic tool to establish the location and strength of prosodic boundaries in order to determine if specific morphemes fall inside or outside the domain of the phonological word. It follows that if morphological constituency is isomorphic with prosodic constituency at this level then affixes will fall within the domain of ω while clitics will not.

I examined specifically /l/ in this study, in word final position, root-final position before affixes, root-final position before clitics, and in affix final position before clitics. For example:

- *ch'i**l*** 'to fry' → word-final /l/
- *tso**l**oñ* '(1st person singular) put in line' → root-final /l/ before an affix
- *choñko**l**ix* 'progressive aspect + already' → root-final /l/ before a clitic
- *mulu**l**tyo* 'wet + still' →affix-final /l/ before a clitic

I examined the behavior of each group of morpheme as they have been classified in the literature, as well as the individual behavior of the affixes as grouped in 3.1. See Appendix B for a full list of the words analyzed in this way and a description of the position of the /l/ in question in each case.

For this experiment I examined the measures of energy and H1-H2 due to the patterns found in the previous study. I also informally took note of potential other processes that could be indicative of prosodic structure such as stress (via duration and energy) and deletion.

It should be noted that there is a greater variety of affixes and clitics present in the word list then were analyzed in the formal experiment. Those affixes that were described in section 3.1 as well as a subset of the second position clitics, were the only morphemes acoustically analyzed for the measures of energy and H1-H2. However, the behavior of the entire wordlist was considered in the informal examination of other phonological processes. Information regarding these additional morphemes is provided where applicable and the full list of the data collected is present in Appendix C.

3.2.3 Methodology

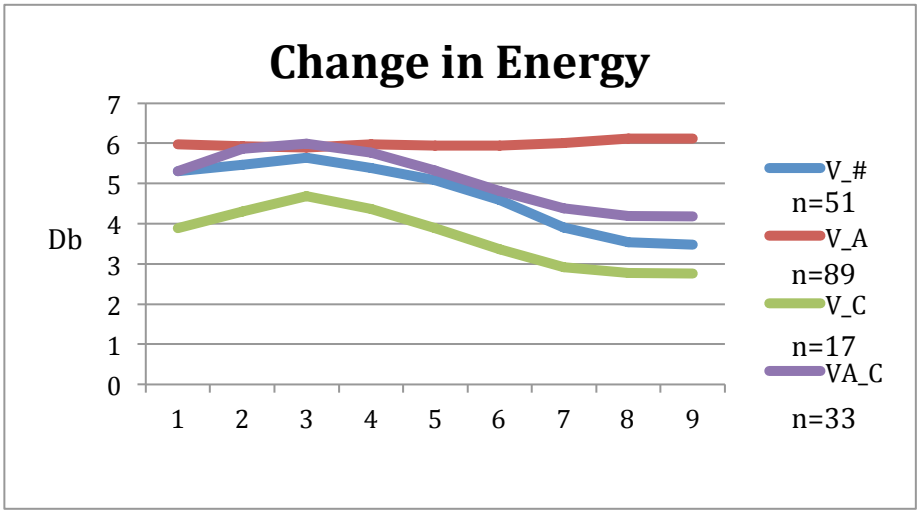
For this experiment the methodology very closely resembles that of the first experiment. The segments were annotated in Praat and then analyzed using VoiceSauce according to the same specifications. The Straight algorithm was used to determine F0, Snack Package was used to determine the formants, and the corrected harmonic values were used for H1-H2.

3.2.4 Results: Grouped

This section presents the results of the data grouped in accordance with the pre-existing classification of Ch'ol affixes and clitics described in 3.1. The data yielded significant results pertaining to the measure of energy.

In terms of energy, there was a statistically significant decrease word-finally and root-finally before clitics. This is illustrated in figure (11) below.

