Palantla Chinantec: Phonetic Experiments on Nasalization, Stress, and Tone

William R. Merrifield; Jerold A. Edmondson

International Journal of American Linguistics, Vol. 65, No. 3 (Jul., 1999), 303-323.

PALANTLA CHINANTEC: PHONETIC EXPERIMENTS ON NASALIZATION, STRESS, AND TONE

WILLIAM R. MERRIFIELD

SUMMER INSTITUTE OF LINGUISTICS AND
UNIVERSITY OF TEXAS AT ARLINGTON

AND

JEROLD A. EDMONDSON

UNIVERSITY OF TEXAS AT ARLINGTON

Palantla Chinantec (PC) is an Otomanguean language spoken by over 15,000 people, primarily rural farmers who reside in the District of Tuxtepec, Oaxaca, Mexico, and in numerous enclaves of the adjoining states of Chiapas and Veracruz formed in the past 50 years by émigrés from Oaxaca. The small village of San Juan Palantla, of perhaps 400 residents (reachable only on foot or by animal) and but one of scores of PC communities like it, lies about 15 km NW of the municipal seat of Valle Nacional and perhaps 60 km SW of the city of Tuxtepec.

This paper elaborates earlier research, reported upon 30 years ago by the first author, which found this language to be of general typological interest with respect to the phonology of nasalization and stress. Specifically, PC exhibits two degrees of nasalized syllables in contrast with oral syllables—A FULLY NASALIZED syllable as over against A LIGHTER NASALIZATION INITIATED LATE IN THE SYLLABLE—and two types of word stress which produce what is referred to as a BALLISTIC SYLLABLE versus a CONTROLLED SYLLABLE. PC is a tone language with six tones—high, mid, low, low-mid, low-high, and high-low. Any detailed discussion of the phonology of stress in PC also invites a discussion of tone, which is intricately related to it, as well as to other phonological features of PC.

The data for this study were gathered by the authors in the village of Palantla and the city of Tuxtepec in late February and early March of 1995.[1] Modern linguistic research on this language was begun by the first

---

[1] A draft of this paper was presented at the Society for the Study of the Indigenous Languages of the Americas summer meeting at the University of New Mexico, Albuquerque, July 8–9, 1995. The research was undertaken during a field trip devoted primarily to lexical documentation of PC by the first author, supported by NSF grant SBR-9321193, and was thereby incidentally supported by that grant. Travel and participation of the second author was supported

[*IJAL*, vol. 65, no. 3, July 1999, pp. 303–23]

0020-7071/99/6503-0003$02.00

author in 1956. The primary published phonological statement on the language is Merrifield (1963), which sets forth, in articulatory terms, a general description of the phonological elements which constitute Palantla Chinantec syllables, including the three phenomena which are the subject of this study.[2]

Most phonological research on PC prior to this study has been based on auditory perceptions of spoken and whistled speech, although claims relating to stress and nazalization have also been tested instrumentally. In 1961, for example, using a tape recording supplied by Merrifield, Norris McKinney, then a graduate student at the University of Michigan, made the first broad-band and narrow-band spectrographs of these data, as well as continuous amplitude displays. Although these methods do not provide a direct means for measuring degrees of nasalization, McKinney (personal communication) found cues in the form of "intensity reduction of the first formant, the presence of anti-resonances, and an increased formant bandwidth" to be compatible with the auditory analysis.

In the late 1960s, phoneticians Peter Ladefoged and William S. Y. Wang verified the presence of this unusual property of Chinantec on a visit to Mexico City with Merrifield, where they used airflow sensors in the nostrils of a single Palantla Chinantec speaker. Unfortunately, Ladefoged and Maddieson (1995) now state that the original recordings are no longer available, but they continue to support the presence of two degrees of nasalization by employing spectrograms, noting the special characteristics of nasals that set them apart from the oral vowels.

Since the original airflow recordings were never published, to the best of our knowledge there is still today no published direct evidence of the two degrees of nasalization. This present experiment was undertaken, in part, to provide this evidence.

---

by a travel grant from the University of Texas at Arlington. Grammatical and lexicographic reports on PC include Merrifield (1968; 1993) and Merrifield and Anderson (1995; 1999).

