Work Papers of the Summer Institute of Linguistics, University of North Dakota Session

Volume 29 Article 1

1985

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FORTIS/LENIS CONSONANTS IN GUICHICOVI MIXE: A PRELIMINARY ACOUSTIC STUDY*

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1. Introduction

This paper focuses on the fortis/lenis contrast in consonants in the Guichicovi dialect[1] of Mixe (Mixe-Zoquean; Oaxaca, Mexico), and uses instrumental data to support a proposed phonological analysis of this contrast. In the remainder of Sect. 1, I briefly survey prior work on this contrast, especially as it impacts on the claim that Mixe has three contrastive vowel lengths. I summarize the phonetic and phonological facts that were determined by ordinary techniques of phonetic transcription, and describe the phonological hypothesis for which I wanted confirmation from instrumental data. In Sect. 2, I describe the instrumental study, including the words tested, the recording procedures, and the measurements made. In Sect. 3, I present the results of this study. In Sect. 4, I discuss the implications of these results for Mixe and for phonological theory, and present some considerations for the design of a larger, more complete study.

1.1. Articulatory background

Hoogshagen (1959) first presented data from the Coatlán dialect of Mixe that appears to support an analysis of three phonemic vowel lengths. Especially convincing are minimal triplets such as the following (taken from Van Haitsma and Van Haitsma, 1976:9)

(1)	ʔoy	'although'
	ʔooy	'he went'
	ʔoooy	'very'

However, Norman Nordell (personal communication) later discovered that in the closely-related Guichicovi dialect, the difference between half-long and long is not contrastive. Rather, it is conditioned by a contrast in the final consonant, which he characterizes as fortis/lenis. More generally, half-long vowels always occur preceding fortis consonants, and full-long vowels preceding lenis consonants. Since the fortis/lenis contrast also occurs following short vowels, he regards it and not vowel length to be underlying; the variation in vowel length is thus conditioned. This contrast is subtle; it escaped his attention for many years. He speculates that something similar may be happening in Coatlán (based on informal auditory impressions of that dialect), although he has not been able to do any careful study. I have heard what appears to be the same contrast in the Mazatlán dialect, which is the third main Eastern dialect of Mixe.

Thus, an understanding of the fortis/lenis contrast in Guichicovi is important to the wider theoretical issue of whether a language can have three contrastive vowel lengths. It is the purpose of this paper to deepen our understanding of the fortis/lenis contrast and its effect on vowel length.

The fortis/lenis distinction is not easily stated in standard phonetic terms; prior to this study there seemed to be no single phonetic parameter which consistently correlated with the phonological contrast, and thus no easy way to characterize the contrast using standard phonological features. One important result of this study is the discovery of a consistent phonetic correlate to the fortis/lenis contrast which can therefore be posited as the "essence" of the phonological contrast.

As mentioned above, the phonetic length of a preceding underlyingly-long vowel is frequently an important phonetic cue for distinguishing fortis from lenis consonants. As the data below indicate, this is also true when the vowel is short, although this had not been noticed previously. This fact shows further the implausibility of the hypothesis that more than two vowel lengths are contrastive. If we were to claim that the fortis/lenis difference on consonants is conditioned by the length of the preceding vowel, we would need to posit _four_ contrastive vowel lengths (short, medium-short, medium-long, and long), which were further subclassified so that short and medium-long vowels formed a natural class which conditioned the following consonant to be fortis, while medium-short and long conditioned the following consonant to be lenis. It is much more reasonable to posit only two degrees of length, but to do so on both vowels and consonants.

The primary phonetic cue for the fortis/lenis contrast in obstruents is susceptibility to voicing.[2] The lenis versions of the consonantal obstruents p, t, k, c, and x are voiced in intervocalic position, whereas the fortis ones are always voiceless. At the end of a phrase, both fortis and lenis consonants are voiceless, but can generally be distinguished by the length of the preceding vowel. Utterance-initially, all obstruents are voiceless, but all are voiced when preceded by the personal proclitics n- '1st person' and m- '2nd person'. Nordell interprets this fact to mean that all word-initial obstruents are lenis. Thus [voice] could be regarded as the feature underlying the fortis/lenis contrast, assuming a rule which neutralizes the contrast in word-final and word-initial position.