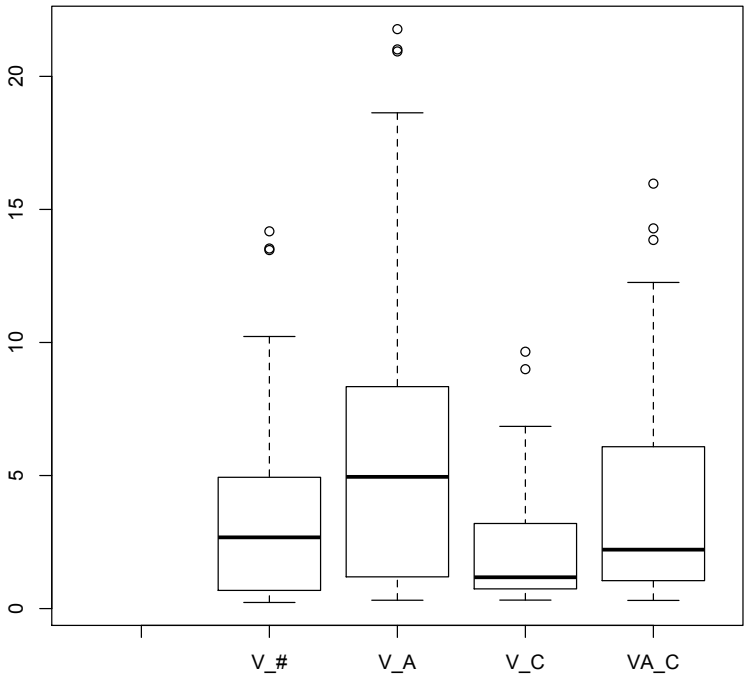
Figure (11): Change in Energy[12]



[12] Here V_# indicates word final /l/, V_A: root-final before affixes, V_C: root-final before clitics, VA_C: affix final before clitics.

The line graph above demonstrates no decrease in energy before affixes, V_A (n=89). It shows word final /l/,V_# (n=51), as well as root final /l/ before a clitic, V_C (n=17), and affix final /l/ before a clitic, VA_C (n=33), all patterning alike. Each of these measures show significant decreases (p<.001) when compared to /l/s that are before affixes, though they do not significantly differ from one another. The boxplot below further illustrates the pattern found.

Figure (12): Change in Energy, Boxplot



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:

(28) energy.model = lmer(energy ~ morpheme + (1+morpheme|speaker), data=energy)

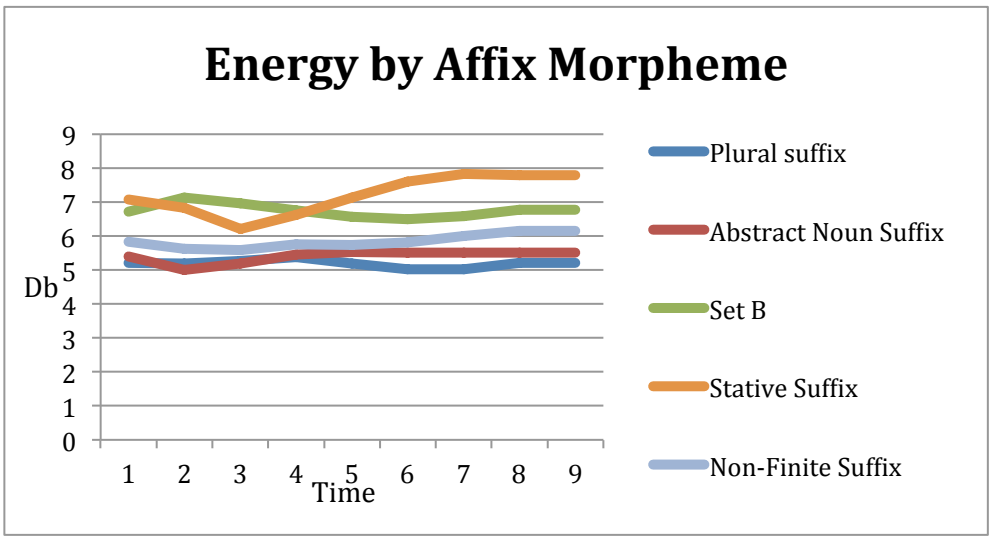
(29) energy.null = lmer(energy ~ morpheme + (1+morpheme|speaker), data=energy, REML=FALSE)

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, clitic (that follows an affix), and null for word final /l/. The individual data points used were the means referring to the end portion of each segment, where the major variation is seen.