[2] PC is the only language in the Chinantecan family of Otomanguean languages that has been described as having two degrees of nasalization. All members of the family whose phonology has been described since ballistic and controlled syllables began to be claimed for PC in the spring of 1962, however, have also been described as exhibiting this same phenomenon, with the single exception of Usila Chinantec (Skinner 1962), the report of which actually reached publication prior to Merrifield (1963). For descriptions of these other Chinantec languages, the reader may wish to consult the following studies: Anderson, Martínez, and Pace (1990), Foris (1973), Gardner and Merrifield (1990), Mugele (1982; 1984), Rensch (1968; 1978), Rupp (1990), Thelin (1980), and Westley (1971). For a similar phenomenon in other Otomanguean languages, see Bauernschmidt (1965) (Amuzgo) and Silverman et al. (1995) (Mazatec). For a general review of linguistic research of Chinantecan languages, see Merrifield (1995).

1. Method. Seven speakers were interviewed by the authors for this study, six in the village of Palantla during a week of study in late February 1995, one in Tuxtepec, the largest city in the area. Speakers are herein identified by first name only and include Agustín, Aniceto, Camilo, Florentino, Mario, Teresa, and Valerio. The subjects interviewed are all very well known to the first author, who lived in Palantla with his family for several years. It was obvious to the second author that the subjects were quite accustomed to being asked about their language; they demonstrated no obvious stress during the interviews.

Acoustic recordings were made with a Sony TCM5000 Professional Quality Tape Recorder with high-quality tape and an ATUS® ATR20 dynamic microphone. At a later date some of the tape-recorded utterances were processed for analysis also using a CECIL Box (JAARS International, Inc.) and an associated S.I.L. speech analysis software package, CECIL v2.1.

Airflow recordings were made with both the Rothenberg mask[3] and with a second mask constructed by Greg Lyons of S.I.L., with the collaboration of Edmondson. The Rothenberg mask consists of a hard plastic mask with a protruding handle, and a soft rubber gasket around the base that prevents air from leaking out when the mask is pressed tightly against the face. The mask has two chambers separated by a piece of plastic and a gasket that runs across the upper lip to divide the space into an oral chamber and a nasal chamber. In each of the two chambers is a pneumotachograph that measures air pressure.

The Lyons mask is of soft plastic, without a handle. It covers the mouth and nose but has only a single chamber. This mask has greater impedance to airflow and, thus, gives a slightly different dynamic profile across the syllable than the Rothenberg mask. Since absolute quantitative values were not the object of this study, the difference between the two masks was not considered significant.

These devices were connected to a small, battery-operated amplifier, interfaced through the CECIL Box to a DOS laptop computer running the CECIL software.

Three kinds of experiments were performed:

- experiments to obtain nasal airflow data (nasalization experiments),
- experiments to obtain oral airflow data (stress experiments), and
- experiments to obtain fundamental frequency (tone experiments).

---

[3] The Rothenberg mask was developed by Martin Rothenberg (Rothenberg 1971; 1972; 1977; 1984). Further information can be found at the Glottal Enterprises, Inc. web site (http://www.glottal.com). The mask designated there as MA-1D was used in this study.

2. Nasalization experiments. Not all speakers of Palantla Chinantec exhibit two degrees of nasalization in their speech.[4] We found several speakers who do, however, and recorded both acoustical and nasal airflow data from Agustín, who reliably distinguished oral, lightly nasal, and fully nasal vowels. The data in (1) and (2) are the same as some of those reported in 1963, but from a different speaker.[5]

(1*a*) *ha*^{LM} 'so much'
(1*b*) *hą*^{LM} 'he opens it wide'
(1*c*) *hã*^{LM} 'foam'
(2*a*) *ʥï*^{L}*ʔe*^{LM}*ʥa si*^{M} [^{n}ʥɯ^{11}ʔe^{13}zə^{11} si^{33}] 'he will go teach reading'
(2*b*) *ʥï*^{L}*ʔę*^{LM}*ʥa háʔ*^{M} [^{n}ʥɯ^{11}ʔę^{13}zə^{11} háʔ^{33}] 'he will go count animals'
(2*c*) *ʥï*^{L}*ʔẽ*^{LM}*ʥa háʔ*^{M} [^{n}ʥɯ^{11}ʔẽ^{13}zə^{11} háʔ^{33}] 'he will go chase animals'

2.1. Results. Figure 1 juxtaposes an acoustical signal (microphone recording) of the PC sentence *ʥï*^{L}*ʔe* ^{LM}*ʥa si*^{M} 'he will go teach reading', in which (the third-person directional form of) the verb stem *ʔe*^{LM} 'teach' (bracketed by vertical lines) is oral (nonnasal), with its corresponding nasal airflow signal (Rothenberg mask recording). With the exception of noncontrastive prenasalization of the initial voiced affricate /ʥ/ of the phrase (which facilitates alignment of the acoustical and airflow waveforms), the absence of nasal resonance through the rest of the phrase is shown by the nearly flat line which shows only incidental leakage of pressure through the nasal passage.[6]

