THE INTERACTION OF LARYNGEALIZED VOWELS, STRESS, AND FALLING PITCH IN MARITECO CORA*

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This analysis considers for the first time the existence of interactions between pitch, stress, and laryngealization in Mariteco Cora phonology. We present pilot case studies of two speakers to determine whether Mariteco Cora has phonologically contrastive tone in addition to lexical stress, as suggested by Casad (n.d.). Distributional and phonetic analysis of words in isolation indicate that lexically specific pitch patterns do not represent an independent contrast. Rather, falling pitch is one of various possible cues to vowel laryngealization, which appears to have a wide range of phonetic realization strategies (cf. Gerfen & Baker 2005 on Mixtec). Our data suggest that the selection and use of different cues to laryngealization depends partly on linguistic factors, particularly stress, but also shows intra- and interspeaker variation whose conditioning is presumably extralinguistic in nature.

Keywords: laryngealization, f0, voice quality, tone-phonation interactions, stress, word prosody, variation

Introduction

In this paper we explore the role of pitch (f0) in the word-prosodic system of the Uto-Aztecan language Cora, as spoken in the community of Jesús María (Nayarit, Mexico). We henceforth refer to this variety as Mariteco Cora. In an early study of the language, Preuss (1932) made no mention of tone, while Casad (1984, n.d.: 21) posits the existence of an independent tonal system but does not give much detail. Because other Uto-Aztecan languages have been shown to have developed lexically contrastive pitch, for example Huichol (Grimes 1959) and Choguita Rarámuri (Caballero & Carroll, forthcoming), our goal was to follow up on Casad's observations and elucidate the relationship of pitch to other parameters, namely stress and laryngealization.

Based on acoustic analysis of wordlists recorded with two speakers, we propose that there is no tonal contrast independent of the contrast between modal versus laryngeal phonation. The reason for the surface distinction between rising and falling pitch is that falling pitch is one of several possible phonetic cues to vowel laryngealization. Laryngealized vowels can be either stressed or unstressed, but these falling-pitch cues are most salient and are predominantly found in stressed position.

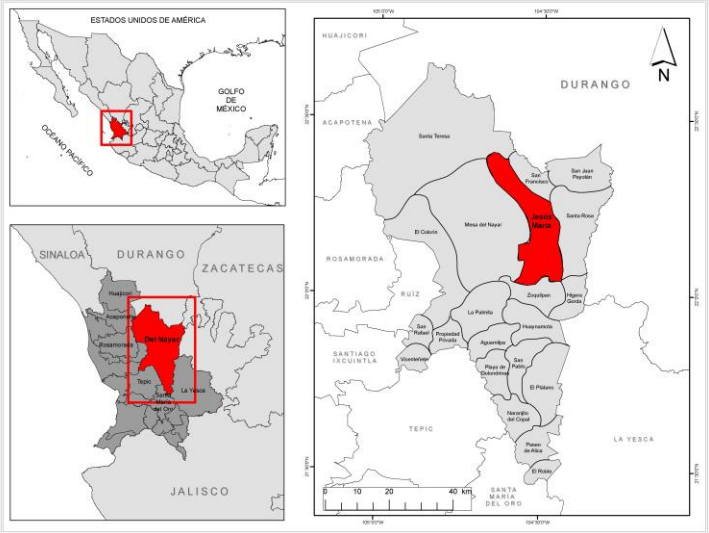
The structure of the paper is as follows. In §1, we give some background on Mariteco Cora phonology and describe our data sources. In §2, we present distributional and phonetic analysis supporting the idea that lexically specific pitch patterns cue modal versus laryngealized vowels, rather than representing a phonologically tone-based or pitch-accent type system. In §3 we describe some parameters that appear to affect the phonetic realization of laryngealized vowels along the voice-quality and pitch-excursion continua. We focus on the phonetic effects of stress alternations and syllable count, while also noting apparent lexical or speaker-specific idiosyncrasies and their possible links to patterns of language variation and change.

* The authors' names appear in alphabetical order. We want to thank Elbanidia Celestino Altamirano and Aurelio Zeferino Melchor. Both worked with us with great patience in the recording of elicited word lists. We also acknowledge the financial support of the Alexander von Humboldt Stiftung that made possible our first working meeting for this paper at the University of Manchester.

1 Mariteco Cora

Cora or Náayeri is a Uto-Aztecan language from the Sonoran family spoken in the state of Nayarit, in western Mexico. There are 20,000 speakers of this language (INEGI 2010), of which around 5,000 speak Mariteco Cora, a dialectal variant spoken by all the inhabitants of the Jesús María agrarian community, situated in the Municipio El Nayar. The maps in (1) show the location of Nayarit state within Mexico (upper left), the location of Municipio del Nayar within Nayarit (lower left), and the location of Jesús María with respect to nearby agrarian communities (right).