3.2.5 Results: Separate

This section examines the variation among the affixes more closely. As was explained in section 3.1, some affixes behave more consistently like affixes then others. Below is a graph representing the variation in energy for each /l/ that occurs before an affix, broken down by affix function.

Figure (13): Change in Energy by Affix Morpheme



As can be seen above, none of the affixes demonstrate the defined pattern of decrease seen above in /l/s before clitics or word finally. There is some variation in starting energy but they remain relatively consistent throughout production.

Set B morphemes as was illustrated by the discussion in section 3.1.2, demonstrate the least affix-like behavior. However, /l/ before these morphemes does not show any decrease comparable to that seen in /l/ before clitics or word finally.

3.2.6 Results: Additional Phonological Processes

In addition to the statistically significant pattern illustrated in the previous section, throughout the investigation I observed other phonological processes of note. These, though not robust or statistically tested are still pertinent and provide potential avenues for future research.

The known details pertaining to Ch'ol stress were outlined in section 1.2. It is evident that this area is understudied for this language. Despite how little is known about Ch'ol stress, I observed some preliminary evidence in which stress appears to fall on the final syllable when that syllable is an affix, and the penultimate syllable when the final syllable is a clitic.

Figure (15): *lajaltyo* 'still the same'

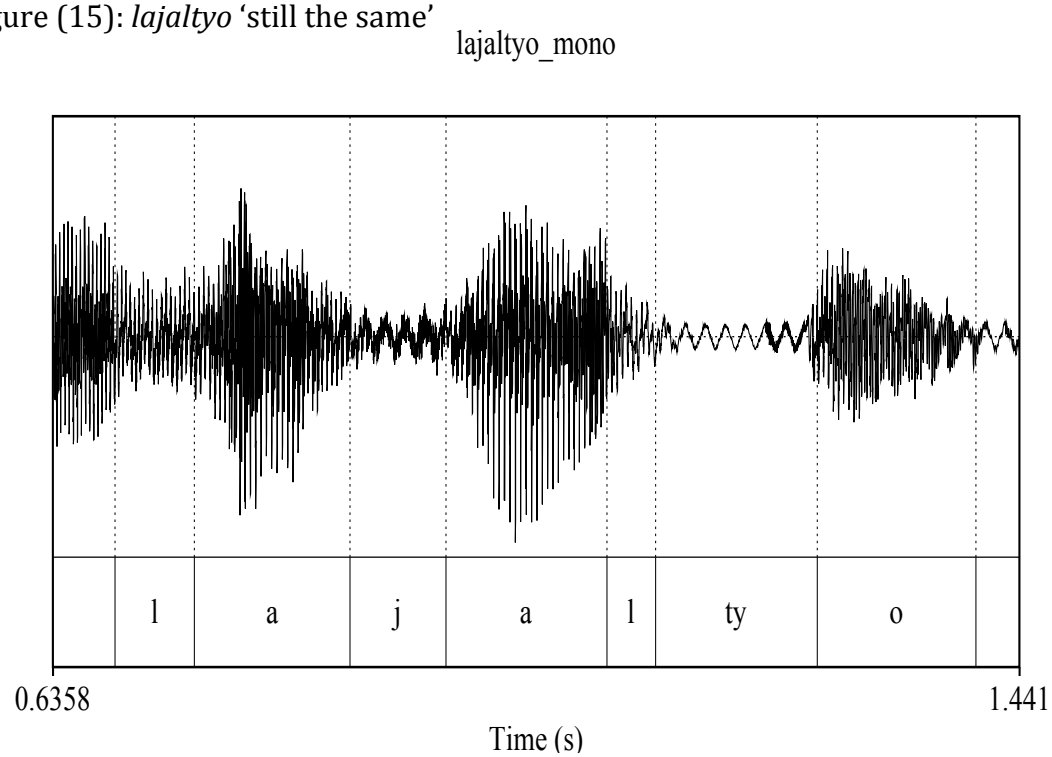
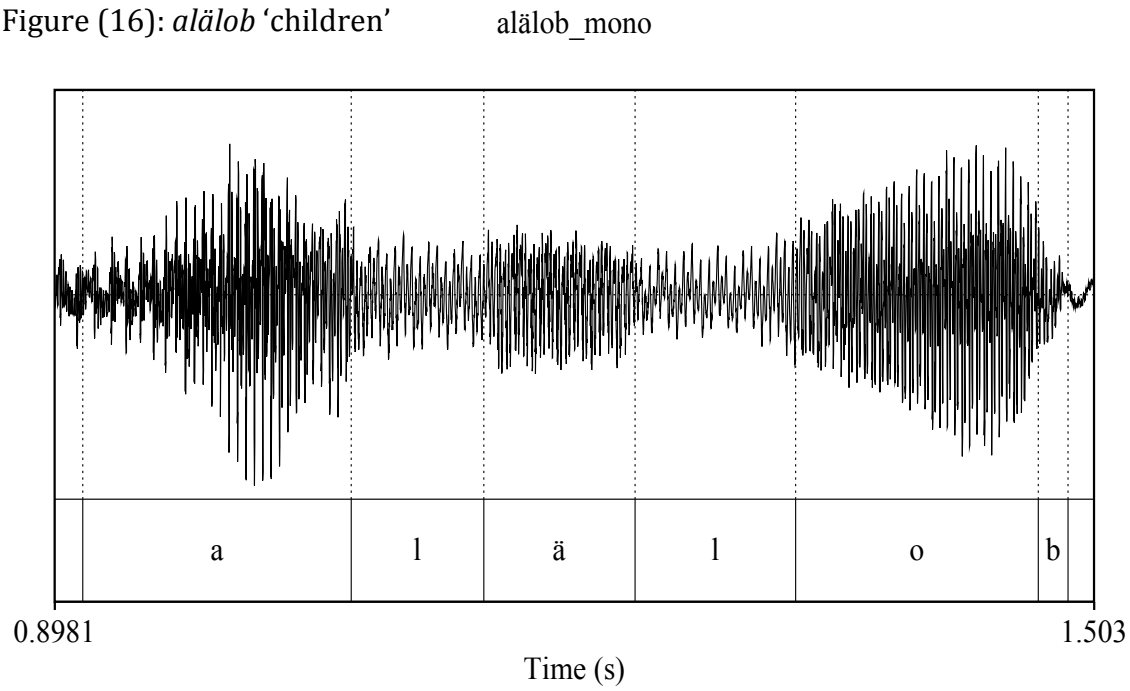


Figure (16): *alälob* 'children'



The relative duration and amplitude of the penultimate vowels in each word show a contrast. The vowel that comes before the clitc –*tyo* in *lajaltyo* (15) is more robust than the final vowel and sounds stressed. The penultimate vowel in *alälob* (16), which precedes the plural suffix –*ob* appears relatively shorter and with a lower amplitude than the final vowel of this word. A similar contrast can be seen in *alälońla* (17) vs *alälobtyak* (18). In this case the former contains the combination stem+affix+clitic and the later stem+affix+affix. Again we see evidence of penultimate stress in the construction containing the clitic and ultimate stress in the construction containing only affixes:

Figure (17): *alälońla* 'our (inclusive) children'