Figure 2 juxtaposes an acoustical signal of the PC sentence *ʥï*^{L}*ʔę* ^{LM}*ʥa háʔ*^{M} 'he will go count animals', in which (the third-person directional form of) the verb stem *ʔę*^{LM} 'count' (bracketed by vertical lines) is lightly nasalized,

---

[4] Of the three forms presented in (1) and (2), for example, some speakers make the three distinctions as indicated (e.g., Agustín, Teresa, Balerio, Camilo), others pronounce both (*a*) and (*b*) forms without nasalization and (*c*) forms as fully nasalized (e.g., Florentino, Marcelo, Mario), while still others pronounce (*a*) forms without nasalization and both (*b*) and (*c*) forms as fully nasalized (e.g., Mardonio). Marcelo and Mardonio are not mentioned above as subjects for this study, because they were interviewed by the first author subsequent to when instrumental data were collected from the seven named subjects by both authors. These comments regarding the speech of Marcelo and Mardonio are based on the noninstrumental perceptions of the first author.

[5] A more or less Americanist phonological notation is used in most citations. These phonetic representations utilize more standard IPA symbols, including the Chao (1934) 1–5 scale for tone. To reference two degrees of nasalization, the traditional Americanist use of a Polish hook under a vowel (*ę*) here represents the light-late nasal of Chinantec, while the IPA usage of tilde over a vowel (*ẽ*) here represents full nasalization.

[6] The acoustical signals and nasal airflow signals in figures 1–3 are drawn from separate recordings of the same phrases since we did not have equipment capable of measuring both types of signal at the same time. The source of the surge at the end of the nasal airflow signal is uncertain.

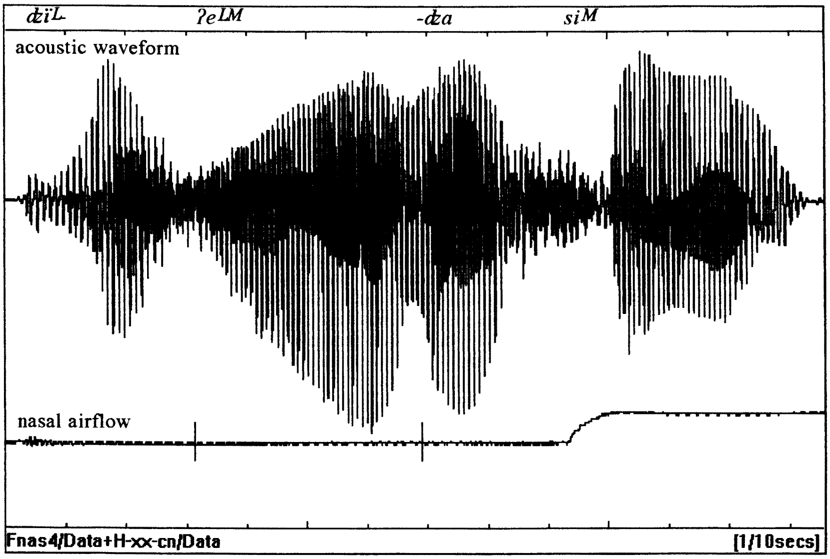

FIG. 1.—Comparison of acoustic signal and nasal airflow for the Palantla Chinantec sentence *ʥï*^{L}*ʔe*^{LM}*ʥa si*^{M} 'He will go teach reading'.

