THE PHONETIC STRUCTURES OF OAXACA CHONTAL

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Abstract

The first description in any detail of aspects of the phonetic structures of the highly endangered Lowland variety of Oaxaca Chontal is presented. The paper includes measurements of the characteristics of the vowels, and a survey of the principal features of the consonant system. Particular attention is paid to the series of glottalized obstruents and sonorants, which vary a great deal in their manner of articulation and the nature and timing of the accompanying glottalization. The relative frequency of different realizations of the glottalized obstruents mirrors the cross-language frequency of glottalized consonant types. Glottalized sonorant realizations cannot be predicted from their position in the syllable. Individual speakers frequently vary when producing consecutive repetitions of the same word. Such a large range of variation may be partly due to an ongoing process of language attrition.

Keywords
Oaxaca Chontal, phonetics, glottalized consonants, language attrition

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1 Introduction

In this paper we present the first description of any detail of the phonetic structures of Oaxaca Chontal, the indigenous language of the region known as the Chontalpa, which lies in the Yautepec and Tehuantepec districts of southeastern Oaxaca state, Mexico. This location is shown in Figure 1. The classification of Oaxacan Chontal remains disputed, but it is frequently included as a member of the proposed Hokan stock, mostly spoken north of the Mexican border. Typologically it shares a number of traits with the other languages of the Mesoamerican area (Suarez 1983, Campbell et al 1986), although unlike many of its neighbors its phonology involves neither tone nor phonation contrasts on syllable nuclei. To avoid confusion is should be noted that the name Chontal, a Nahuatl word meaning ‘stranger’, is also used for one of the languages in the

Cholan subgroup of the Mayan family. This 'Chontal of Tabasco' is unconnected to Oaxaca Chontal.

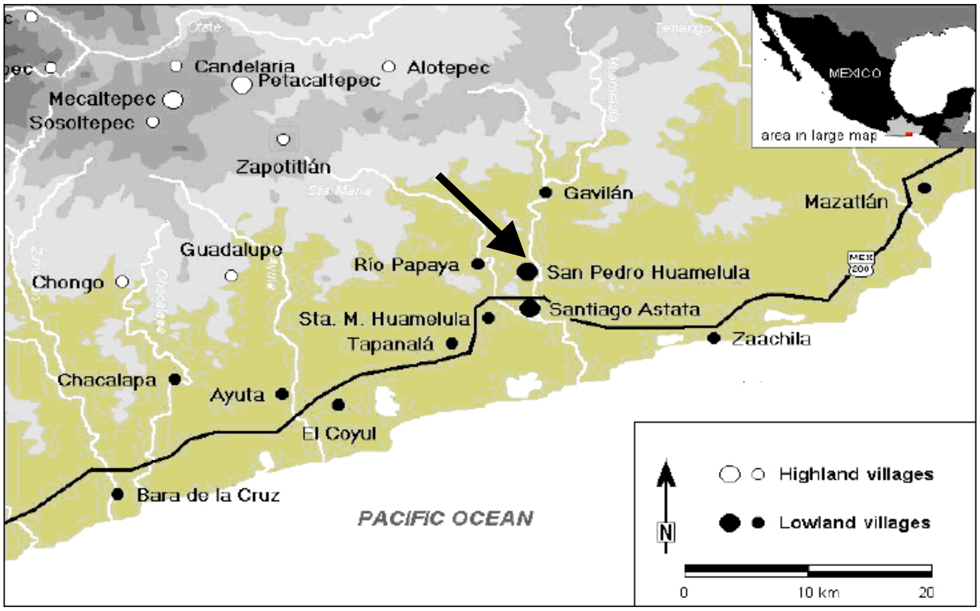


Figure 1 approximately here.
Map showing Chontalpa region of Mexico (courtesy of Peter Kröfges)

The Lowland variety of Chontal was spoken in the coastal municipalities of Astata and San Pedro Huamelula and a few smaller outlying settlements in the south of Oaxaca (shown in the enlarged section of Figure 1). Today rather few people retain a good command of the language and its further survival is doubtful. There is also a Highland dialect, described by Turner (1966), which has limited mutual intelligibility with the Lowland variety. Highland Chontal, also known as Sierra Chontal, is generally agreed to be more conservative than Lowland Chontal (Turner 1979, Waterhouse 1979, Langdon 1996). It too is endangered. A third variety, described by de Angulo & Freeland (1925), was formerly spoken around the town of Tequisistlan but is now extinct. This was closer to the Lowland than to the Highland variety (Waterhouse 1985). It is this variety that is the origin of the name Tequistlatecan sometimes used to refer to the Chontal dialects as a whole (following Brinton 1890). The division between Lowland and Highland Chontal goes back at least to the time of the Spanish conquest, and most likely existed considerably earlier (Bartolomé & Barabas 1996, Winter 1986, Kröfges 2004).

Lowland Chontal is clearly a highly endangered language. There were about 900 self-declared Chontal speakers among the 15,000 or so ethnic Chontals counted in the 1990 national census of Mexico, but the 2000 census identifies a highly improbable increase to 4959 speakers (INEGI 2003).. More realistic is the total of 394 fluent speakers of Oaxaca Chontal varieties identified in a count performed by the *Instituto Nacional Indigenista* in 1990 (INI 1993). There is a larger community of semi-speakers with various levels of linguistic ability. At the time of the field work on which the present report is based, December 2003, we were unable to identify any individuals for whom Chontal was the primary language. Even elderly married couples, both of whom had good command of the language, reported that they habitually spoke to each other in Spanish. There are no known monolinguals in Lowland Chontal and no children learn it as a first language. Our impression is that limited use of the language over a considerable period of time has affected its phonetic patterns, as well as all other levels of the grammar (cf Waterhouse 1949).

The present sociolinguistic situation is marked by the dominance of Spanish, which pervades the media, the school system, the workplace, the government, and the home (O'Connor & Kröfges 2003). Chontals must speak Spanish to participate fully in the larger national society, and literacy is normally in Spanish. Most children and young adults are literate in Spanish, but most elderly Chontals are not literate in any language. Semi-speakers with some literacy in Chontal are also literate in Spanish. The most common current public use of spoken Chontal is in ritual speech related to harvest, weather, and well-being, where it serves as a sign of ethnic authenticity (O'Connor, 2004). Although fluent conversation in Chontal is rare, simple greetings or observations in Chontal typically receive replies in the same language. Transmission of the language across the generations was in fact actively discouraged through the education system until rather recently, and the bilingual education programs that exist in several area elementary schools operate with small budgets, teachers with minimal training, and a lack of appropriate linguistic materials. Through these programs students are taught words and phrases as well as extracts of poetry and songs to perform in competitions, but have no real opportunity to reach fluency.

Apart from Belmar's study of Highland Chontal (1900), documentation of Chontal varieties before the 1920's consisted mainly of short wordlists. Belmar's work is described as a grammar by Waterhouse 1962 but is listed as only containing phrases, stories and vocabulary in the catalog entry of the Bibioteca Nacional.of Mexico. Over the last 50 years substantial linguistic work on Lowland Chontal has been published covering phonological, grammatical and discourse features, as well as some historical and sociolinguistic issues (Waterhouse 1949, 1957, 1962, 1967, 1969, 1976, 1985, Waterhouse & Morrison 1950, O'Connor 1999, 2000, 2004). The Highland variety of Chontal has been studied by Turner (1966, 1967b) and by Waterhouse in collaboration with Muriel Parrott (Waterhouse & Parrott 1970, Parrot and Waterhouse 1975).

In addition to her descriptive work Waterhouse produced some booklets for primary education and translated portions of the New Testament. The creation of a practical orthography for Chontal continues to present a challenge. Chontal has a considerably larger number of distinct consonant phonemes than Spanish, which makes the use of a Spanish-based orthography problematical. Yet for practical reasons an orthography consistent with Spanish usage is desirable. The phonological patterning of the language also results in the occurrence of certain salient types of sounds which have sometimes been written with distinct symbols, but which may not be contrastive. We will mention some of these issues in the presentation below.

There is no consensus as to whether the genetic relationship of Chontal to other languages has been satisfactorily demonstrated. It was included as part of the proposed Hokan stock in the early classifications of Kroeber (1915) and Sapir (1918), which grouped together a number of small language families and isolates of California and northwest Mexico, most notably the Yuman and Pomo languages. A relationship with Yuman has earlier been proposed by Brinton. The validity of Chontal's inclusion in Hokan has been debated somewhat inconclusively since then (see, for example, Waterhouse 1976, Turner 1967a), sometimes in the context of a wider discussion of whether any genuine Hokan linguistic stock exists at all (Kaufman 1988, Poser 1995, Campbell 1997, Mithun 1999). Oltrogge (1977) suggested a particularly close affiliation of Chontal with Tol (also known as Jicaque) and the now-extinct Subtiaba, two languages of Nicaragua. Greenberg and Swadesh (1953) had earlier proposed the affiliation of Tol with Hokan, which seems to lead to the proposal by Suárez (1983) of a "Tequistlatec-Jicaque" family.

2 Data and materials

This report is based primarily on a short period of fieldwork conducted in San Pedro Huamelula by the first two authors in early December 2003. During this period, a number of elders with good command of Lowland Chontal were interviewed and their production of a selected list of words observed and recorded. The selection of items to record was guided by the insights provided by the earlier work of Waterhouse and also draws heavily on ongoing study by the third author. A total of eight speakers were recorded, five female and three male. These speakers are identified by codes as F1-5 and M1-3. Five of the recordings were done individually at the speakers' houses, the remaining three speakers were recorded together at the local school. The self-reported ages of these speakers ranged from 61 to 81, with the majority being in their 70's.

The individual recordings were made using a headworn microphone designed to attenuate background noise levels. Using the headmount the microphone can be positioned a few centimeters from the mouth, and a good signal-to-noise ratio often obtained even under unfavorable conditions. The group recording was made using the same microphone taped to a small stick which served as a boom, enabling the microphone to be held near each speaker's mouth in turn. Movements of the boom and the less-controlled mouth-to-microphone distance result in a poorer signal to noise ratio for these recordings. San Pedro Huamelula is a noisy place, where people live close together. There is vibrant bird life, and strong winds blow in from the Pacific Ocean. These factors mean that the recording quality is far from ideal, but the results are nonetheless of high enough quality to serve as the basis for a variety of both qualitative and quantitative investigations of the sound patterns of the language.

In addition to the elders recorded, a group recording was made of six of the teachers involved in introducing some instruction in Chontal under a program designed to encourage bilingual education. The participants ranged in age from 62 to 31 years. Two had grown up in households where they heard quite frequent use of Chontal, but others had had little exposure to the language until their adult years. This recording was designed to provide an insight into which sounds might be considered the most difficult to pronounce for learners of the language.

All recordings were digitized at either 44.1 or 22.05 kHz depending on the intended analysis and the software used, PCQuirer (SCICONRD) or Praat (Boersma & Weenink 2005). Auditory and acoustic analysis of the recordings is supplemented by information provided in the discussions with the speakers, and by the extensive fieldwork (primarily focused on the morphology and syntax of the language, and semantic and pragmatic issues) conducted by the third author.

3 Vowels

The basic vowel inventory of Chontal is straightforward, containing the most common set of five vowels in a 'triangular' arrangement, /i, e, a, o, u/. All of these show some allophonic lengthening in certain environments, frequently in pretonic syllables, but we did not find support for the idea that vowel length is contrastive, as suggested by Waterhouse. For example, Waterhouse (1967) cites /amác'/ 'year', /amáac'/ 'years' (her transcription) among other examples of length alternations in noun plural formation. None of the six speakers from whom we recorded this pair made a distinction between these forms. The mean duration of the vowel in the singular form is 101 ms and in the plural 99 ms (2-4 tokens of each word from each speaker).