However, [voice] does not work for sonorants, since both fortis and lenis sonorants are voiced. In all positions, fortis sonorants seem louder and longer than their lenis counterparts. As for h, the phonetic correlates of the contrast are also length and possibly amplitude. Previous to this study, both fortis and lenis versions of h were heard as voiceless, although this study shows that lenis h is subject to a certain amount of intervocalic voicing, like obstruents. For sonorants and h, then, consonantal length or gemination seemed like a better choice than voicing for representing the underlying distinction. One purpose of the present study was to measure the length and amplitude of these fortis/lenis pairs, and to determine which phonetic cue provides the most consistent basis for characterizing the fortis/lenis contrast using standard phonological features.

1.2. A possible analysis

Based on Nordell's description of the contrast, summarized above, I hypothesized that the underlying contrast in all cases was consonantal length, or more precisely, single (lenis) vs. geminate (fortis) consonants. This would directly account for the observed difference in length in sonorants and h. The greater amplitude of fortis consonants could be accounted for by a low level phonetic rule, or possibly by universal principles.

This analysis also provides a plausible account of the contrast in obstruents, assuming that single consonants are voiced between two voiced segments (i.e., either intervocalically, or following the nasal proclitics and preceding a vowel).

(2) <u>Single consonant voicing</u>
$C \rightarrow [+voice] / [+voice] \_\_\_ [+voice]$

Fortis consonants are immune to voicing because they are geminates.

Besides being very natural, this rule is supported by the fact that all obstruent clusters in Mixe are voiceless. Interestingly, all obstruent clusters in Nordell (n.d.) are written with an initial fortis consonant. This may have been Nordell's way of indicating that obstruent clusters, like fortis consonants, are immune to voicing.

To my knowledge, no consistent difference in length between fortis and lenis consonants had been observed prior to this study. Although the data below show that in careful speech, there is in fact a difference in length; it is possible that in fast speech the length contrast is reduced or eliminated, which might account for the failure to notice a significant phonetic contrast in length. In other words, it may be necessary to posit a rule such as the following:

(3) <u>Degemination</u>
$C_i C_i \rightarrow C_i$ (optional, fast speech)

This rule, if it is correct, would need to be ordered after the rules responsible for voicing single consonants and for adjusting the length of the preceding vowel. On the other hand, informal listening to recordings of casual speech seems to indicate that the difference in length is retained in casual speech, although I do not currently have the opportunity to check this out in detail.

Further evidence comes from Nordell's observation that all initial consonants are lenis. This follows automatically under my hypothesis from a rule that must be stated independently in the grammar of Guichicovi: words cannot begin with obstruent clusters.

Finally, it is very reasonable that long vowels would be shortened somewhat preceding double consonants. To test this fully, we should check to see if the same shortening occurs preceding a consonant cluster. Although Nordell (n.d.) does not mention this environment as one which causes shortening, it should be noted again that he writes obstruent clusters as if they contained fortis consonants.[3]

Thus, on purely phonological grounds, the hypothesis that fortis consonants are geminates has considerable attractiveness, both on the basis of language internal evidence, and on universal considerations of naturalness. The purposes of the current study were to seek instrumental confirmation of the phonetic description given above, to identify further phonetic detail which had not been noticed, and to test my hypothesis that the fortis/lenis contrast was essentially a matter of length.

Ultimately, Nordell and I would like to co-author a paper on this contrast, so that the current study also serves as a pilot study for our later work. Sect. 4 of this paper includes a discussion of the deficiencies of the work done so far, and how to correct them.

2. Procedure

2.1. Data collection

Nordell and I developed a set of six pairs of words which exhibited the fortis/lenis contrast. The words are given in (4) below. Four show contrast in intervocalic position. The other two exhibit the contrast in word-final position following a long vowel, and thus illustrate the two phonetic lengths of this vowel.

(4) Pairs of words used for studying fortis/lenis contrast

Consonant	Lenis	Fortis
p	kapɨk 'no (quot)'	kappɨk 'carry it (imp)'
h	kohɨp 'he should build'	kohhɨk 'build (imp, quot)'
n	tunɨp 'he should work'	tunnɨk 'work (imp, quot)'
y	huyɨp 'he should buy'	huyyɨk 'buy (imp, quot)'
t	peeet 'Peter'	peett 'he swept'
n	tuuun 'oblong, oval'	tuunn 'he worked'

In line with the hypothesis sketched above, I have written fortis consonants as geminates. For now, this can be regarded purely as a notational convenience. I have also distinguished the half-long vs. long vowels, even though this difference is not contrastive.