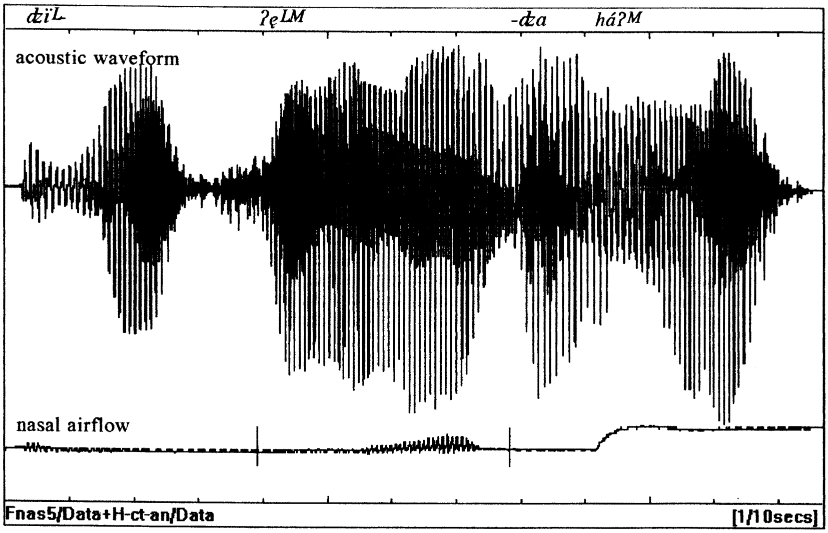

FIG. 2.—Comparison of acoustic signal and nasal airflow for the Palantla Chinantec sentence *ʥï*^{L}*ʔę*^{LM}*ʥa háʔ*^{M} 'He will go count animals'.

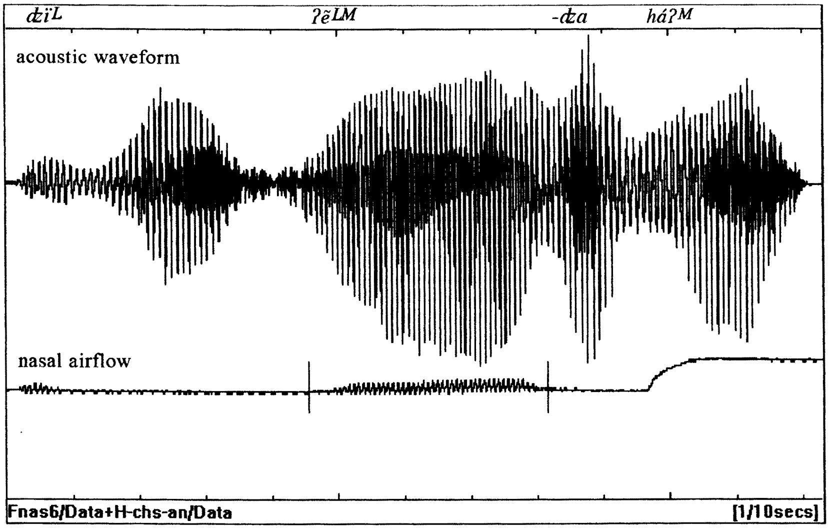

FIG. 3.—Comparison of acoustic signal and nasal airflow for the Palantla Chinantec sentence *ʥï*^{Lʔ}*ẽ*^{LM}*ʥa há*^{ʔM} 'He will go chase animals'.

with its corresponding nasal airflow signal. In this case, it can be seen that nasal resonance begins late in the syllable and gradually increases to its greatest level at the end of the syllable before declining rapidly.

Figure 3 juxtaposes an acoustical signal of the PC sentence *ʥï*^{Lʔ}*ẽ*^{LM}*ʥa há*^{ʔM} 'he will go chase animals', in which (the third-person directional form of) the verb stem ^{ʔ}*ẽ*^{LM} 'chase' (bracketed by vertical lines) is fully nasalized, with its corresponding airflow signal. In this case, it can be seen that nasal resonance is relatively constant throughout the syllable.

2.2. Discussion. Based on noninstrumental data, Merrifield (1963) found two degrees of nasalization in Palantla Chinantec. The claim was made (1963:5) that, in full contrast with nonnasal syllables:

> . . . certain idiolects of Palantla Chinantec exhibit two degrees of nasalization which occur in identical environment, thus defining lexical contrasts. The actualization of the two degrees differs in quantity and in timing. A heavy nasalization involves full opening of the velic and nasalization of all elements of the syllable. Light nasalization involves a late opening of the velic after the vowel has been initiated and not so full an opening as in heavy nasalization.[7]

As can be seen in figure 1, there is effectively no nasal airflow activity after the initial prenasalization of the affricate [ʥ]. In figure 2, however,

---

[7] This statement was made with the caveat that the exact behavior of the "velic" was not directly observed (n. 8). (It may be helpful to note for some readers that "velic" was distinguished,

there is nasal airflow of growing intensity that begins at a position about halfway through the second syllable which lasts to the end of that syllable. In figure 3, on the other hand, nasal airflow begins shortly after the release of the initial glottal stop of the second syllable and continues at a relatively constant level to the end of the syllable. These three figures confirm the earlier findings that two degrees of nasalization differ in timing, but not that the opening of the "lighter" nasalization is "not so full an opening as in heavy nasalization." The mentioned quantitative difference turns out to be that of a gradual increase in airflow as opposed to a more immediate flow of nasal air at a constant level.