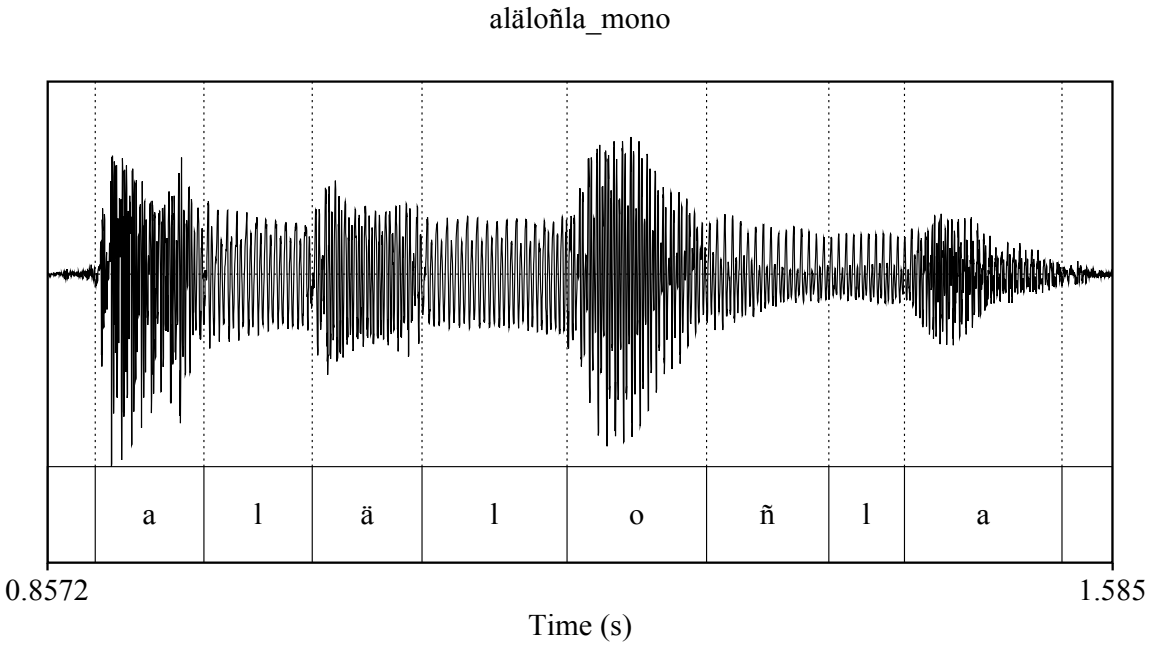
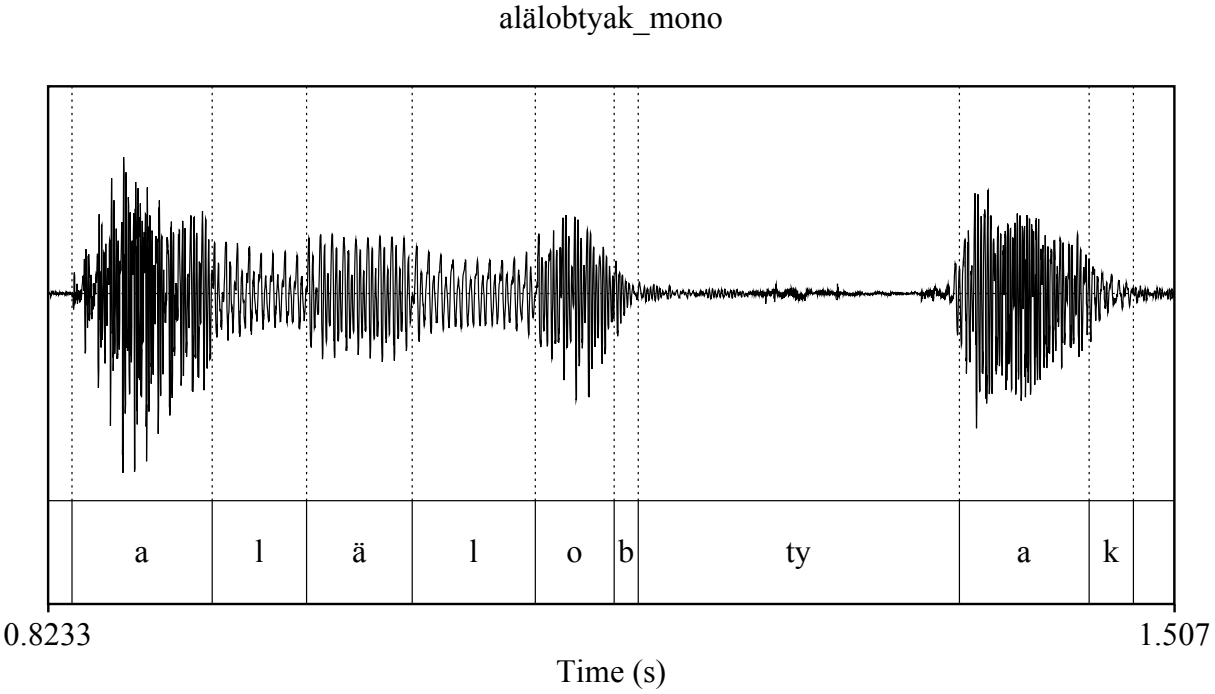