(1) Maps of Mariteco Cora territory



The consonant inventory of Mariteco Cora is given in (2), based on the analysis by Valdovinos (2010-2013).

(2) Mariteco Cora consonant phonemes

CONSONANTS		BILABIAL	ALVEOLAR	ALVEO-PALATAL	RETROFLEX	PALATAL	VELAR	GLOTTAL
PLOSIVE	Vl	p pʷ	t tʸ tʷ				k kʷ	
AFFRICATE	Vl		ts	tʃ tʃʷ				
FRICATIVE	vl		s	ʃ				h
	vd	β						
NASAL	vd	m mʷ	n nʸ nʷ					
LATERAL APPROXIMANT	vd				l lʸ			
TAP	vd				ɾ ɾʷ			
APPROXIMANT	vd	w				j		

Among other characteristics of the consonant inventory, there is also a phonemic contrast between apico-alveolar and lamino-alveolar stops, and contrastive secondary labialization is present on just under half of consonants. For orthographic convenience, the lamino-alveolars will be rendered as C^y digraphs, e.g. t^y and n^y.

The vowel inventory is shown in (3). Mariteco Cora has five contrastive vowel qualities [i ɛ a ɨ u]; the open-mid back [ɔ] appears to be restricted to diphthongal combinations where it is followed by [u]. Importantly for our purposes, all five principal vowel qualities come in phonemic modal and laryngealized variants. The laryngealized vowels are transcribed as interrupted vowels. In modal vowels only, Preuss (1932: 4), Casad (n.d.: 14) and Valdovinos (2010-2013) recognize a vowel length distinction, the distribution of which would merit further investigation.

(3) Mariteco Cora vowels

VOWELS		FRONT	CENTRAL	BACK
		UNROUNDED		ROUNDED
CLOSE	[- ATR]	i iː iʼi		u uː uʼu
	[+ATR]		ɨ ɨː ɨʼɨ	
OPEN-MID		ɛ ɛː ɛʼɛ		ɔ
OPEN		a aː aʼa		

The acute accent on vowels (v́) indicates the location of stress. Tones are not expressed on the text, but their shapes are illustrated on the following spectrograms.

1.1 Data and Methodology

For this analysis we used words recorded in isolation obtained from two speakers on two different field trips. One data set was obtained in 2010 by eliciting the 200-word Swadesh list with a 20-year-old woman (Minidisc Sharp 1-Bit Net MD-LP4). From this list, 12 monosyllabic words and 50 disyllabic words, with two repetitions each, were selected for analysis. Other words were set aside for the present study due to morphological complexity, particularly verbal forms, but also some nouns and adjectives that were produced with prefixes. A supplementary wordlist with the same speaker was recorded in order to enable comparison between stressed and unstressed alternants of the same syllable. This list consisted of 32 monomorphemic nouns recorded first in isolation and then with the definite article prefix *ɨ-*, with one repetition each. Because the definite article prefix [ɨ-] is stress-attracting, the noun loses its stress in this construction.

The second data set consists of an elicitation of the lexical list proposed by Haspelmath and Tadmor (2009) adapted by the INALI for Mesoamerican languages, made in 2012 with a 60-year-old man (Edirol by Roland 24 bit WAVE-R09). Each word was repeated three times in isolation in response to a Spanish prompt. A set of 22 monosyllables and 67 disyllables (all monomorphemic) were included in our analysis.

2 Distribution of stress, laryngealization, and falling pitch

2.1 Monosyllables

The monosyllable data consists of 12 words for the younger female speaker and 22 words for the older male speaker, comprising 23 different lexical items overall (since all but one of the younger female speaker's words was also elicited from the older male speaker). The predominant rime shapes and pitch patterns, along with the number of words in each category, are listed in (4).

(4) Rime shapes in monosyllabic words (V=monophthong, VV=diphthong)

	Shape	n =	Tonal profile	Phonation
a.	V(h)	7	Level/rising	Modal
b.	V(h)	6	Falling	Modal ~ nonmodal variation
c.	VV(h)	3	Level/rising	Modal
d.	VV(h)	5	Falling	Modal ~ non-modal variation

The glottal fricative [h] appears in parentheses due to a phonetically variable tendency to devoice the end of a vowel in prepausal position. Only 21 words are included in the table in (4) because two words had nasal codas, [mʷaŋ] 'you, pl.' (falling pitch) and [naiŋ] 'all' (level/rising pitch), were the only ones of their kind. They had modal phonation only and did not exhibit any other unique prosodic characteristics in comparison with the other words.