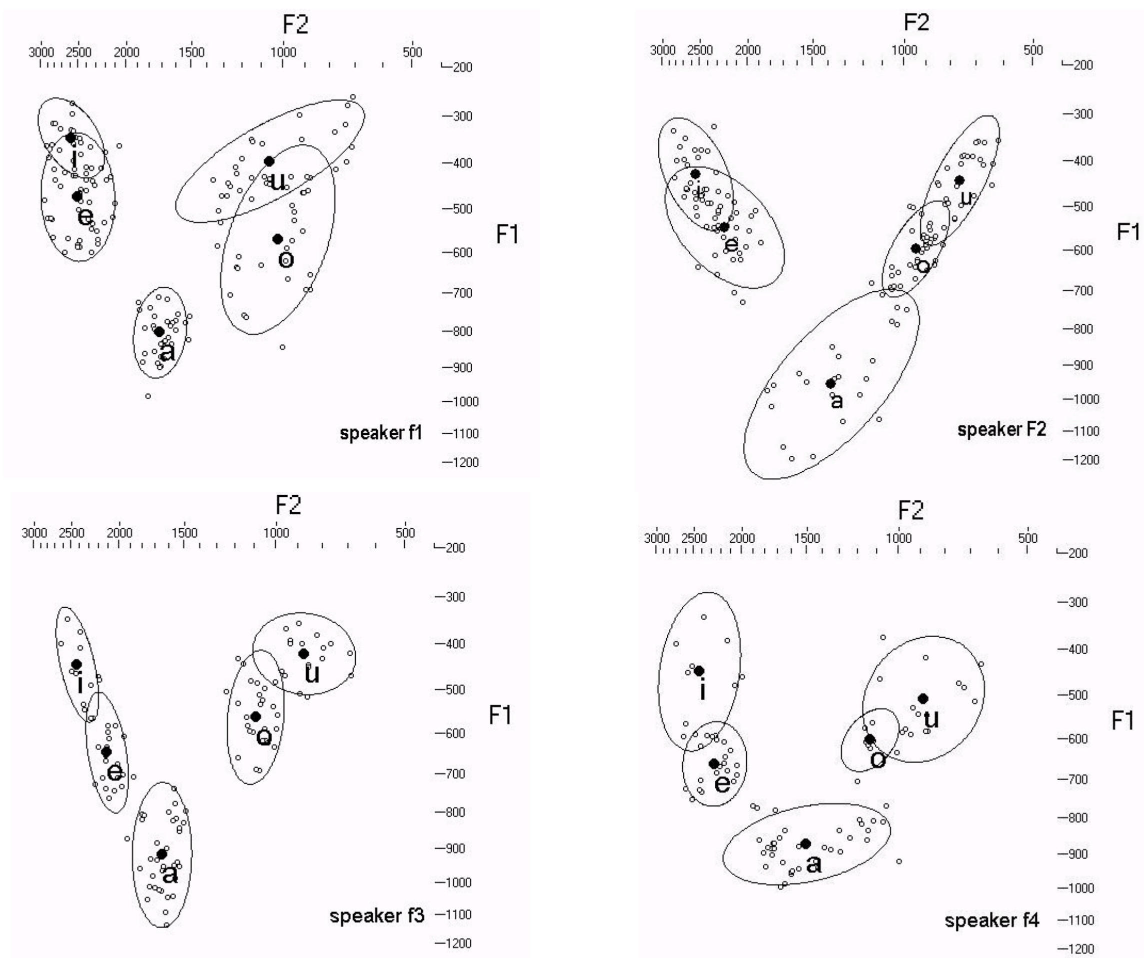
Waterhouse (1967: 352) remarks that /e/ is 'open', and that /a/ "has a raised allophone before /k'/", but that otherwise the vowel symbols represent their traditional phonetic values.. To characterize the qualities of the vowels more precisely, the values of the first four formants were estimated using the LPC analysis in the PcQuirerX program on files sampled at 22,050 Hz. The LPC formant analysis was usually calculated using 14 coefficients but in a number of problematic cases a higher number of coefficients was used. The LPC formant estimates were confirmed by examining a simultaneous FFT spectrum display, calculated over a 23 ms window. Due to voice properties associated with the age of the speakers and/or the noise of the recordings, the higher formants of many tokens were difficult to measure and their values are considered unreliable. Consequently, only values of the first two formants are reported. The usual abbreviations F1, and F2 are used to refer to formants, but context should avoid any confusion with reference to speakers F1 and F2. In general, the formant values were estimated at about the mid-point of the vowel; however, in a number of cases where preceding consonant transitions were long, the formants were measured at a later point where the formant structure was steady.

Vowel formants were measured in stressed syllables in a CV(C) environment. The number of tokens measured varied by vowel and speaker, ranging from a high of 73 tokens of /a/ for speaker F3 to a low of 9 tokens of /o/ for speaker F4. The resulting means for each speaker are given in Table 1.

Table 1. Mean values of F1 and F2, by speaker (*n* = number of tokens).

Females		*n*	**F1**	**F2**	**Males**		*n*	**F1**	**F2**
	i	*18*	345	2605		**i**	*18*	382	2405
	e	*53*	474	2512		**e**	*52*	518	2216
F1	**a**	*34*	807	1718	**M1**	**a**	*43*	818	1576
	o	*29*	575	1028		**o**	*21*	472	888
	u	*28*	397	1076		**u**	*37*	370	808
	i	*25*	430	2551		**i**	*18*	488	2412
	e	*36*	549	2237		**e**	*38*	532	2122
F2	**a**	*27*	960	1402	**M2**	**a**	*56*	753	1554
	o	*35*	599	947		**o**	*14*	491	964
	u	*27*	443	764		**u**	*24*	420	781
	i	*22*	425	2431		**i**	*17*	443	2347
	e	*47*	647	2113		**e**	*39*	558	1984
F3	**a**	*73*	925	1651	**M3**	**a**	*41*	759	1545
	o	*27*	566	1096		**o**	*22*	504	993
	u	*17*	422	878		**u**	*18*	452	841
	i	*15*	448	2457					
	e	*25*	657	2248					
F4	**a**	*41*	876	1541					
	o	*9*	605	1137					
	u	*16*	505	913					
	i	*14*	424	2794					
	e	*30*	597	2497					
F5	**a**	*36*	809	1412					
	o	*19*	589	1127					
	u	*17*	420	921					

The pattern of dispersion of the vowels in an F1/F2 space is shown in Figure 2 individually for each speaker. The ellipses enclose an area defined by axes two standard deviations long on the first two principal components of the distribution for each vowel. There are no indications of sytematic differences between the vowel systems of the female and male speakers in these plots. For all speakers the area occupied by the low vowel /a/ is well separated from the mid vowels, but mid and high vowels generally show some overlap of the areas occupied by the members of the front and back pairs. The observation by Waterhouse & Morrison (1950) and Waterhouse (1962, 1967) that /e/ was realized as an open vowel rather than a close one does not appear particularly to be the case in our data. Averaging across the speaker means in Table 2, /e/ has a mean F1 only about 140 Hz higher than /i/ (567 vs 423 Hz), whereas F1 for /a/ is about 260 Hz higher than for /e/. Thus /e/ is nearer to /i/ than to /a/. Similarly the mean F1 for /o/ is only about 120 Hz higher than for /u/ (550 vs 429 Hz). The overlap in the distributions of the mid and front vowels in both the front and back sets seems due to a relatively high realization of the mid vowels, coupled with absence of particularly high realizations of the high vowels. The front and back members of the high and mid back vowel pairs have very similar F1 values to each other (mean across speakers of 423 Hz for /i/, 429 Hz for /u/; 567 Hz for /e/, 550 Hz for /o/). All other pairwise F1 comparisons across the speaker means are highly significant in an analysis of variance ($p < .0001$) except for these two. This pattern is contrary to a relatively common cross-language tendency for back vowels to have a higher F1 value than front vowels of corresponding phonological height, including in Mexican Spanish (Avelino, to appear).



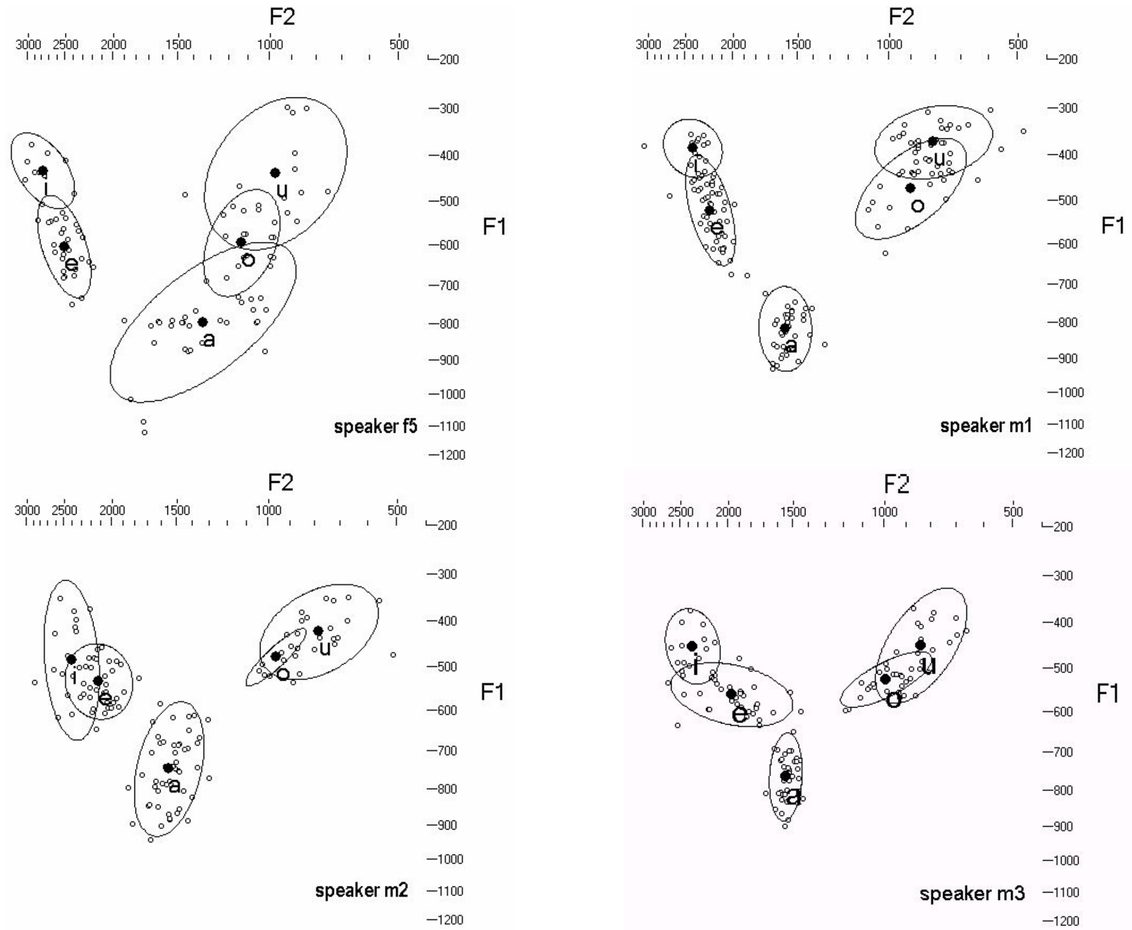


Figure 2 approximately here.
Dispersion of vowels in F1/F2 space, by speaker

We did not observe any salient allophonic variations in the quality of the vowels, and in particular did not detect an audible difference between the pronunciation of /a/ before [k’] and in other environments. Measurements of the first formant frequency of this vowel in words with final [-ak’] in /kosax’/ ‘maize’ and /naxax’/ ~ /n^{j}axax’/ ‘calves (of the leg)’ and with a final open syllable in /tata/ ‘father’ and /wata/ ‘woman’ were compared for the 6 speakers for whom multiple tokens of these words were available. No significant difference was found in the first formant in an analysis of variance with speaker and context as main effects. The mean of speaker means is an insignificant 10 Hz higher before [k’] than in an open syllable, and this small difference is in the direction counter to that predicted by Waterhouse’s claim.