Figure (18): *alälobtyak* 'some children'



These waveforms provide non-intonation based evidence of a potential pattern regarding stress in Ch'ol. This removes the possibility of this phenomenon being attributed to the phrase final H%. The use of the carrier phrase assures that this is not a movement of phrasal or sentential stress. Additionally these findings are in line with what was observed in the previous literature in that some amount of stress can be seen stem finally.

(30) buch-**ul**-ø=kú (Vázquez Álvarez 2011)

seated-STAT-B3-AFFR

'Yes, s/he is seated'

I have reproduced the example cited in 1.2 above for convenience. If the final clitic in these constructions were to be receiving main lexical stress and not phrase level stress, this would be uncommon crosslinguistically according to Nespor and Vogel (2007). They, in describing the Clitic Group explain that most languages give relative prominence to the host word as opposed to the clitic.

Moving now to deletion, as was mentioned in section 1.2, Vázquez Álvarez (2011) describes a process of deletion in which /l/ is sometimes deleted word-finally when the word is bi-syllabic. Such deletion was never witnessed before affixes but limited deletion was seen before second position clitics *=ix* and *=tyo*. Two of the six speakers deleted the final /l/ of *lajal* in the construction *lajaltyo*. One speaker deleted the /l/ of *choñkol,* the progressive aspect auxiliary, in the token *choñkolix.*

Finally, a quick note about vowel hiatus, a topic which was also described in 1.2. Vowel hiatus is remedied in different ways in Ch'ol, most notably through the

insertion of a glide (Coon 2010a, Vázquez Álvarez 2011). This can be seen between the Set A markers and their corresponding verbs as well as between affixes and Set B morphology. However, when vowels occur in hiatus between a clitic and its host, hiatus is remedied differently. Below I have reproduced an example from 1.2:

(31) *la'pi'äl* 'your (plural) friends' (Vazquez Alvarez 2011)

/laapiʔɨl/ → [laʔpiʔɨl]

→ *[lawapiʔɨl]

Instead of insertion of the glide /w/ as is seen in instances of vowel hiatus between roots and affixes or affixes and affixes, we see deletion of one vowel and glottal stop epenthesis.

3.3 Analysis

As evidenced by the results given above, no consistent pattern of variation was found for the measure of H1-H2. For this measure, there was a great deal of inter-speaker variation. Ladefoged (2003) explains that high levels of energy can obscure the relationship of high H2 relative to H1, which typically occurs during glottalization. The fact that this was a wordlist, as well as the nature of the carrier phrase, resulted in high overall energy and potential focusing of the target word. Subsequently I posit that any consistent variation for this measure was thwarted by heightened levels of energy caused by the design of the experiment. It would be fruitful in the future to study this measure using more natural speech data such as in recorded narratives or more complex sentences like those used in Clemens and Coon (*to appear*). Also Markó 2012 explains that the use of irregular phonation

varies a lot by speaker. Overall, this emphasizes the importance of not relying on one given acoustic correlate in investigations of prosody.