For both monophthongs and diphthongs, there is a clear split between words with a level or slightly rising pitch, and words with a falling pitch. There is some correlation of pitch with phonation type: the level/rising words are exclusively modal, while the falling-pitch words show variation. The words in each category are listed in (5). Of the 11 lexical items that were produced by both speakers, all were consistent in having the same type of pitch contour in every repetition.

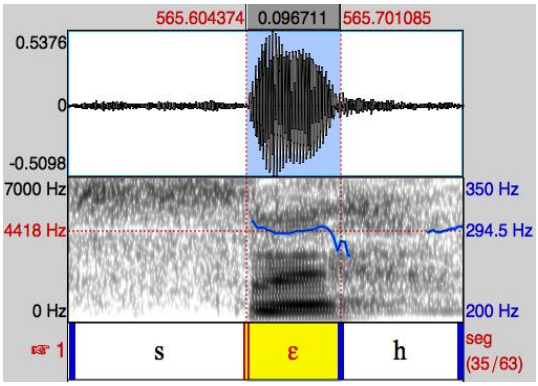
(5) Monosyllables (*=produced by both speakers)

	Level/rising			Falling	
a.	[sɛh]*	'sand'	m.	[mʷa]	'you, sg.'
b.	[hah]*	'water'	n.	[tsɨ]*	'dog'
c.	[heh]	'yes'	o.	[tʃi]	'house'
d.	[haː]	'swollen'	p.	[mu]	'head'
e.	[ɽuh]	'life'	q.	[βɛ]	'big'
f.	[tʸeh]	'long'	r.	[mʷi]	'much'
g.	[taih]*	'fire'	s.	[mʷaŋ]*	'you, pl.'
h.	[tʃʷah]*	'earth'	t.	[weih]*	'fish'
i.	[sɛih]*	'other'	u.	[haɨh]	'ant'
j.	[saɨh]*	'one'	v.	[sauh]	'quail'
k.	[tʷah]	'oak'	w.	[tauh]*	'egg'
l.	[naiŋ]*	'all'			

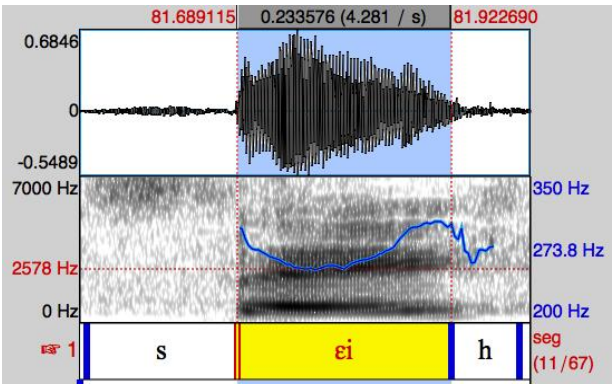
Some representative examples of level/rising pitch from both speakers are shown in (6) and (7).

(6) Level/rising pitch, younger female

a. [sɛh] ‘sand’



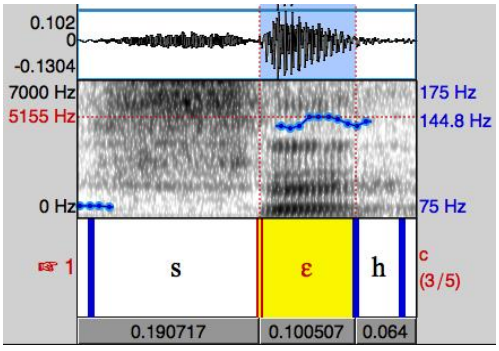
b. [sɛih] ‘other’



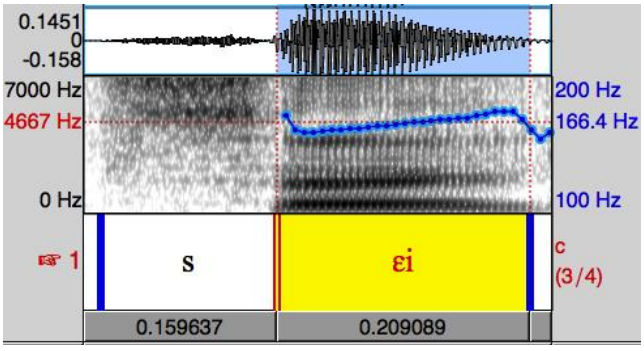
In both (6) and (7) we can observe regular glottal pulses and a lack of sudden amplitude changes, both of which are compatible with modal phonation. Shorter vowel durations carried a level pitch contour while longer durations were associated with rising pitch, as in (6b) and (7b), although there was no clearly discrete difference between level and rising contours, and some phonetic variation could be found between repetitions of the same lexical item.