In addition to the five monothongal vowels, a vowel sequence /ai/ occurs in a number of forms, such as the first singular possessive prefix /lai-/. This sequence appears to constitute a single syllable nucleus whose realizations vary from ones in which there are two relatively clear steady states with a short transition between them, to those with a diphthong consisting entirely of transition, to realizations with a single coalesced vowel [e]. Some instances of /ai/ are derived. For example, one pattern of noun pluralization involves a suffix /-iʔ/, which appears with that surface form when suffixed to a consonant-final noun. When suffixed to a vowel-final noun with /a/ as its final vowel our speakers showed three patterns. For some, a vowel sequence or diphthong is retained. For some, a 'compromise' vowel /e/ is produced. But for some the suffix vowel replaces the stem-final vowel. Thus pronunciations of /aw'a + iʔ/ 'child (pl)' from different speakers varied between [aw'aiʔ], [aw'eʔ] and [aw'iʔ] (these transcriptions ignore variation in /w'/).

4. Consonants and consonant processes

4.1 Consonant inventory

Waterhouse (1962, 1967) analyzes the Lowland Chontal consonant inventory as containing 34 consonants. Table 2 shows the non-glottalized consonants that she recognizes and Table 3 gives the glottalized consonants. Her chart has been re-arranged to display the categories of segments more clearly, as we interpret her descriptions, and her symbols have been replaced by IPA equivalents where appropriate.

Table 2. Lowland Chontal non-glottalized consonant phonemes (after Waterhouse 1967)

	bilabial	labiodental	alveolar	palatalized alveolar	palato-alveolar	palatal	velar	glottal
plosives	p b		t d	tʲ			k g	ʔ
affricates			ts		tʃ			
fricatives		f	s		ʃ		x	
nasals	m		n	nʲ				
lateral fricatives			ɬ	ɬʲ				
lateral approximants			l	lʲ				
trill			r					
flap			ɾ					
central approximant	w					j		

Table 3. Lowland Chontal glottalized consonant phonemes (after Waterhouse 1967)

	bilabial	labiodental	alveolar	palato-alveolar	velar
ejective stops					k'
ejective affricates			ts'	tʃ'	
glottalized fricatives		f'			
glottalized lateral fricatives			ɬ'		
glottalized nasals	m'		n'		
glottalized lateral approximants			l'		
glottalized central approximant	w'				

There are a number of points to note about the inventory shown in these charts. As we will discuss more fully below, the occurrence of the palatalized alveolars and palato-alveolars is largely predictable from vowel environment. Interestingly, Waterhouse does not note palatalized counterparts of any of the glottalized alveolars, apart from her [tʃ'], but we believe they occur in parallel environments. We will also elaborate below on the realization of the glottalized obstruents. Waterhouse does not use the term 'ejective', but we have interpreted her use of the transcriptions < c', č', k'> as implying that she viewed this manner of production to be most typical of these segments. She uses fricative symbols for the segments she transcribes as < f', ɬ' > but her text describes these as being "glottalized affricates", leading to the transcriptions <pɸ', tɬ'.> used in Suárez (1983). The glottalized obstruents are phonologically related to the plain fricatives, and are quite variable in their realization. Because of their connection to plain fricatives we propose for phonological purposes that the best transcription would represent them all with fricative symbols. We did not find a contrast between trill [r] and flap [ɾ], as she reports, but cannot categorically assert that it does not exist. It may occur because of borrowing from Spanish

The glottal stop is contrastive in word-medial and final positions, but not initially. An utterance-initial vowel has a glottal stop onset, but this is not part of the phonological structure of the word, as is shown by its general absence when a consonant precedes a word beginning with a vowel, and the choice of the variant /l/ of the definite marker on nouns, rather than the pre-consonantal form /el/. Waterhouse classes the glottal stop with the glottalized consonants on distributional grounds, but the others occur distinctively in word-initial position.

The segment /n/ is regularly pronounced as a velar nasal ([ŋ]) in coda position unless a coronal consonant follows, in which case it is generally but not invariably homorganic with that consonant. In their 1950 article Waterhouse and Morrison had recognized a voiceless counterpart of /n/, as well as voiceless approximants /j̥ / and /w̥/. In later work these elements are correctly reanalyzed as sequences of /x/ and a voiced segment, which is their phonetic nature as well as the appropriate phonological interpretation. Chontal phonotactics permits quite a variety of consonant clusters in onset and coda positions, as well as word-medially across syllable boundaries. The consonant inventory given by Suárez (1983: 36) includes the spurious voiceless segments /n̥/, /j̥ / and /w̥/.and hence leads him to credit Chontal as the language with the largest number of consonants in Mesoamerica.

In the following sections we will provide some detailed phonetic information on several aspects of the consonant realizations of Chontal, including the voice onset time of voiceless plosives, the palatalization process, and the realization of the glottalized consonants in both the obstruent and sonorant categories, so that the phonetic patterns of this language can be compared with others, and related to proposed universals.

4.2 Voice Onset Time and Closure Duration

The plosives of Lowland Chontal occur in voiceless/voiced pairs at three places of articulation, bilabial, alveolar and velar. The voiced members of these pairs are frequently pronounced in intervocalic position with incomplete closure, producing lightly fricated or approximant variants in a manner not unlike that of the voiced stops of Spanish. The closure duration and voice onset time (VOT) was measured for the voiceless plosives using simultaneous displays of waveforms and spectrograms of words containing intervocalic examples. The majority of the words contain the target consonant before /a/ in a stressed syllable. The number of tokens measured ranges from a low of 3 for /k/ from speaker F5 to a high of 13 for /p/ from speakers F2 and M3. Figure 3 shows the mean durations for all speakers averaged across the individual speaker means, so that each speaker contributes equally. The mean closure duration for bilabial stops is significantly longer than that of either alveolar or velar stops in a post-hoc comparison of means using Scheffé's test and the VOT is significantly longer for velars than for alveolars or labials (the significance level is set to $p < .05$). The fact that the closure duration is shortest for velars may be partly due to the fact that the only words available with intervocalic /k/ are /ǎkaˈnʼoʔ/ ‘woman’ and /akaɬˈnoʔ/ ‘women’, where /k/ is the onset to an unstressed syllable, and the closure duration of /p/ may be longer in part because of the high proportion of monosyllabic stems measured, such as /paɬ/ ‘tongue’ and /peɬ/ ‘leg’ (produced with the first person possessive prefix /lai-/), which seem to have a higher level of stress.

Nonetheless these results are consistent with the well known relation across languages between place of articulation, closure duration and VOT (Maddieson 1997, Cho & Ladefoged 1999). In almost all languages in which VOT has been examined it is reliably shorter for bilabials than for velars, with coronals often having an intermediate value between these two. There is also often an inverse correlation between a plosive’s closure duration and its VOT, with bilabial closures reliably longer than velars, and coronals often intermediate. This pattern is reflected in the results in Figure 3, but the magnitude of the closure duration differences is much larger than the differences in VOT. Hence the total duration of /p/, summing both closure and VOT, is considerably longer than that of /t/ or /k/.

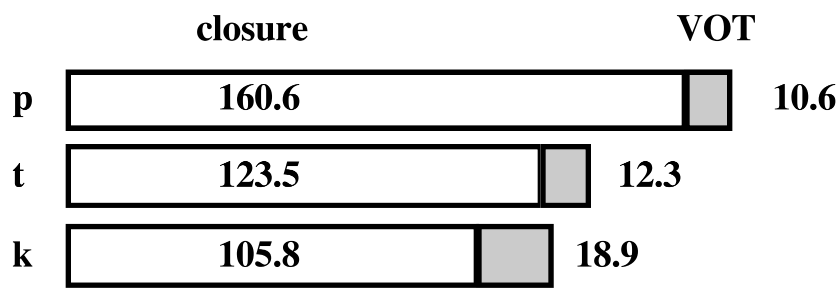


Figure 3 approximately here.
Mean closure duration and voice onset time of intervocalic voiceless plosives.

There are some indications that the cross-language durational patterns related to place found in plosives are echoed in ejective stops (Maddieson 2001). Since Chontal does not have an ejective stop series this issue cannot be investigated in the language. However, as we will describe in more detail below, the realization of the glottalized velar obstruent /x’/ of Chontal is frequently as an ejective velar stop, [k’], enabling timing patterns in [k] and [k’] to be compared. The VOT and closure duration of tokens with this variant were obtained from the forms [ʔaxa k’eduj] ‘s/he brings water’ and [ʔajwalak’ex] ‘deer, wild horse’ and further values of VOT from [k’enʔajuj ʔaxa], also meaning ‘s/he brings water’. The data is from five of the eight speakers (30 tokens total from speakers F2, F4, M1, M2, M3). Voice onset time in ejective stops is measured as the interval from the oral release to the onset of the vowel (as in Maddieson 2001), not to the glottal release as has sometimes been done (e.g. McDonough & Ladefoged 1993). The mean closure duration of velar ejective stops is 108 msc, which is very close to the value obtained for the corresponding plosive, whereas the mean VOT for the ejective at 44 ms is more than double that for the plosive.

A small-scale comparison of timing in pulmonic affricates [ts, ts^j] and ejective affricate realizations of /s’/ was also conducted. Suitable tokens for this comparison were only available from two speakers (F1 and M1). The mean closure duration and the mean duration of the following frication plus any voice onset delay are very similar across the two types The similarity of the frication plus VOT durations is consistent with the expectation of a shorter frication duration in an ejective due to limited available air volume which could be ‘compensated’ by a longer delay before voicing begins, as observed for the velar ejective stops.

4.3 Palatalization

Waterhouse recognized five “alveopalatal” consonants. We would rather describe these sounds as palatalized alveolar segments, and would accordingly write them as < t^j, ts^j, ɬ^j, n^j, l^j >. In Waterhouse’s account, these palatalized segments contrast with plain alveolars and can occur both directly before a vowel or preceding a palatal approximant. Although our investigation did not allow an in-depth investigation of their distribution, it is clear that a great majority of the occurrences of palatalized segments can be predicted from the environment. However, some instances of /ts^j, n^j/ in unexpected environments were noted. This may have some connection to speakers’ familiarity with Spanish whose inventory includes /tʃ/ and /ɲ/ (Mexican Spanish does not include the palatal lateral /ʎ/).

Waterhouse noted that “palatalization occurs after high vowels and *y*”(i.e. /j/), but to us it appears that either a preceding or a following high vowel conditions the palatalized variant of any of these alveolar segments. This process is active in the phonological patterning of the language. For example /tata/ ‘father’ is pronounced with an initial plain alveolar plosive after the 2nd sg prefix /lo-/, but as [t^{j}ata] after the 1st sg prefix /lai-/. Speakers’ awareness of the distributional limitations is demonstrated by the fact that Spanish loanwords are made to conform, as, for example, /an^{j}ima/ ‘heart’ (from Spanish *anima* ‘spirit’), as well as by pronunciations such as [bain^{j}a] for Spanish *baña* ‘bath’ in the Spanish of Chontal speakers reported by Waterhouse (1961). We measured the effect of plain vs palatalized alveolars on the onset of the lowest two formants of the first /a/ of /-tata/ in at least 3 repetitions of ‘your father’ and ‘my father’ from 6 speakers. The onset of the first formant is significantly lower and the onset of the second formant significantly higher after [t^j] than after [t], yielding a much greater interval between the two formants, as shown in Figure 4. The mean F1-F2 difference is 1737 Hz at the vowel onset after [t^j], compared with 1046 Hz after [t] (mean of speaker means). The third formant values show only a small difference.