Most of these words are morphologically complex. This was considered unimportant, since the relevant phenomena are insensitive to the internal structure of words. Better pairs could probably be found, but these were deemed adequate for a pilot study.

Recordings of these words were made in April, 1984, in Mitla, Oaxaca, Mexico, with the help of Simón López, a native speaker of the Guichicovi dialect from the village of Mogoñé Viejo, who is in his late teens. Prior to recording each word, Nordell discussed it with him, using both Mixe and Spanish, to make sure that he understood which word he was expected to pronounce. Then we recorded Nordell saying the meaning of the target word in Spanish, and three tokens of López saying the target Mixe word, using careful pronunciation. Even with preparation, he at times said the wrong word, (in many cases because of confusion or ambiguity introduced by the use of Spanish), and sometimes Nordell was not satisfied that all three tokens were clear examples of the consonant under study. In these cases, we recorded an extra set of three tokens.

2.2. Instrumental measurements

Using this tape, I made spectrographs of each valid token. By "valid", I mean each instance of every word in our test list. I thus included those words which Nordell thought were not clearly pronounced, but discarded examples of other words which were recorded accidentally due to López's misunderstanding of our intent. In most cases, the unclear tokens yielded measurements comparable to the clear ones; apparently the particular phonetic cues which I was measuring were not the ones that Nordell relied on to determine clarity of pronunciation.

On each token, I measured the length of the fortis or lenis consonant, and the length of the preceding vowel. Then, for each word, I computed averages of the two measurements made on each token.

Determining the length of each segment was sometimes difficult because of the vague boundary that separates certain segments. Although nasals and voiceless obstruents displayed clear boundaries with adjacent vowels, the boundaries of other consonants were less clear. For example, regular glottal pulses on a vowel give way gradually to the random noise of /hh/, and /p/ (phonetically [b]) and y appear mostly as varied formant structures which show gradual transitions to the surrounding vowels.

I used a trace of average amplitude superimposed on the standard bar spectrogram to resolve this difficulty; somewhat arbitrarily, I considered a consonant to begin at the moment that the amplitude trace started decreasing at the end of the vowel. Although in some cases this "falling off" of the amplitude occurred significantly before voicing quit, it at least provided a consistent and precise criterion for measurement. Only in one case, y, did this not work, because there was no consistent drop in amplitude on this consonant. Instead, I relied on a relatively sudden shift in the frequency of the second formant at the beginning of the y. Data from this study about consonant and vowel length should not be lightly compared to data from other languages without taking into account the conventions used to measure these segments.

3. Results

3.1. Amplitude

Although I made amplitude traces for all the tokens, and had originally intended to measure amplitude of fortis and lenis consonants, I did not do so, for two reasons. The first was that something in the amplification circuits of the spectrograph was varying with the amount of time the machine had been turned on. This could conceivably make absolute measurements based on the amplitude traces unreliable, although the traces were still adequate for determining the boundaries of consonants.

The second reason was that it soon became apparent that amplitude was not going to provide a consistent phonetic cue for the fortis/lenis contrast. In intervocalic obstruents, the lenis stops, which were voiced, were louder than the fortis stops, which being voiceless had zero amplitude. On the other hand, the instrumental data seemed to support the characterization of fortis sonorants as louder, but this was not true in all tokens. Finally, when both fortis and lenis consonants were voiceless, as in the case of word-final obstruents, the amplitude was zero in both cases. Thus even when there was a discernible difference in amplitude, sometimes lenis consonants and sometimes fortis consonants were the loudest in a pair.

Without phonetic consistency, it would be difficult to claim that amplitude was the underlying "essence" of the fortis/lenis contrast. Although amplitude may be useful as a phonetic cue of the fortis/lenis distinction for subclasses of consonants, it does not appear to provide a good basis for a characterization of the phonological nature of this contrast.

3.2. Consonantal length

The measurements of consonant length for intervocalic consonants are presented in (5).

(5) Average length (in milliseconds) of intervocalic consonants

Consonant	Lenis	Fortis
p	60	179
h	136	224
n	68	81
y	86	133

Clearly, in each case, the fortis consonant was longer than the lenis one. This, of course, was expected for sonorants and h, based on our auditory impressions of these consonants. In the case of n, it is possible that the difference in length is not statistically significant, but the others show a large difference which is almost certainly significant.