(7) Level/rising pitch, older male

a. [sɛh] ‘sand’



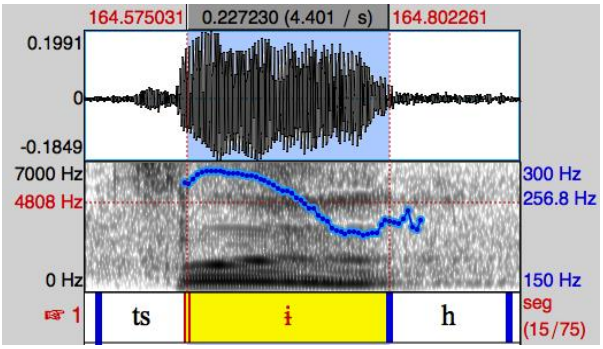
b. [sɛih] ‘other’

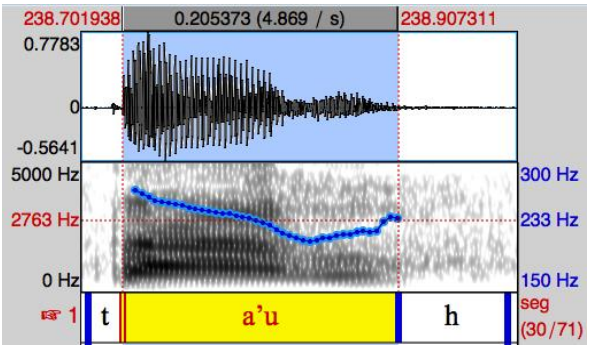


In contrast to the level/rising pitch words with uniformly modal voicing, the words with falling pitch showed variation between apparent modal-voice tokens (8a), and tokens with creak (irregular glottal pulses) and/or sudden amplitude drops (8b). The latter give the auditory impression of laryngealized, “interrupted” vowels. In the apparent modal-voice tokens, with regular glottal pulses, preliminary visual inspection of FFT spectra did not reveal any salient trends in relative amplitude of different harmonics between words with falling pitch and words with level/rising pitch. However, a more extensive study is needed to confirm whether falling-pitch monosyllables do occur with fully modal phonation. For the younger speaker, four of 5 falling-pitch words were of the more modal-like type in all repetitions.

(8) Modal-like and laryngealized falling-pitch words, younger female speaker

a. [tsɨh] ‘dog’ b. [tauh] ‘egg’



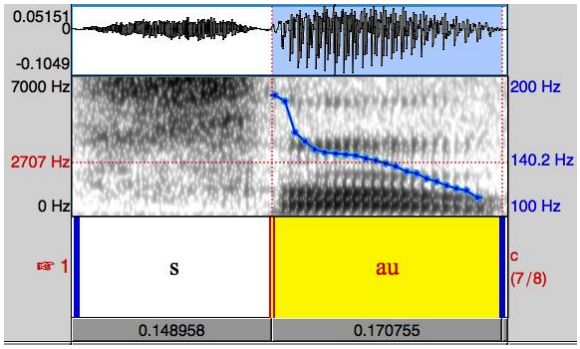


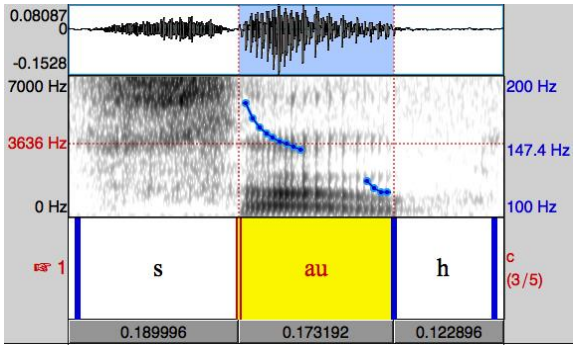
In short, typical acoustic cues to vowel laryngealization are restricted to falling-pitch items in our data. A priori this is not a reason to think that falling pitch, creak, and amplitude drops are in a cue trading relationship, since there could simply be a phonation contrast within the falling-pitch words. However, the older male speaker produces modal-like and clearly laryngealized tokens of the same lexical item across repetitions, leading us to hypothesize that falling pitch and laryngealization are two sides of the same coin in Mariteco Cora.

The illustrations in (9) show two realizations of [sau(h)] ‘quail’ by the older male speaker. The token in (9a) features regular glottal pulses and no obvious amplitude disturbances. In contrast, the token in (9b) has clear creak in the middle of the vowel. The “interrupted” nature of the vowel and reversion to regularity towards the last few glottal pulses suggests that the non-modal phonation here may be lexically specified, rather than being an artifact of the prepausal context. For the older male speaker, there are five words (out of 12 falling-pitch words) where creak is found on at least one of the three repetitions.