Regardless, energy did significantly decrease before clitics and word-finally while it did not do so before affixes. This gives evidence that the morphemes previously classified as affixes, despite some variation in their behavior, do indeed fall within the domain of the phonological word while clitics do not. This is illustrative of isomorphism between the phonological and morpho-syntactic elements of the grammar.

The evidence regarding stress also provides support for this analysis. This evidence was very preliminary and did not take into account syllable weight and other important conditions but it still raises the question, *Is the decrease in energy seen above the result of stress or non-modal phonation?* I argue that it is indicative of the latter because if it were caused by stress we would not see the observed pattern in energy over time. It follows that if we were seeing an increase in energy during stress on a vowel, the sonorant following that vowel would have higher energy that would then fall in moving towards a neutral non-stressed syllable. However, what we see is all segments starting with roughly the same energy, and this energy falling for word-final and pre-clitic segments. Segments before clitics in fact start with slightly lower energy. In short we would expect the pre-clitic segments to start with energy that is higher than the other segments and fall to their level as opposed to starting at their level and falling below it. Additionally, Frazier (2009) in her examination of glottalization in Yucatec refers to decreased energy as the most reliable correlate of glottalization in that language.

The stress-based evidence along with the evidence from deletion demonstrate more evidence placing the clitics outside of the domain of the phonological word. The evidence from vowel hiatus demonstrates that the process of glide epenthesis works within the domain of the phonological word but not across word boundaries. There is an additional process of deletion and glottal stop epenthesis occurring at the level of the Clitic Group. This distinction gives further motivation to place the analyzed Ch'ol affixes within the domain of the phonological word and clitics outside of that domain.

3.4 Discussion

The main aim of this experiment was to observe the phonological behavior of certain morphemes that have been previously classified as either affixes or clitics in order to support or call into question those established classifications. The experiment demonstrated that despite some variation among affixes, the existing delimitations of the affixes and clitics tested are in line with prosodic data. Still, this is based off of predominantly one acoustic parameter. As described previously, I posit that the lack of a consistent pattern for H1-H2 was greatly due to the presence of much higher energy levels and ultimately the design of the experiment. Nonetheless, the lack of consistency does pose a challenge for the conclusions of the first experiment.

In terms of H1-H2, a consistent pattern was found in the first experiment that was highly significant statistically speaking ($p<.001$). The results of the second experiment in effect, reaffirm the statement made in the discussion in section 2.4.

That is, ultimately more research is necessary in order to pin down the exact nature of this process.

I think an experiment specifically designed to look for indicators of glottalization would be fruitful in establishing where this process sits on the phonation spectrum. It would also be useful in adding more acoustic correlates of prosodic phrasing to our repertoire thus facilitating future investigations at the interfaces. I also believe, as illustrated by my limited findings in the domain of stress, that a thorough investigation of the stress patterns of Ch'ol would be a very worthy avenue for future research.

4: Summary and Final Conclusions

In this thesis I have demonstrated a holistic approach to problem solving that illustrates the importance of careful descriptive work as well as its potential application at the interfaces. First, through consideration of the Ch'ol phoneme inventory, I set out to determine Ch'ol-specific correlates of boundary marking, in and of itself a descriptive endeavor. However, such an endeavor provides a workable foundation, facilitating future research in Ch'ol prosody.

Then, by using a broad spectrum of acoustic correlates and the guidance of native speaker perceptions, I observed three acoustic correlates of prosodic phrasing, specific to Ch'ol. These I argued to be indicators of non-modal phonation, specifically non-modal phonation that is more towards the closed side of the phonation spectrum. I then used this as a tool to delimit phonological word boundaries in morphologically complex constructions. By considering the

phonology-morphology interface and the existing classifications of Ch'ol affixes and clitics I was able to strengthen existing arguments regarding those classifications. Classifications that previously rested predominantly on morphological behavior that exhibited a large degree of variation.