One of the surprises of this study was the striking contrast in length with the obstruent p, which had not been previously noticed.[4] After being alerted to the possibility that obstruents might also differ in length, this difference was clearly discernable by ear.

Another fact not noticed by ear was a difference in voicing on h comparable to that noted for obstruents. In lenis /h/ there were clear glottal pulses throughout, but in fortis /hh/, glottal pulses very quickly dropped off to zero. Thus intervocallic lenis h is voiced, like other obstruents. Up to this point, I have avoided referring to h as an obstruent, since its precise analysis in distinctive features (i.e. [+son] or [-son]) has not been crucial. This susceptibility to voicing is evidence that h is [-son].[5]

Another surprise was that it was possible to measure the length of t in final position, even though both fortis and lenis versions are voiceless. Most tokens exhibited a release at the end of the consonant; whenever this was apparent, I measured it. (Measurement of n was easy, since it is voiced.) The results are shown in (6).

(6) Average length (in milliseconds) of final consonants

Consonant	Lenis	Fortis
t	131	229
n	85	104

Again, fortis consonants are longer than lenis ones, although the difference for n may not be significant. This difference had not been previously noticed on obstruents, since the phonetic cue (a slight pop when the stop was released) has such a low amplitude.

3.3. Vowel Length

The measurements of vowel length for underlyingly long vowels are given in (7).

(7) Vowel length (in milliseconds) for long vowels preceding final fortis and lenis consonants

Following consonant	/___ Lenis	/___ Fortis
t	262	142
n	312	205

As expected, underlyingly long vowels are significantly shorter preceding a fortis consonant.

The third major surprise in the study was that this phonetic difference in length also occurs on phonemically short vowels, as illustrated in (8).

(8) Vowel length in milliseconds for short vowels preceding medial fortis and lenis consonants

Following consonant	/___ Lenis	/___ Fortis
p	138	108
h	110	91
n	118	92
y	100	82

This difference is somewhat subtler than that which occurs with long vowels; this partly explains why it was not noticed before.

4. Discussion

4.1. The analysis of the fortis/lenis contrast

In all six pairs of words, exemplifying all major classes of consonants in both positions where the contrast occurs, the fortis/lenis contrast correlates directly with a phonetic difference in length. This correlation appears even in situations where it was not previously noticed. Only for n is this difference subtle enough that it may not be statistically significant. Thus the hypothesis that fortis consonants are geminates is not only reasonable phonologically, it has a strong phonetic basis as well.

As noted throughout, the putative third contrastive length in Mixe vowels is in fact a conditioned phonetic variation, at least in the Guichicovi dialect. This variation is also apparent in a subtler form on underlying short vowels. Although the subtlety of this difference for short vowels might raise questions of its significance, the consistency of the results suggests that either 1) native speakers are in fact aware of this conditioned variation, 2) they automatically generalize the rule for long vowels so that it also applies on short vowels, or 3) the process of vowel shortening before a double consonant is a natural process in the sense of Stampe (1973), and therefore does not need to be learned.

At any rate, the length of the preceding vowel appears to be a consistent (and most likely statistically significant) phonetic cue for the underlying contrast in consonant length.

Although amplitude and voicing may be significant phonetic manifestations of the fortis/lenis contrast, they do not provide consistent correlations with the underlying contrast, since they vary depending on the type of consonant and its environment. Therefore, these variations are best analyzed as the result of conditioned variation.

The fact that the Mixe fortis/lenis contrast can be identified with underlying gemination suggests that other cases where the fortis/lenis distinction has been claimed could also be the same phenomenon. If so, the failure to identify the contrast immediately as one of gemination could be due to the operation of phonological rules such as voicing and spirantization of single consonants, and possibly subsequent degemination. For example, the description of the fortis/lenis contrast in Cajonos Zápotec given by Nellis and Hollenbach (1980) is very similar to what has been noted in Mixe. Although they argue (p. 103) against the possibility that fortis/lenis in Cajonos is a matter of gemination, they do not reject the possibility (p. 98) that it might be due to an underlying feature [long] on a single consonant. Similarly, McKinney (1984), using instrumental data, demonstrates that the fortis/lenis contrast in initial consonants in Jju (also known as Kaje, a Benue-Congo Plateau language of Nigeria) is consistently correlated with length; see his paper for details on the measurements involved.