(9) Modal-like and laryngealized tokens of the same falling-pitch word, older male speaker

a. Modal-like [sau(h)] ‘quail’ b. Creaky/interrupted [sau(h)] ‘quail’

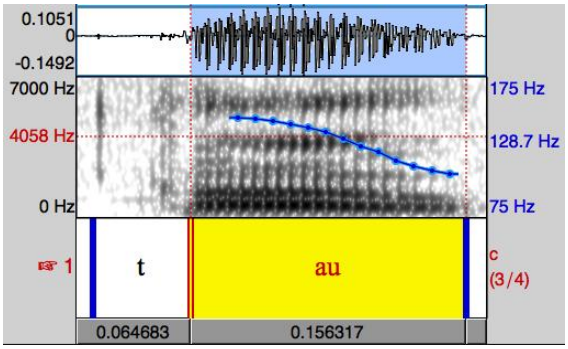




Furthermore, the two speakers display different phonetic strategies on the same lexical item. In (10) we see the older male speaker’s modal-like production of [tauh] ‘egg’, the same word that was

produced as an interrupted vowel by the younger female speaker in (8b). The token shown here is the first of three very similar repetitions of this word.

(10) Modal-like realization of [tauh] ‘egg’ by older male speaker, cf. (8b)



The distributional and acoustic evidence in monosyllables points to a complementarity between falling pitch and vowel laryngealization, such that there is no evidence for a tonal contrast independently of the modal-laryngeal distinction or vice versa. We now turn to disyllables.

2.2 Disyllables

Disyllables introduce the dimension of stress to the analysis. Initial stress and final stress are both found. Cues include a high pitch prominence on the stressed syllable and devoicing of final unstressed vowels; duration also likely plays a role.

We observe that on disyllabic words produced in isolation, the pitch/laryngealization contrasts described in the previous section are found only on initial syllables, whether stressed or unstressed. Stressed final syllables do not show any salient falling pitch or acoustic hallmarks of laryngealization. Unstressed final syllables sometimes have creaky voice, which appears to be contrastive, but as it is difficult to reliably distinguish laryngealization from utterance-final creak in this context, or falling pitch from final lowering, we will not examine these here. The numerical counts of disyllabic words in the dataset in each of three categories – initial stress with level/rising pitch, initial stress with falling pitch and/or laryngealization, and final stress – are given for both speakers in (12).

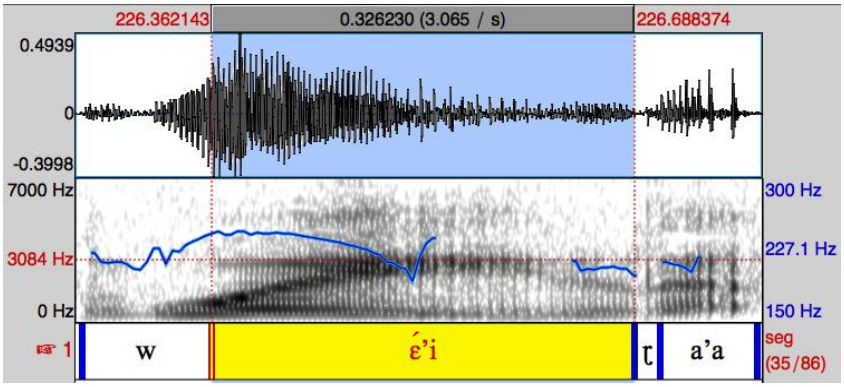
(12) Disyllables: data count

Younger female speaker			Older male speaker		
Initial stress, level/rising	Initial stress, falling/laryngealized	Final stress	Initial stress, level/rising	Initial stress, falling/laryngealized	Final stress
n=24	n=4	n=22	n=25	n=5	n=37

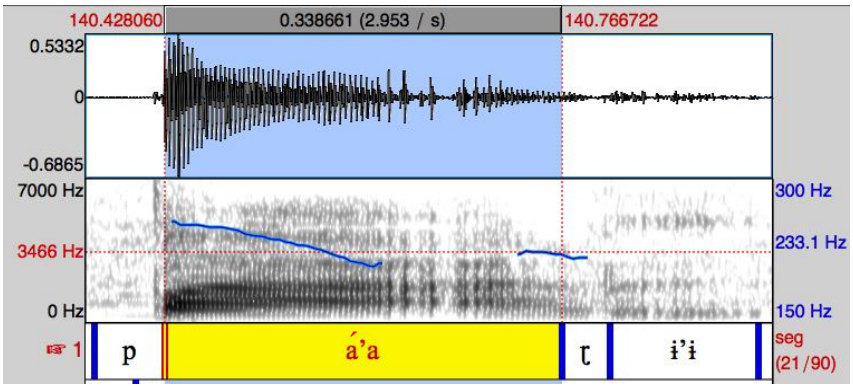
For the younger female speaker, the most striking difference between the monosyllables and disyllables is the consistent use of non-modal phonation in stressed initial syllables of the falling-pitch category. Whereas most falling-pitch monosyllables had modal voice, all repetitions of all four relevant words in the disyllabic category had audibly non-modal phonation in conjunction with falling pitch. Some examples are shown in (13).