Throughout the investigation, I highlighted several avenues of potentially fruitful research including but not limited to: determining the specific type of non-modal phonation occurring at prosodic boundaries and examining the nature of stress.

Overall, the work conducted facilitates future research, helps to clarify an outstanding structural question, and poses new questions. Moreover I think the methodology outlined here could prove valuable to future work, particularly work on understudied languages. That is essentially, a methodology that builds a language specific tool kit of tactical descriptive research to then use in the theoretical domain. Additionally, understudied languages stand to benefit from as many resources as are possible and work at the interfaces, can, as it did in my second experiment, provide an entire new source of data with which to approach an outstanding problem.

Appendices

Appendix A: Individual Segments Analyzed (per speaker)

Environment	*l*	*m*	*ñ*	*n*
V_% ‘V	*yumäl (x2)* *bu’ul*	*ixim (x2)* *bajlum (x2)* *chityam (x2)*		*ajDavid-Ivan* *ajManuel-Martin*
V_% Vd				*ajDavid-Ivan*
V_% Vls	*pimel (x4)* *yumäl (x2)* *bu’ul (x3)*	*lukum (x4)* *ixim (x2)* *bajlum (x2)* *chityam (x2)*		*ajManuel-Martin*
V_# ‘V	*juch’ul(x2)*	*ch’äyem (x2)*	*p’ump’uñ (x2)*	
V_# Vd			*k’äñk’äñ (x2)* *tsäwañ (x2)* *cha’añ (x8)*	
V_# Vls	*kabäl (x2)*		*tyäkiñ (x2)*	
Vd_V	*tabla (x4)* *Pablo (x2)*			
V_V	*alob(x4)* *ipulu(x4)* *ich’ili(x4)* *pulul(x2)* *tyala(x4)* *ijulu(x4)* *wajali (x4)*	*uma’(x4)* *ich’ämä(x4)*	*ichoño(x4)* *imäña (x4)*	

Appendix B: Words Formally Analyzed (per speaker)

V_#	ch'i**l** bu'u**l** ja'le**l** ak'bäle**l** ja'bile**l** ktso**l** tso**l** choñko**l** (x2) ojba**l**
V_A	choñko**l**oñ alä**l**ob (x2) tso**l**oñ (x2) ch'i**l**il iju**l**el yixik**l**el iwa'tyä**l**el ik'uñ**l**el iwiñik**l**el ipi'ä**l**oñ ktso**l**oñ maj**l**el
V_C	ch'i**l**ixku choñko**l**ix laja**l**tyo
VA_C	ch'ä**l**älbi pu**l**ulix ipu**l**eltsa' mu**l**ultyo

Appendix C: Full Word List

‘ch’il’
mik tsoloñ
ch’ilil
ijulel
cholcholña
belbelña
bu’lel
bu’ul
alälob
alälobtyak
iwiñiklel
pi’ältyak
ja’lel
ik’uñlel
alältyakob
jolts’i’
kpislel waj
ak’bälel
iwa’tyälel
yixiklel
ja’bilel
mulultyo
tsololixba
ch’ilixku
mux ijulelob
jäläloñäch
mululetyixbi
pululix
ch’älälbi
ch’älältyoka
choñkoloñ tyi k’ay
juñk’alpajl ja’as
majlel
juñk’al alälob
choñkolix
choñkol tyi k’ay
mik tsol
mik tsoloñ
muk’ix ktsol
muk’ix ktsoloñ
ipi’äloñ
aläletytyo
wa’tyälä
pi’äletyixloñ

alälo̱ñla
ch’älälixme
aläletyla
xk’iñejelob
icholeltyakobäch
uxtyikiletyla
lajaltyo
laklumaltyome
laklumalächix
choñkol ityä’lañoñ ojbal
ktyä’lañety
mululächix

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