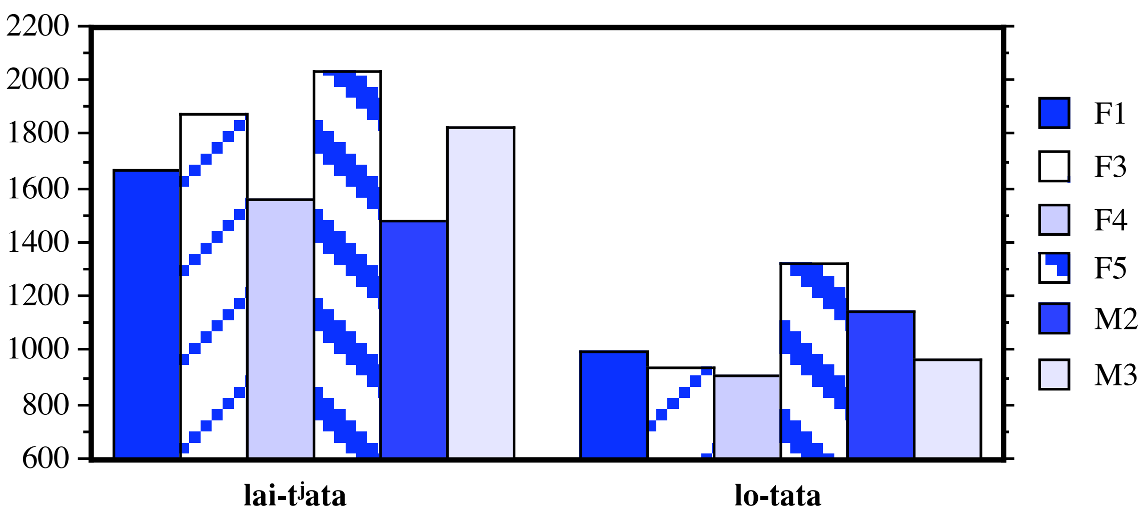


Figure 4 approximately here.
Difference between first and second formant at onset of /a/ in /lai-tata/ ‘your father’ (on left) and /lo-tata/ ‘my father’ (on right) for 6 speakers

Formant values were also measured at the onset of /u/ after the palatalized alveolar stop in [at^{j}u] ‘fish’. Despite the inherently low second formant in this vowel, at the onset a higher value was found than for /a/ after plain [t]. The mean difference between F1 and F2 at the onset of /u/ in this context is 1582 Hz — more than three times the difference found at the vowel's steady state which is 450 Hz (mean of speaker means in both cases).

By omitting palatalized counterparts of the glottalized alveolar consonants, Waterhouse implies that the palatalization process does not apply to glottalized segments. We found this to be incorrect, although the phonetic effects of its presence may be auditorily more subtle than with the plain segments. This is because the presence of a glottal constriction can increase the temporal separation of the palatalized articulation from the vowels whose modified formant transitions are the most salient cue to palatalization. Palatalized variants of glottalized segments were observed in words such as /muɬ'a/ 'moon' (see Figure 12 below), and /axuɬ'/ 'house'. In a limited comparison of data from speaker F3, the mean offset of the second formant in the /u/ in four repetitions of the latter word is 2271 Hz, in comparison with 1794 Hz at the offset of /o/ in three repetitions of /imoɬ'/ 'sheep (pl.), goats'. The much higher F2 before the consonant after /u/ is attributable to palatalization of the consonant. In the steady state portion of vowels, this speaker has a mean second formant in /u/ about 200 Hz ***lower*** than that in /o/.

4.4 Glottalized obstruents

Chontal has a single series of glottalized obstruents which vary considerably both in their manner of oral articulation and in the nature of the accompanying glottalization. The variants range over fricative, affricate and stop realizations; the glottal constriction may be complete and the larynx raised to produce a true ejective or there may be no larynx raising and varying degrees and timing of a glottal constriction. These variations constitute one of the most intriguing aspects of Chontal phonetics.

The glottalized obstruents are contrastive but are clearly related in the morphophonology to the plain voiceless fricatives of the language and we therefore transcribe them in broad phonological notation with the fricative symbols plus a diacritic to indicate glottalization, i.e. as /f', s', ɬ', x'/. The relationship is demonstrated by one common noun plural formation process which adds glottalization to a final consonant (eg. /apix/ 'stone', /apix'/ 'stones', /ex/ 'tree, stick', /ex'/ 'trees, firewood'). After a vowel the same plural morpheme is realized as a glottal stop (eg. /u/ 'eye', /uʔ/ 'eyes'). Sequences of separate voiceless fricative + glottal stop also occur which are never realized as glottalized obstruents (e.g. /asʔuɬ/ 'mouse', /asʔe/ 'atole').

Our recordings were analyzed in order to determine the influence of two parameters on the distribution of the variants in pronunciation of the glottalized obstruents. The first factor is the place of articulation of the consonant — labial, coronal or dorsal, with the coronals further distinguished by laterality. The second is position in the word, whether initial, medial or final.

All word tokens containing glottalized obstruents were examined by the first two authors using visual displays of waveforms and spectrograms and careful listening, and a consensus classification of each glottalized obstruent was reached. The segments were classified as to whether they were ejective or not in their initiation, whether they were fricative, affricate or stop in manner, and in the non-ejective cases whether glottalization was apparent at the onset of the consonant, at its offset, or at both.

Ejectives were identified by a combination of their auditory characteristics, particularly of their releases, and visible features of the acoustic displays. By an ejective we mean a segment in which larynx raising with the glottis closed provides the source of energy for any burst or frication noise. Ejectives necessarily have a full glottal closure which is maintained until after any oral constriction is released. This creates a (nearly) silent interval following the oral release. A following vowel will generally have an abrupt onset. In utterance-final cases a separate release of the glottal closure can often be seen in the acoustic displays. The glottal closure may be completed before the oral constriction is made; in such cases a preceding vowel will terminate in a way that looks like a transition to a glottal stop, for example, showing reduced extents of formant transitions compared to a transition to an oral closure. Ejectives also have characteristic release bursts, which were attended to in the auditory evaluation. In our specifically phonetic (as opposed to phonological) transcriptions ejectives are the only segments marked with the diacritic [’].

The glottalized obstruents that are not ejective involve a full or partial glottal constriction with the source of any air flows and pressures developed being pulmonic. A full glottal constriction creates a silent interval. A partial constriction is apparent from periods of laryngealized phonation which are generally characterized by longer period duration as well as by high-amplitude onsets and high damping of formant resonances. This creates a characteristic spectrographic image with salient vertical striations. Laryngealized phonation may occur by itself or as a zone of transition between a complete glottal closure and modal phonation. The tokens were classified as having pre- or postglottalization or both. The phonetic notation repesents these distinctions by placing the glottal stop symbol, [ʔ], before any symbols representing the place and manner of the consonant, or after them or in both positions. No attempt is was made to distinguish between obstruent tokens with complete versus partial glottal constriction — the occurring tokens range along a continuum between these.

The classification according to constriction type is independent of the classification according to glottal activity. Tokens with an obvious oral closure and no salient frication of the release were classed as stops, tokens with an oral closure followed by homorganic frication were classed as affricates, and tokens with frication not preceded by an oral closure were classed as fricatives. Plain stops, affricates and fricatives with no sign of glottalization were discarded from further analysis, being regarded as pronunciation errors.

In some cases, poor signal-to-noise ratios or confounding factors in the signal itself, such as an overall constricted voice quality, made a classification of particular tokens impossible to reach. In addition, it must be recognized that the segmental context in which a particular segment occurs may not reveal its articulatory character when only acoustic and auditory cues are being evaluated, and the probability of certain classifications is obviously affected by this. For example, preglottalization of an utterance-initial fricative may not be recognized even if present.

The classification resulted in six primary phonetic categories of glottalized obstruents being established. These are laid out in Table 4 below, together with the phonetic symbolization employed, using the labial place symbols as representative. Fricatives with all three timings of glottal constriction were observed, those with both pre- and postglottalization being the most surprising in view of the multiple adjustments of glottal position over a short time interval required. Very few ejective fricatives were detected. Post-glottalized and ejective affricates and ejective stops were also observed, but no tokens of the other potential types, such as postglottalized stops or pre- and postglottalized affricates.

Table 4. Categories of glottalized obstruents

Category label	symbol	Characteristics
1. Postglottalized fricative	fʔ	frication followed by glottal constriction
2. Preglottalized fricative	ʔf	frication preceded by glottal constriction
3. Pre- and postglottalized fricative	ʔfʔ	frication preceded and followed by glottal constriction
4. Ejective fricative	f'	frication generated by accompanying glottal closure and larynx raising,
5. Post-glottalized affricate	pfʔ	oral closure released into frication and followed by glottal constriction
6. Ejective affricate	pf'	oral closure with accompanying glottal closure and larynx raising, released into frication with continuing glottal closure
7. Ejective stop	p'	oral closure with accompanying glottal closure and larynx raising, released with continuing glottal closure

The distribution of these six types of glottalized obstruent realizations in our data was examined according to two of the factors mentioned above, namely, which of the four phonological consonants is concerned, and the position of its occurrence in a root word. Most importantly this means that possessive or specific clitics preceding nouns are not regarded as altering the word-initial status of the root-initial consonant. Since speakers often produced consecutive tokens of the same word with and without these clitics, this seemed the most reasonable procedure.

The data is unbalanced in many ways (e.g. unequal numbers of tokens of given segments from the speakers, and unequal numbers of tokens in different word-positions), so only major trends in the results should be considered important. The findings with respect to segment type are quite striking. The labial glottalized obstruent is most frequently a glottalized fricative of some type, and relatively rarely an ejective. The coronal glottalized obstruents, whether central or lateral, are typically produced as affricates and frequently as ejective affricates. The velar is most often produced as an ejective stop. Overall trends by position in word are less marked, but there seems to be some favoring of ejective realizations in word-final position. The realizations of each of the four segments /f', s', ɬ', x'/ will be discussed in turn. A relatively large number of spectrograms are included to illustrate the acoustic patterns which characterize the various types. Tokens that were produced with no detectable glottalization at all are not counted in the analyses (about 5 % of tokens where glottalization was expected had none)..

Table 5 shows the frequency of occurrence of different realizations of the labial glottalized obstruent. The layout of this and the similar following tables allows the reader to see the total number of tokens available to be classified in word-initial, word-medial and word-final positions, in addition to showing which variants occur most often in each position. There is no one dominant variant of this segment. On the largest number of occasions it is produced as a post-glottalized labio-dental fricative. An example of this type is illustrated by the spectrogram of the word /uf'aneʔ/ 'corncob'in Figure 5. There is a direct transition from the initial vowel to the frication, which is then terminated by a glottal closure released into laryngealized phonation at the onset of the following vowel. Fricative realizations with pre-glottalization are also quite frequent. Both post-glottalized and ejective affricates are also heard. In the affricates the closure is bilabial. A spectrogram of an ejective affricate realization is shown in Figure 6. A segment of this type is not known to occur in any other language. Note that the tokens in Figure 5 and Figure 6 were produced by the same speaker as consecutive pronunciations of the same word. No realization of /f'/ as an unaffricated ejective stop, [p'], was observed. Unfortunately, many tokens of the word expected to provide examples of /f'/ in word-final position, /xololof'/ — the plural of 'trousers' — happened to be obscured by noise and the nature of the realization could not be determined. A few instances of other variants, including an unreleased bilabial stop and a preglottalized affricate, as well as fricatives which lack any glottalization are not tabulated.