(13) Stressed initial syllables with laryngealization and falling pitch, younger female speaker

a. [wɛ́’iɽa’a] ‘meat’



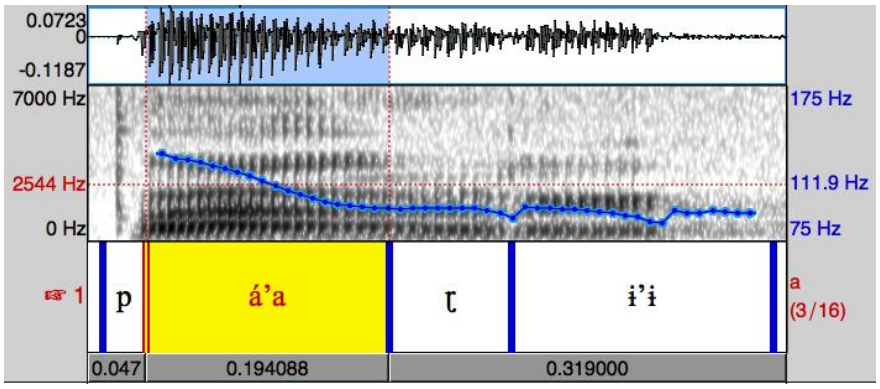
b. [pá’aɽɨ’ɨ] ‘child’



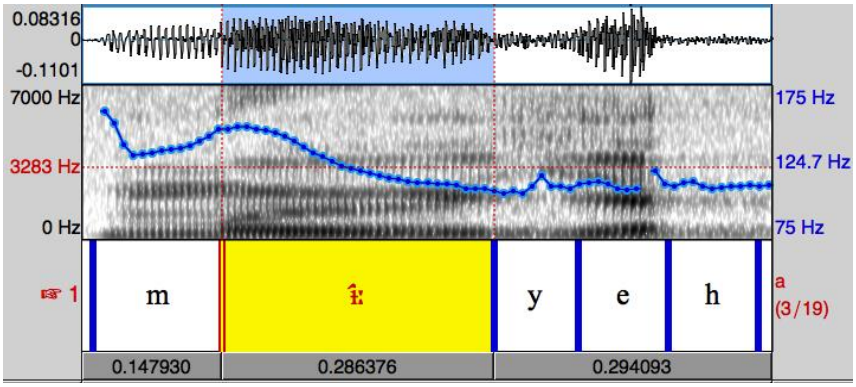
For the older male speaker, whose dataset contained five disyllabic words with stressed laryngealized/falling-pitch initial syllables, the picture is very different. Glottal pulses are regular, and despite some fluctuation in amplitude, sudden amplitude changes comparable to those in e.g. (8b) are not evident. If phonation is not modal, the cues are far subtler than in the younger female speaker’s speech.

(14) Stressed initial syllables with laryngealization and falling pitch, older male speaker

a. [pá’aɽɨ’ɨ] ‘child’



b. [mɨ́ːjɛh] ‘current’

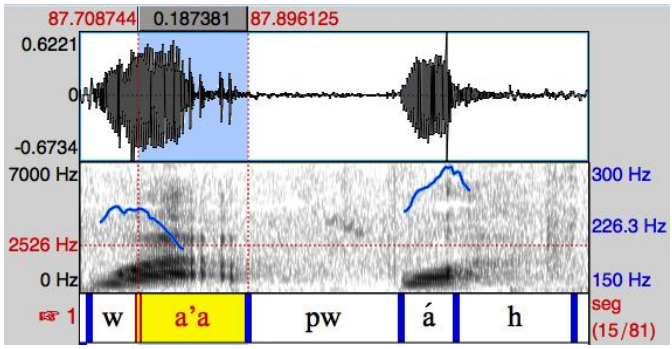


Comparing (14a) with (13b), we see the two speakers’ varying pronunciations of the same lexical item, confirming the variability of acoustic cues to this particular distinction in Mariteco Cora. The remaining lexical items of this type in the older male speaker’s dataset are [ʃáhkaŋ] ‘orphan’, [mí:tʸuh] ‘cat’, and [tú:kah] ‘spider’. All three repetitions of each of the five words resemble the illustrations in (14).