4.2. Considerations for further study

Certain weaknesses in the pilot study are summarized here, so that the later complete study can avoid them; other design requirements for that study are also noted.

For a more complete study, a larger set of words should be used. Attempt should be made to find examples of the fortis/lenis contrast for all consonants and all positions, including palatalized consonants as well as nonpalatalized. Vowel length should also be studied before clear cases of consonant clusters, and the other six types of vowel nuclei should be exemplified.[6]

Some set of consistent, reliable, and most importantly, standard criteria should be developed for fixing the boundary between consonants and vowels for the purposes of measurement. The measurements taken by McKinney (1984) should be strongly considered.

In the current study, all three tokens of a word were recorded in sequence. A better approach, which controls for the effects of tiredness, list intonation, etc., would be to record each token separately in a frame, and to randomize the order of recording. This may require a literate subject. Another way to avoid this problem would be to record tokens in an alternating sequence, thus:

(9) huyɨp
huyyɨp
huyyɨp
huyɨp

The recording quality, although adequate for a pilot study, could have been improved. We recorded the words in a kitchen, so that there was a fair amount of noise in the background. It was difficult to control the recording level, because the microphone was hand-held and López had difficulty controlling the distance from it to his mouth. These two factors combined made it difficult to get a good spectrogram for some tokens. Since there are at least two professional quality recording studios in the Mitla area which are available for use in linguistic studies, these facilities should be employed in the next study, together with the assistance of professional recording technicians.

I had no clear notion of how much difference in length could be considered statistically significant. Some thought must therefore be given to statistical reliability.

At some point, it may be desirable to explore the relative importance of the various phonetic cues (consonant length, vowel length, voicing, and amplitude, and possibly others) for the perception of these words. This would involve synthesized speech presented to native speakers in some controlled fashion. However, such a study clearly must follow a more careful and complete determination of the relevant phonetic parameters.

Finally, in order to settle the issue of the number of contrastive vowel lengths in Mixe, it must be determined whether the fortis/lenis contrast is also present in the dialects of Coatlán and Mazatlán. Some spectrographic studies of these dialects may also be desirable.

4.3. Comments and addresses

Comments on this paper are very welcome. Until at least May 1986, I can be reached at UCSD, and can always be reached through SIL in Tucson.

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Notes

*I wish to express my appreciation to the phonetics lab at the University of California, San Diego, for the use of the sound spectrograph; to Simón López, for his assistance in recording the list of test words; and to Margaret Langdon and Hu Mathews for comments on earlier drafts. Most importantly, this study would have been completely impossible without Norman Nordell, whose knowledge of Mixe is far more extensive than mine. Unfortunately, it has not been possible to obtain comments from him on the results or on the discussion below; the results of this paper must therefore be regarded as tentative. Due to the preliminary nature of this study, please do not make direct quotations without first consulting me. The inevitable errors are of course my own.

[1]Guichicovi Mixe is spoken in and near the municipio of San Juan Guichicovi, in eastern Oaxaca, Mexico, just north of Matías Romero. It has also been called Isthmus Mixe, Eastern Mixe, and Mixe of Mogoñé.

[2]Both fortis and lenis versions also are subject to palatalization, giving a four-way contrast at each point of articulation. However, palatalized consonants are not included in this study. For simplicity, I will often refer to a point of articulation with a single letter which is not surrounded by slashes; thus p in the discussion will stand for both the fortis and lenis bilabial stops. In transcriptions of lexical items, or within slashes, /p/ will represent only the lenis stop. Two points of articulation mentioned here will not be discussed further: c representing coronal affricates /ts, tts/ and x representing coronal fricatives /ṣ̌, ṣ̌ṣ̌/.

[3] To make the test completely valid, the cluster must be tested after unstressed syllables, since consonants are frequently strengthened after stressed syllables. (See the various strengthening rules in Nordell n.d.:44-61)

[4] At least, I had not noticed it, and I don't remember Nordell ever mentioning this to me.

[5] In one environment, the rule of intervocalic voicing is bled by another rule. An initial consonant cluster consisting of a nasal stop plus a (lenis) h coalesces to a voiceless nasal stop, rather than causing the h to become voiced. For example, m + huyɨp surfaces as [Muyɨp], where [M] is a voiceless bilabial nasal stop.

[6] These involve various combinations of short and long vowels with /h/, /ʔ/, and laryngealization.

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