Table 5. Phonetic realizations of /f'/ by position in word

	initial	medial	final
fʔ	26	17	0
ʔf	0	6	2
ʔfʔ	0	11	0
pfʔ	5	7	0
pf'	12	1	3

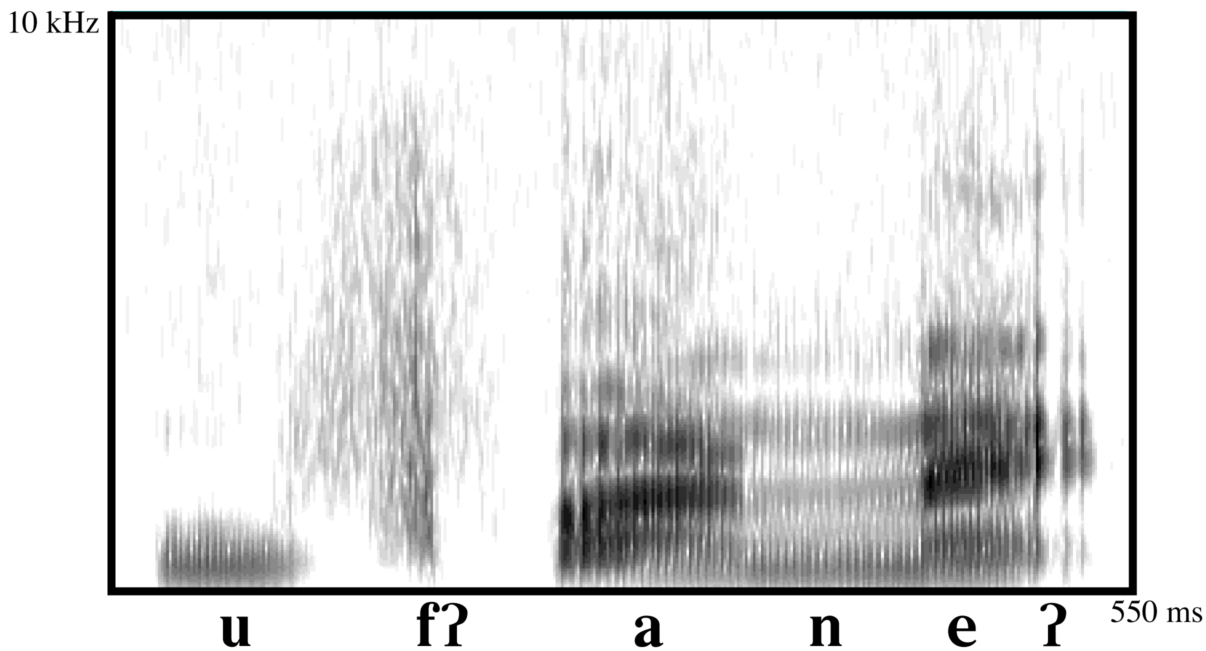


Figure 5 approximately here.
Postglottalized fricative realization of /f'/ in the word /uf'aneʔ/ 'corncob', Speaker F3.

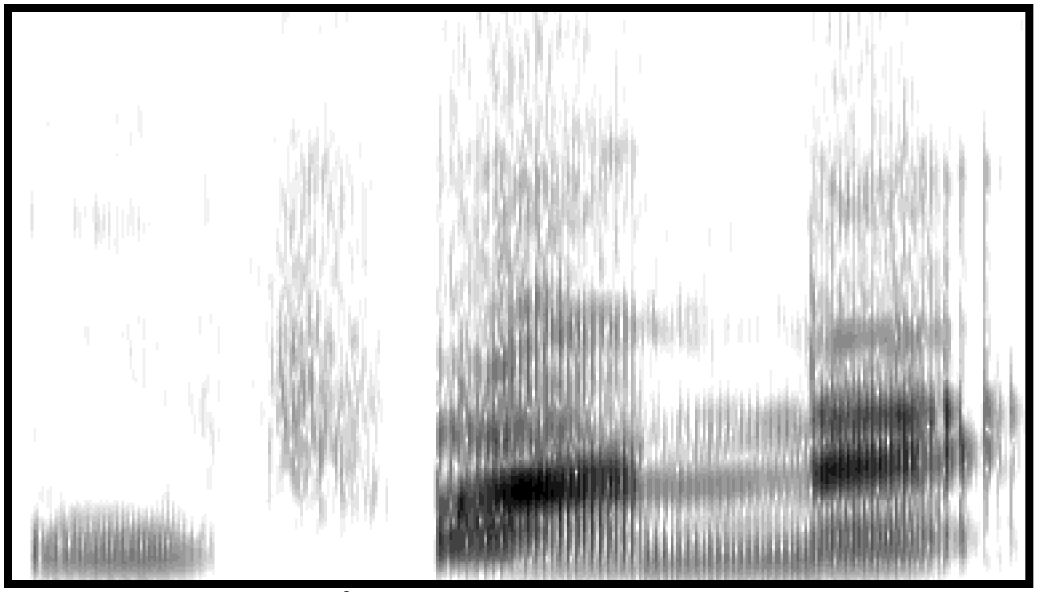


Figure 6 approximately here.
Ejective affricate realization of /f’/ in the word /uf’aneʔ/ ‘corncob’, Speaker F3.

Table 6 shows the realizations of the glottalized coronal sibilant obstruent. No distinction is made between palatalized and non-palatalized instances in this tabulation. For this segment affricate realizations predominate, with ejective affricates particularly common in word-medial and final positions. Affricate realizations may be favored in word-final position by the fact that the plain sibilant fricative /s/ is not among the set of common coda consonants, whereas the non-glottalized affricate /ts/ is. Hence noun plurals created by the glottalization process preserve greater similarity between the singular and plural forms if the plural realization is also phonetically an affricate. Post-glottalized affricate realizations are quite common in initial and medial positions, and fricative realizations with no oral closure, and stop realizations with no frication also both occur with a relatively low frequency. We observed a single instance of what seems to be an ejective fricative in the word /s’os/ ‘cold’ from speaker M2. This is not listed in the table.

Table 6. Phonetic realizations of /s’/ by position in word

	initial	medial	final
sʔ	5	8	2
ʔs	1	0	2
tsʔ	22	35	0
ts’	25	69	102
t’	0	0	9

A word-initial ejective affricate, [ts’], is illustrated in Figure 7 showing the word /s’os/ ‘cold’. The frication noise has a fairly short duration and is followed by a silent interval of similar duration due to the sustained glottal closure. The release of this closure is very visible on the spectrogram just a little before the vowel begins.

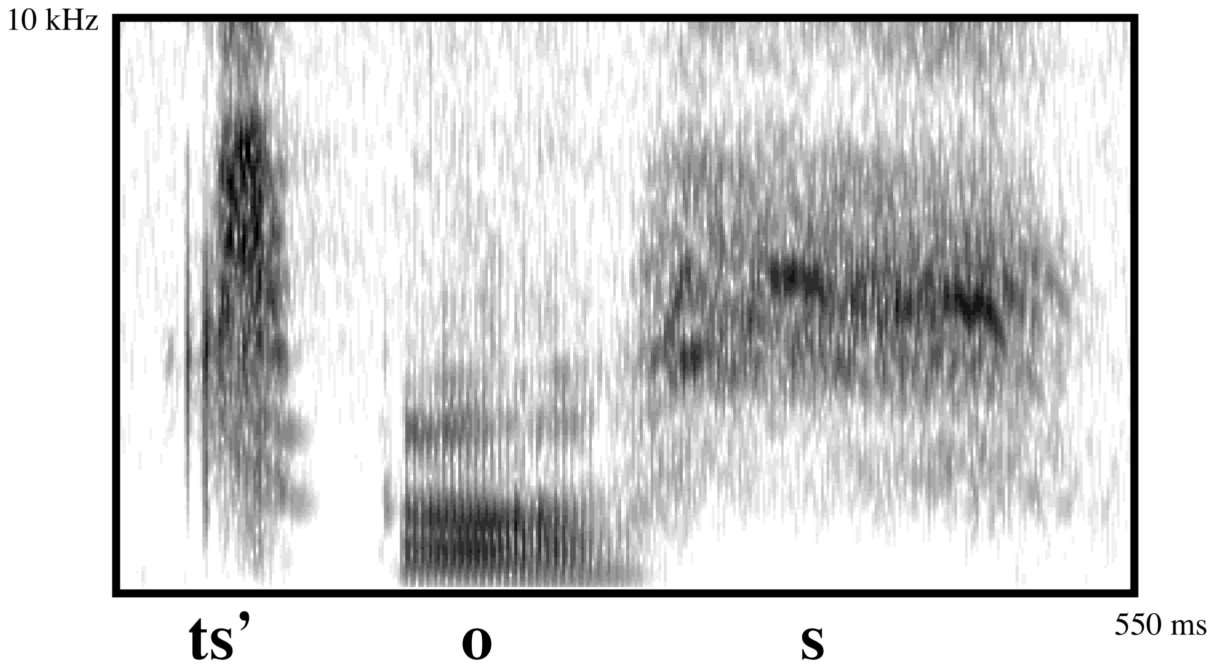


Figure 7 approximately here.
Ejective affricate realization of /s’/ in the word /s’os/ ‘cold’, speaker F3

The relatively unusual realization [sʔ] is illustrated by Figure 8. In this utterance-initial case a quite slow build-up of the frication amplitude can be seen at the onset, and the fricative is sustained for about 180 ms before being truncated by a glottal closure, which is released with marked laryngealization of the initial periods of the following vowel.

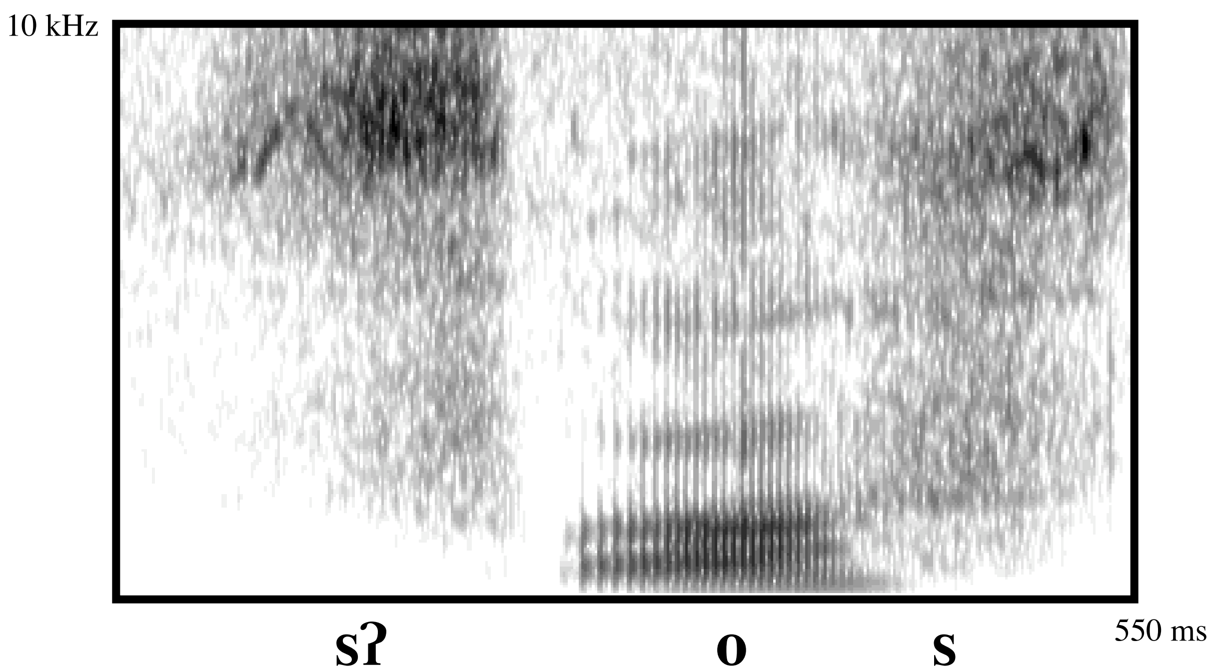


Figure 8 approximately here.
Postglottalized fricative realization of /s’/ in the word /s’os/ ‘cold’, Speaker F1

Table 7 shows the realizations of the glottalized coronal lateral obstruent. The largest number of different variant pronunciations was observed for this segment, including some which fall outside the types enumerated in Table 4 above. As with the sibilant coronal, the most frequent realization of /ƛ'/ is as an affricate, but the lateral cases are almost always ejective rather than post-glottalized. A laterally-released ejective stop — a variant unknown to us from any other language — also occurs quite frequently. We transcribe this as [tˡ'] and it is illustrated by the token in Figure 9. The lateral also provided a few tokens of a true ejective fricative, as shown in Figure 10. The trill-like excitation of the frication in this token is like that noted as characteristic of the ejective fricatives of Tlingit (Maddieson, Smith & Bessell 2001), and is presumed to be due to a particularly constricted oral escape channel for the airflow.