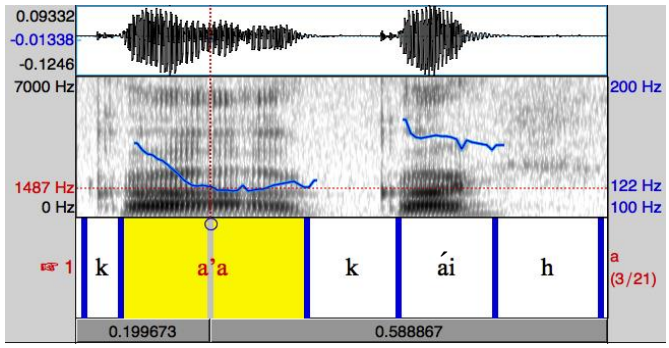
Nevertheless, the two speakers’ behavior converges on final-stress words. Of the words with final stress, a minority have laryngealization/falling pitch on the unstressed vowel in the initial syllable. These comprise two of the 22 final-stress words in the younger female speaker’s data ([wa’apʷáh] ‘two’, [kʷa’atʸíh] ‘soft’), and two of the 37 final-stress words in the older male speaker’s data ([tsɛ’ɛpɛ́h] ‘gnat’, [ka’akáih] ‘huarache’). It is notable that on all repetitions of all of these words, the initial syllable carries both falling pitch and clearly non-modal phonation, either amplitude fluctuations or creak. Some examples are shown in (15). These initial unstressed syllables are distinct from other initial unstressed syllables, which uniformly carry a low level pitch.

(15) Unstressed initial vowels with laryngealization/falling pitch

a. Younger female speaker, [wa’apʷáh] ‘two’



b. Older male speaker, [ka’akáih] ‘huarache’



To summarize, the younger female speaker has a greater tendency to laryngealize vowels via creak and sudden amplitude-change cues in disyllabic words as compared with monosyllables. Conversely, the older male speaker does not use creaky or interrupted vowels in disyllables. However, falling pitch is always present.

3 Linguistic and extra-linguistic conditions on variation

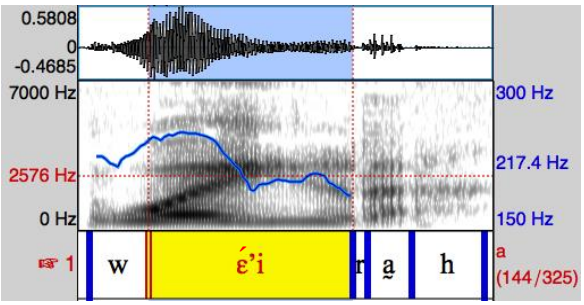
The variation in acoustic cues to phonation in falling-pitch syllables raises the question of what conditions the choice of one phonetic realization over another. Our goal in this brief section is to outline some directions for further research along these lines.

3.1 Stressed versus unstressed syllables

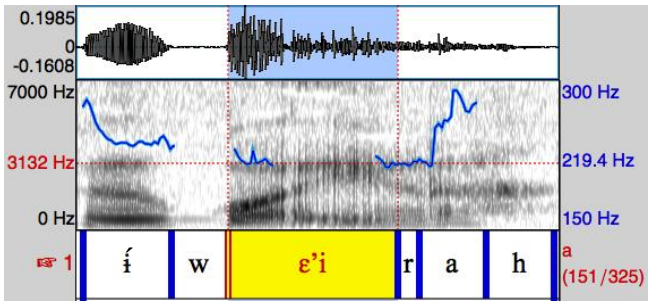
The definite-article dataset recorded with the younger female speaker, where the stress-attracting prefix *í-* was placed in front of various nouns, which then lost their stress, affords a chance to see how stress alternations affect the realization of the vowels in question. In the two examples of stress alternation on words with falling-pitch syllables, there is more pronounced creak in the unstressed context. The waveforms and spectrograms in (16) show the pairs of bare noun (16ac) and definite article plus noun (16bd).

(16) Stress alternations and laryngealization, younger female speaker

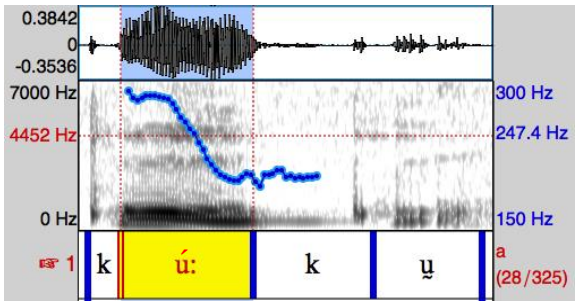
a. [wɛ́’iɽa’a] ‘meat’



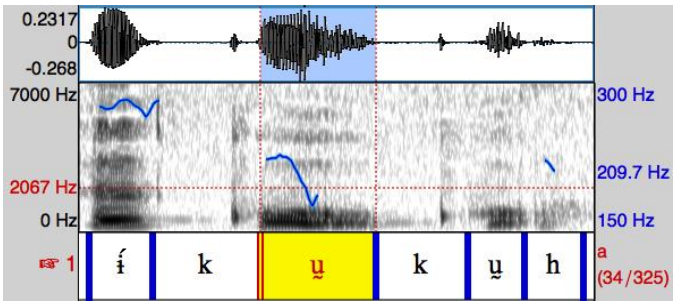
b. [ɨ́ wɛ’iɽa’a] ‘the meat’



c. [kú:ku:] ‘viper’



d. [ɨ́ ku:ku:] ‘the viper’



In the stressed alternants in (16ac), a falling pitch contour is clearly visible, although in (16a) there is a very abrupt change in pitch trajectory along with a sharp decrease in the amplitude envelope; amplitude changes in (16c) are smaller, if still present. Nevertheless, both unstressed tokens in (16bd) have periods of irregular glottal pulses within the vowel. This type of alternation would not necessarily be predicted on the basis of the other results, as the younger female speaker has a tendency to use creaky voice anyway except in monosyllables, but these stress shift behaviors could point to one factor influencing a laryngealized vowel’s realization on the continuum of phonetic possibilities in the language.

3.2 Sociolinguistic factors

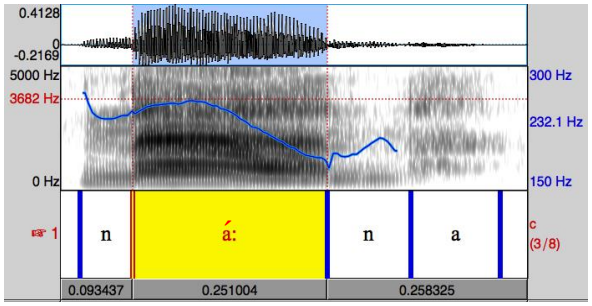
Although this pilot study included only two speakers, it is likely that some aspects of the observed variation in their speech are representative of the age, gender, and/or other relevant groups to which they belong in Cora society. A larger study would be able to establish whether Mariteco Cora is undergoing a language change in progress, either transphonologization of laryngealization and falling pitch (compare Riad 2009 on a link between sharp f0 falls in Swedish and the *stød* phenomenon of Danish) or a redistribution of which cues are used in different phonological contexts.

3.3 Lexical factors?

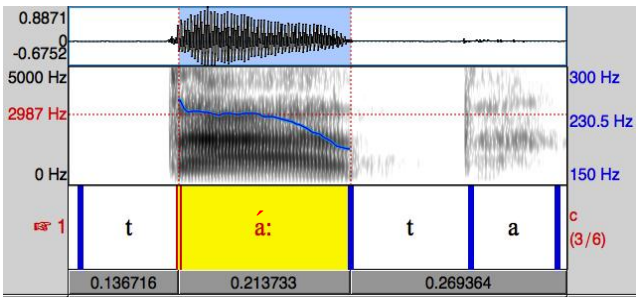
Another possibility is that there are lexically specific tendencies in the realization of laryngealization. For example, in the words for ‘mother’ and ‘father’, the younger speaker produces all repetitions with falling pitch, but without creak, as illustrated in (17). This phonetic strategy runs counter to the younger speaker’s usual habit of producing irregular glottal pulses in conjunction with falling pitch. On the other hand, to the extent that these are reduplicated words, the lack of creak may be connected to this speaker’s dominantly modal-like strategy for monosyllabic words as seen in §2.1.

(17) Lack of creak in [ná:na] ‘mother’ and [tá:ta] ‘father’

a. [ná:na] ‘mother’



b. [tá:ta] ‘father’



4 Conclusion

Our findings open a number of puzzles for future research. No laryngealization contrasts were observed on stressed final syllables of disyllables in isolation, possibly due to final neutralization processes affecting vowels. For a full picture, it is therefore important to study the realizations of these words in suffixed, phrase-medial, and other non-pre-pausal contexts. Phonetically, the discovery of variation in laryngealized-vowel realizations raises the question of what exactly the relevant cues are. Detailed quantitative work, incorporating additional potential cues such as amplitude and spectral tilt, will be a prerequisite to the kinds of perceptual studies that can resolve these issues, given that cues can be highly variable and subtle (Blankenship 2002, Gerfen and Baker 2005). Lastly, the Cora case may shed light on diachronic pathways around vowel laryngealization, as well as on the study of synchronic relationships between different word-prosodic parameters.

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