Table 7. Phonetic realizations of /ƛ'/ by position in word.

	initial	medial	final
ɬʔ	3	4	0
ʔɬ	2	0	5
ʔɬʔ	1	11	0
ɬ'	0	0	2
tɬʔ	2	5	1
tɬ'	26	15	23
tˡ'	16	1	11
others	2	12	5

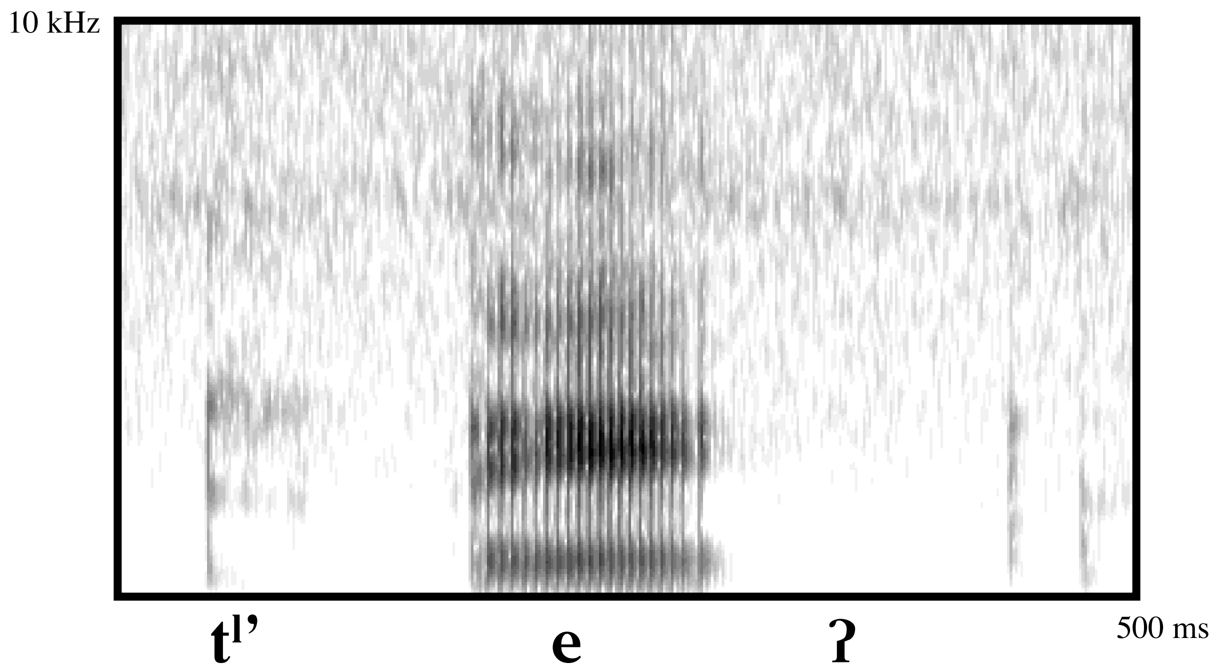


Figure 9 approximately here.
Laterally-released ejective stop realization of /ƛ'/ in the word /ƛ'eʔ/ 'vixen', Speaker F1

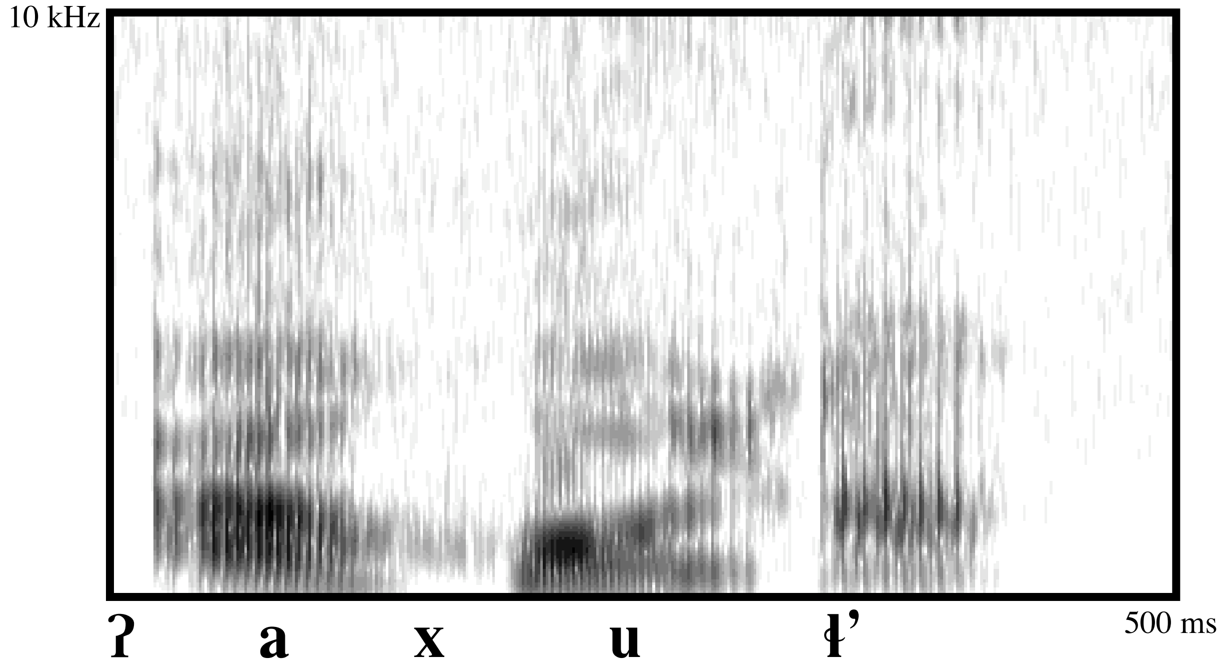


Figure 10 approximately here.
Ejective fricative realization of /ɬ’/ in the
word /axuɬ’/ ‘house’, Speaker F3

Table 7 includes a row labeled “others”, since there were a number of realizations observed that were unlike any pattern seen with the other glottalized obstruents. These are mostly a number of types in which there is a lateral portion that is partly or wholly voiced, with or without laryngealization. One of these variants is illustrated in Figure 11 which shows a pronunciation of the word /muɬ’a/ ‘moon (preceded by the specific marker /el/). In this utterance the initial portion of the lateral is a voiceless fricative (preceded by a very brief pre-stopping of less than 10 ms duration), which is released into a voiced laryngealized lateral portion before the final vowel, which also begins with laryngealized phonation. Since this lateral is preceded by a high vowel it is also palatalized. We transcribe this complex segment phonetically as [ɬl̰ʲ].

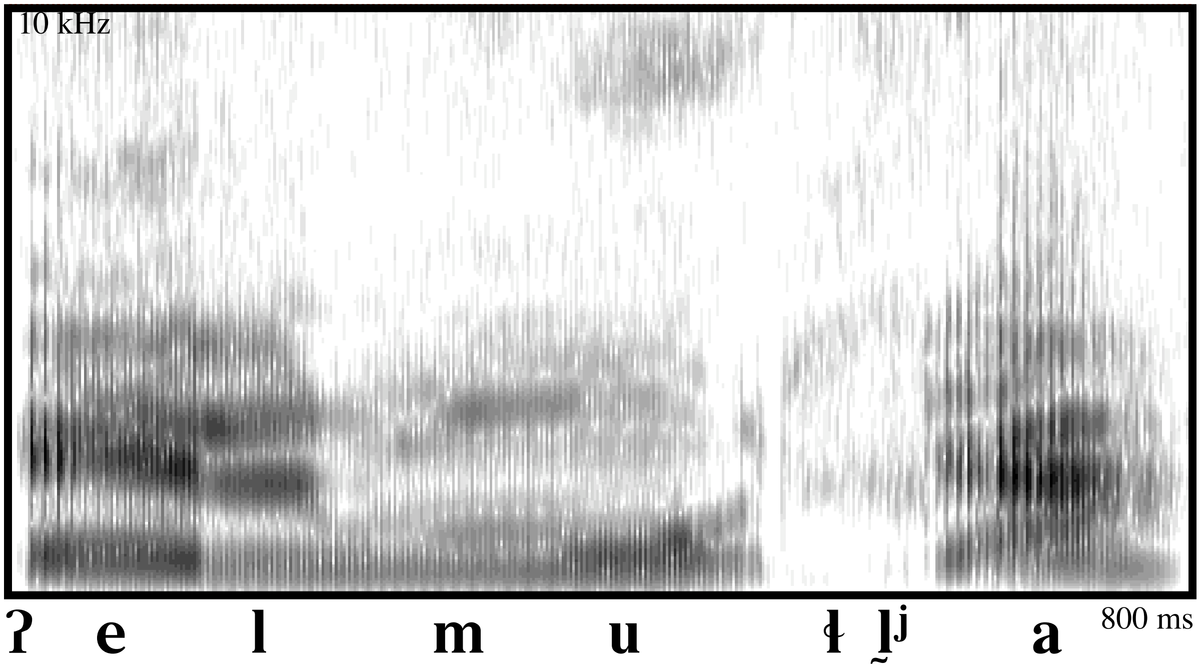


Figure 11 approximately here.
Partially voiced laryngealized lateral fricative realization
of /ɬ’/ in the word /muɬ’a/ ‘moon’, speaker F3.

Table 8 shows the realizations of the glottalized velar obstruent, /x’/. For this segment, the great majority of realizations are as ejective stops, although preglottalized fricatives, postglottalized affricates and ejective affricates also occur. The great majority of tokens in our data containing this segment have it in word-final position, which may favor the ejective realization. An example is illustrated by the spectrogram of /ex’/ ‘trees, firewood’ in Figure 12. The release of the glottal closure very substantially later than the oral release is quite visible. This word is the plural form of /ex/ ‘tree’.

Table 8. Phonetic realizations of /x’/ by position in word

	initial	medial	final
ʔx	0	0	1
kxʔ	5	6	0
kx’	2	0	0
kʔ	0	0	4
k’	18	3	74

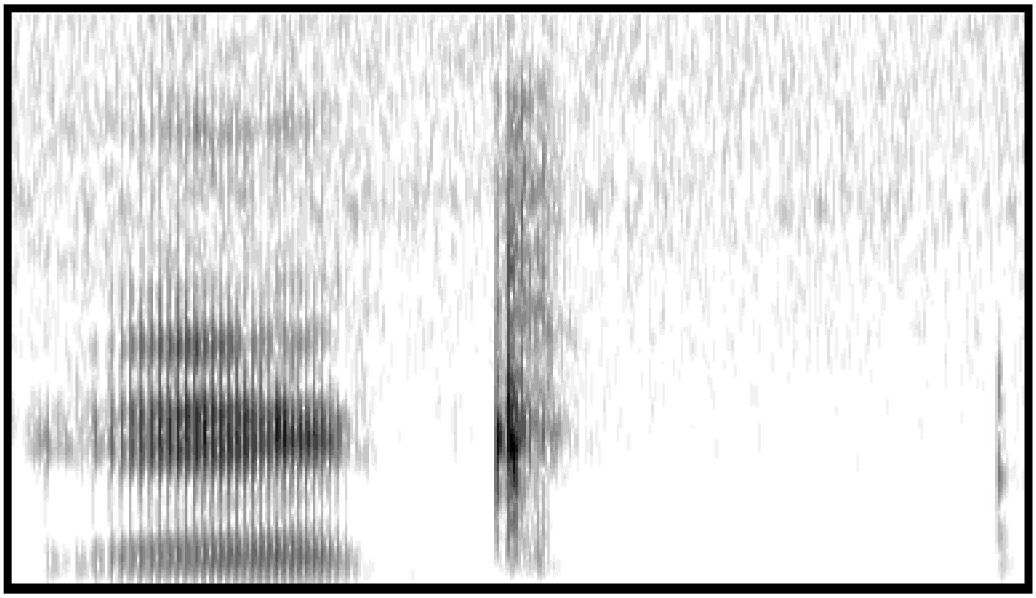


Figure 12 approximately here.
Ejective velar stop realization of /x'/ in the word /ex'/ 'trees, firewood', speaker F1.

The patterns we observed in the realization of the four glottalized obstruents in Chontal presumably are similar to those which influenced the decision by Waterhouse (1962, 1967) to represent them as different classes of segments, /f'/, /ts' ~ tʃ'/, /ɬ'/, and /k'/ (her symbols replaced by IPA equivalents), rather than to represent them all uniformly as fricatives, stops or affricates. The labial is most often a fricative, the coronal sibilant is most often an affricate and the velar is most often a stop. However, on the basis of its most frequent realization, the lateral would also have been expected to be represented as an affricate.

It is striking that the relative frequency of ejective realizations of the four glottalized obstruents mirrors the frequency of occurrence in consonant inventories of segments whose canonical realization is as an ejective (see, e.g. Maddieson 1984). Among the major place categories bilabial ejectives are the least common, and velar ejectives the most common. Distinctively affricated ejectives, like other affricates, are most often coronal.

4.5 Glottalized sonorants

The glottalized sonorants of Chontal include nasals and central and lateral approximants. We transcribe these as Waterhouse does, with the sonorant symbols followed by a diacritic indicating glottalization /m', n', l', w'/. As in other languages with similar segments the accompanying glottal constriction is variable in degree and timing (e.g. Maddieson & Larson 2002). We distinguish three different types of realizations of these glottalized sonorants. Those in which glottal constriction occurs primarily at their onset are labeled preglottalized, those in which the glottalization occurs at the mid-point or extends throughout the duration of the segment are labeled laryngealized, and those in which a glottal constriction primarily at the offset of the segment. The tokens of the four segments /m', n', l' w'/ in our data were classified into these three types and by position in the word. Since these segments do not occur in final position only word-initial and word-medial positions were examined. The frequency of occurrence of the different types in these two positions is tabulated in Table 9. The wordlist contained relatively few words with these sounds, and the nasals are the only ones of them to occur in word-initial position in the list. About 15% of tokens of words expected to contain a glottalized sonorant had no detectable glottalization on the segment. These are not tabulated.

Table 9. Phonetic realizations of glottalized sonorants by position in word

	initial	medial
ʔm	37	13
m̰	8	1
mʔ	0	0
ʔn	5	38
n̰	1	1
nʔ	0	0
ʔl	0	1
l̰	0	14
lʔ	0	12
ʔw	0	31
w̰	0	44
wʔ	0	1

The great majority of glottalized nasal tokens in both word initial and medial position are preglottalized. One variant of this type is illustrated in Figure 13, showing the word /m'aɬ/ 'maguey'. In this token complete glottal closure overlays most of the duration of the segment and only a very brief nasal portion is audible before the following vowel, whose onset is marked by laryngealization. A laryngealized realization of a glottalized nasal shown in Figure 14. There are only a few tokens of this type. In this example laryngealized phonation is present during the majority of the duration of the nasal.

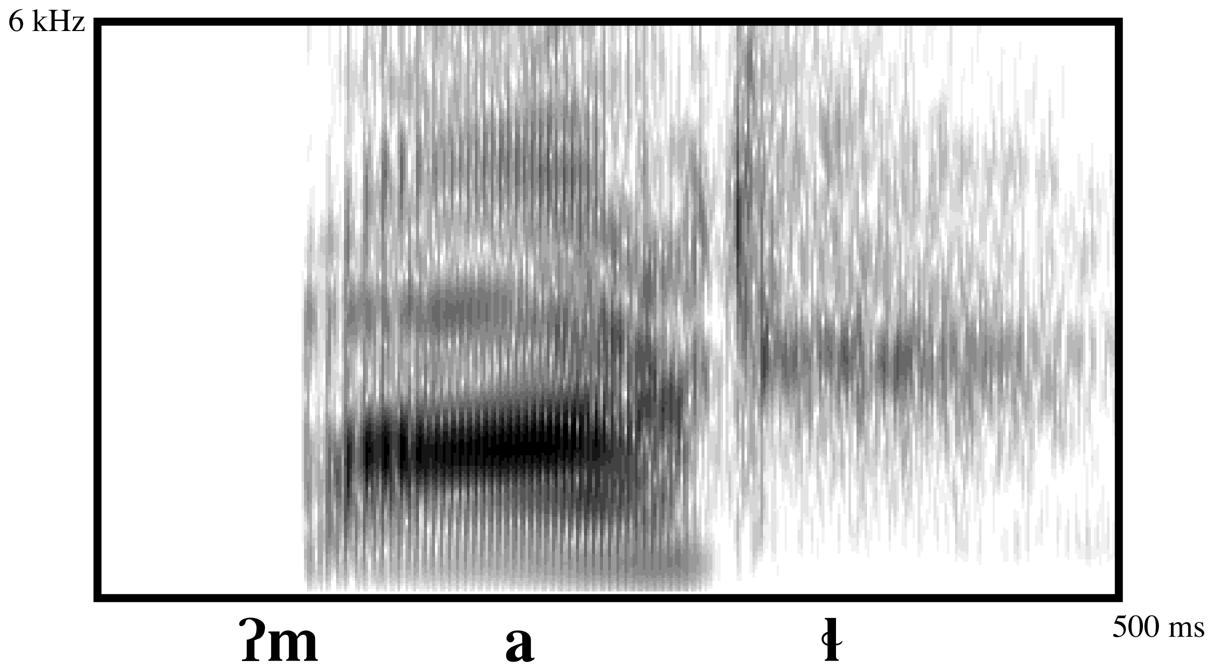


Figure 13 approximately here.
Preglottalized realization of /m'/ in the word /m'aɬ/ 'maguey', Speaker F3

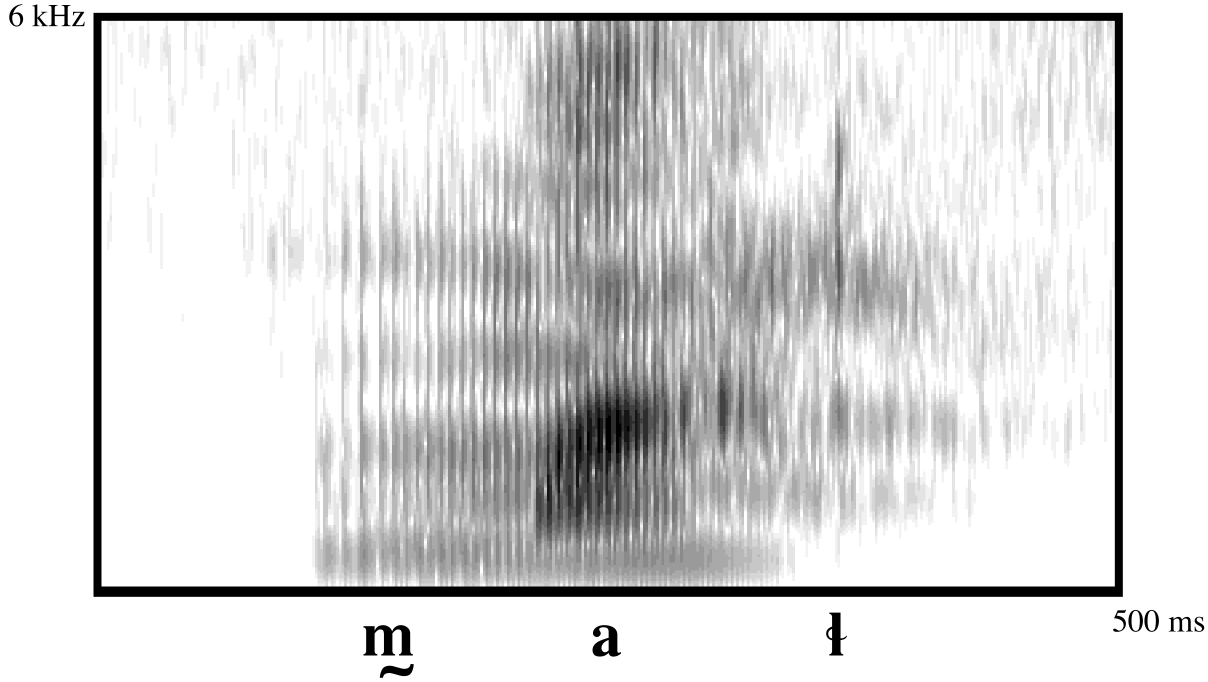


Figure 14 approximately here.
Laryngealized realization of of /m'/ in the word /m'aɬ/ 'maguey', Speaker F1

In contrast with nasals, a majority of the glottalized lateral and central approximants are of the laryngealized type. One variant is illustrated in Figure 15 in the word /simonl'es/ 'mamey (*Pouteria sapota*)'. In this token laryngealized phonation overlaps the entire duration of the lateral. The flanking segments (/n/ and /e/) are realized with modal phonation, and are quite sharply demarcated from the lateral by this property. On a finer scale, the laryngealization can be seen to be most intense at the onset of the lateral, and to weaken as the segment progresses. This realization thus has a degree of similarity to a preglottalized one, as is also the case with the nasal segment in Figure 14.

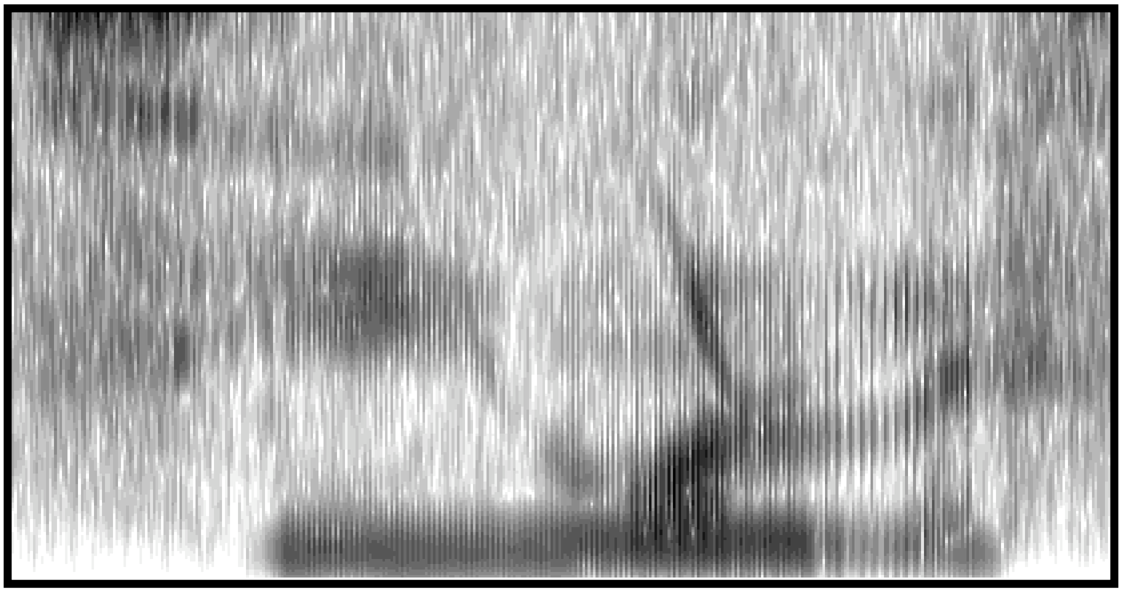


Figure 15 approximately here.
Laryngealized realization of /l'/ in the word /simonl'es/ 'mamey', Speaker F1

Approximants also occur with postglottalization. Figure 16 illustrates a postglottalized variant of the lateral, produced by the same speaker. In this token, the segment starts with an initial portion which is more-or-less modally voiced. This is followed by a full glottal constriction during which the oral constriction is released, resulting in a glottal stop onset to the following vowel.

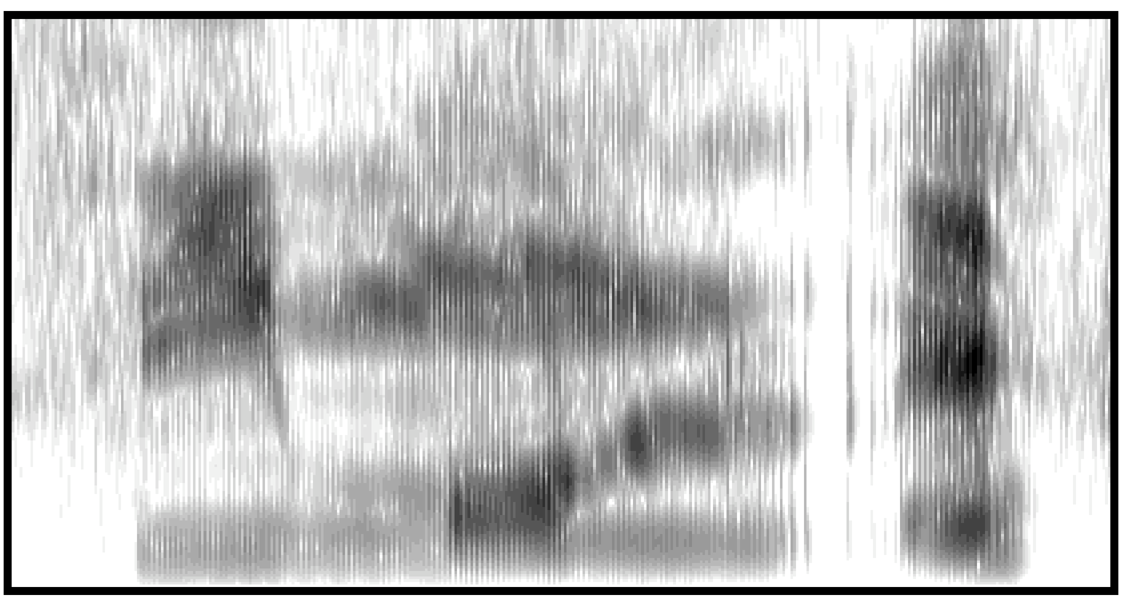


Figure 16 approximately here.
Post-glottalized realization of /l'/ in the word /simonl'es/ 'mamey', Speaker F2

The glottalized labial-velar approximant /w’/ occurred only in medial position in our data, mostly in the word /aw’aʔ/ ‘child’ and phrases containing this form. Figure 17 illustrates one of the realizations observed for this segment, with laryngealized phonation focused at the center of the oral articulation. For comparison, figure 18 shows the sequence /ʔw/ in the word /uʔwe/ ‘salt’, with an unequivocal long glottal closure (160 ms) between the initial vowel and the approximant, which is produced with modal voice. Note in this case that the formants lower for the approximant after the glottal closure is released, making the separation into two segments particularly clear.

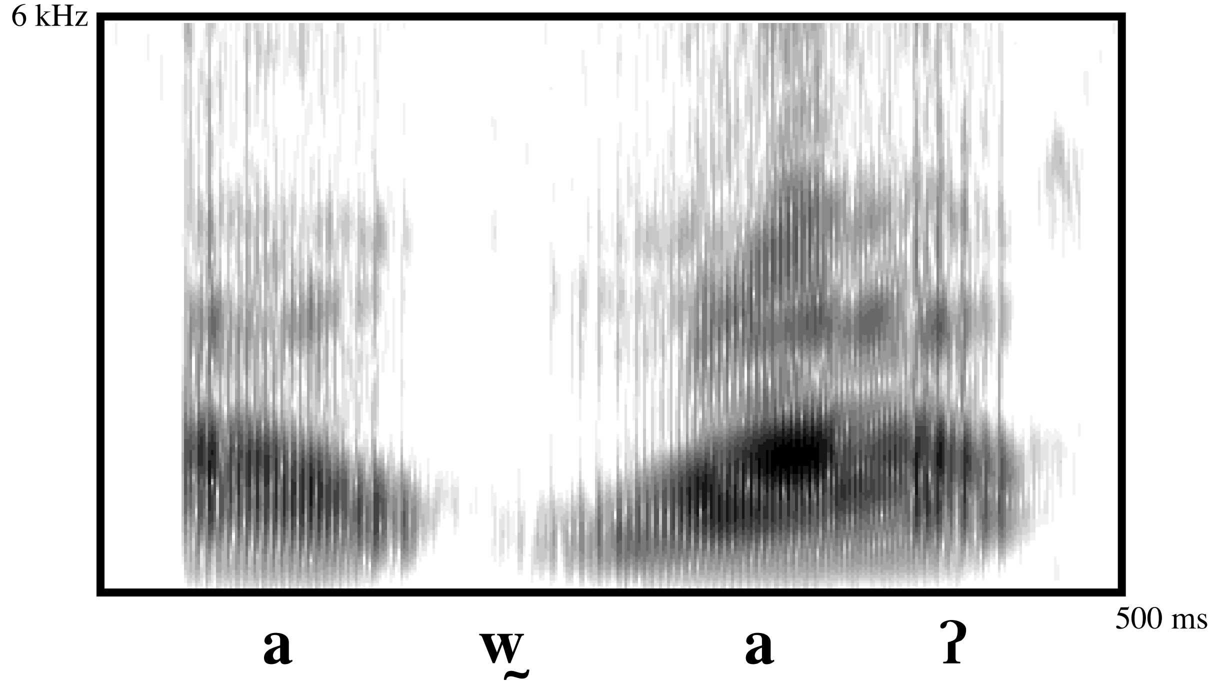


Figure 17 approximately here.
Laryngealized realization of /w’/ in the word /aw’aʔ/ ‘child’, Speaker F3.

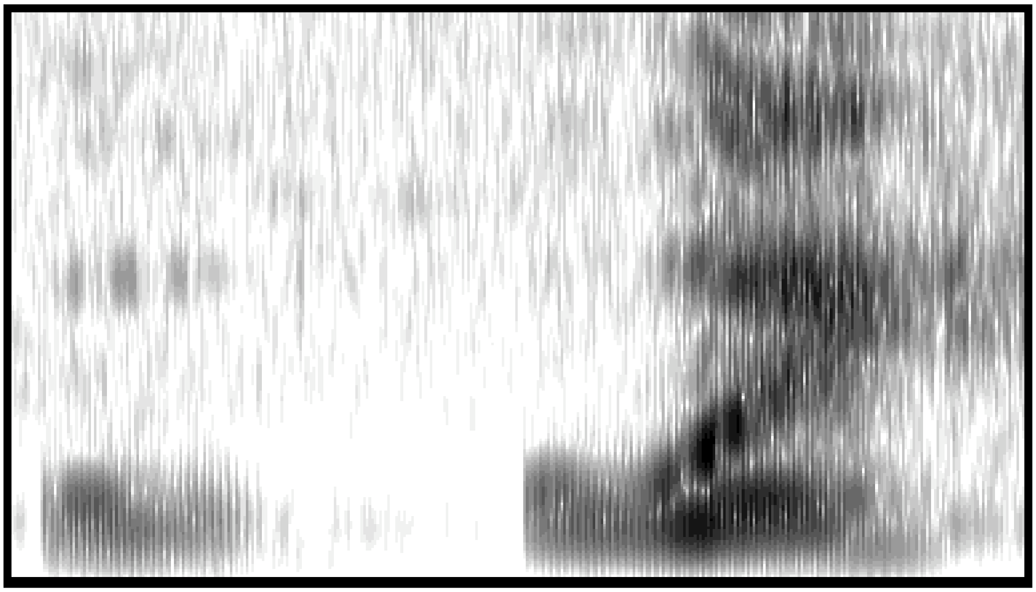


Figure 18 approximately here.
Sequence /ʔw/ in the word /uwʔe/ ‘salt’, Speaker F5.

It has been suggested that glottalized sonorant realizations are universally conditioned by their position in the syllable, being generally pre-glottalized in the syllable onset, and post-glottalized in the coda (Um 2001). This issue can only be partially addressed in Chontal as even the word-medial glottalized sonorants in our data are in syllable-initial position. The nasals are generally pre-glottalized in this position, according to expectation. However, the most typical realization of the glottalized approximants is as the laryngealized type, and post-glottalized realizations also occur in this position, particularly for the lateral. The suggested generalization concerning glottalized sonorants in onset position therefore only partially describes the situation in Chontal.

5 Effects of language attrition?

In our experience with Chontal we have the strong impression that the speakers we observed are producing an unusually large amount of variation in pronunciation, particularly of those segments that are cross-linguistically less common, such as the lateral fricative /ɬ/ and the glottalized segments. In addition to some consistent between-speaker differences, we were especially struck by instances of marked variation in production of repetitions of the same word by the same speaker under conditions in which fairly careful elicitation is being conducted. For example, one speaker in three successive repetitions of the word /ɬ’eʔ/, usually glossed as ‘vixen’ (Spanish zorra) produced the initial segment as an ejective lateral affricate followed by a voiced lateral approximant, as a voiceless lateral fricative followed by a glottal constriction (the definite marker /l/ precedes this token), and as a preglottalized voiced lateral approximant (i.e. as [tɬ’leʔ], [el ɬʔeʔ], and [ʔleʔ]). Is such variability due to infrequent use of the language leading to uncertainty over the pronunciation, or part of an older ‘natural’ variation? This issue cannot be resolved, but we strongly suspect that the attrition of language use is in fact directly related to the high degree of variability we observed.

Some support for this idea might be found in comparing the speech of the oldest of the speakers recorded (M1, aged 81 at the time) with that of the youngest (F5, aged 61). In 25 tokens of words expected to have /ƛ'/ the oldest speaker produced 24 realizations of the segment as the predominant ejective affricate variant, [tɬ']. In only 8 tokens, speaker F5 has 5 different variants of this segment, all pre- or post-glottalized rather than ejective. Moreover, for zorra she gives a form with a sibilant [ts'eʔ], which may indicate either a phonological contamination or a lexical shift. The teacher's group, who span a continuum from semi-speakers to L2 learners, most typically produce the /ƛ'/ in the same word as a velar stop followed by a voiced lateral segment, including the variants [k'l], [kʔl], and [kl]. Only the oldest produces [tɬ']. Thus over apparent time, and in the transition from the relatively fluent speakers (i.e. those with good control of the morphology), to those with more limited mastery of the language, there seem to be signs of an increase in the variations produced, and progressive steps away from the likely original form. If the language continues to be spoken, a likely end of this process may be stable pronunciations which conform more to the phonology of Spanish than that of earlier stages of the language. Parallel processes in syntax were already noted by Waterhouse (1949) several generations ago.

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