Once the presence of two degrees of nasalization is established for PC, the question then arises as to what universal linguistic categories are required to account for them. Ladefoged and Wang were convinced long ago of the presence of these differences, but they were not convinced that "it is necessary to assign an in-between value at the systematic phonemic level [since] it is possible that the underlying forms differ in the number of segments involved, so that the three-way contrasts between oral, lightly nasalized, and heavily nasalized vowels are really contrasts of the form *a* ~ *ã* ~ *ãn*, the final consonants not appearing in the phonetic output" (Ladefoged 1971:35).

In support of such an interpretation, it is in fact the case that some contemporary Chinantec languages exhibit an inflectional person–number morpheme in the form of /n/ with certain verbs. It is highly likely that the light nasalization of PC has its source, historically, in such a person–number morpheme.[8] There is, however, no such morpheme in contemporary PC, as far as we know, nor is this category of nasalization ever realized consonantally. Nevertheless, more research is called for to rule out the existence of such a morpheme altogether. The matter has been elusive to date due to variations in speech among individual PC speakers and the lack of research opportunity to pursue the matter with those speakers who clearly show the contrast.[9]

---

at least in the 1950s and 1960s, as "the upper part of the soft palate facing the nasopharynx," as opposed to the "velum," as "the lower side towards the mouth" [Hamp 1957:59].)

[8] Note that the suggested sequence *a* ~ *ã* ~ *ãn* should rather be *a* ~ *an* ~ *ã*, since it is the intermediate form that is to be interpreted, in this view, as having the final consonant.

[9] While there are no syllable-final nasals in PC nor does there seem to be a person–number morpheme that can be associated with light nasalization, there is a strong correlation between heavy nasalization and animacy in some word pairs. Note the inanimate–animate pairs *bá*^{M} vs. *bą́*^{M} 'strike', *kïʔ*^{LM} vs. *kąʔ*^{LM} 'fall over', *kuï*^{LM} vs. *kuą*^{LM} 'give', *ʔai*^{LM} vs. *ʔą*^{LM} 'hang'. There are very many such pairs. But note also that nasalization is not invariably associated with animacy in other pairs: *kïg*^{M} vs. *kug*^{M} 'burn', *ʔnagʔ*^{M} vs. *ʔnáʔ*^{LM} 'seek', *hḯʔ*^{M} vs. *hë́ʔ*^{M} 'move'; and nasalization is clearly lexical in innumerable pairs like *haʔ*^{LM} 'fist' vs. *hąʔ*^{LM} 'edible greens' and *ta*^{LM} 'ladder' vs. *tą*^{LM} 'bird'.

3. Stress experiments. In order to study PC stress, a series of airflow experiments were performed, using both the Rothenberg mask and the Lyons mask in the city of Tuxtepec with the PC speaker Agustín. He produced pairs of syllables differing minimally by stress in alternating orders, of the sort listed in (3).

(3)	*kï*^{L}, *kḯ*^{L}	'I dreamed, I paid'
	kḯ^{L}, *kï*^{L}	'I paid, I dreamed'
	kï^{M}, *kḯ*^{M}	'we are dreaming, (the rain) stopped'
	kḯ^{M}, *kï*^{M}	'(the rain) stopped, we are dreaming'
	kï^{H}, *kḯ*^{H}	'dream!, we will dream'
	kḯ^{H}, *kï*^{H}	'we will dream, dream!'
	kï^{LM}, *kḯ*^{LM}	'I am dreaming, I am paying'
	kḯ^{LM}, *kï*^{LM}	'I am paying, I am dreaming'
	kï^{LH}, *kḯ*^{LH}	'I will dream, I will pay'
	kḯ^{LH}, *kï*^{LH}	'I will pay, I will dream'

3.1. Results. Figures 4 and 5 represent oral airflow for the PC ballistic syllable *kḯ*^{M} 'it ceased (raining)' and the PC controlled *kï*^{M} 'we are dreaming about it' on the same time scale. The ballistic syllable appears above the controlled syllable in figure 4; they are presented as a composite in figure 5.

3.2. Discussion. Merrifield (1963:2) claimed "three contrastive syllable types" for PC, one unstressed type not to be discussed here and two stressed types defined by two types of word stress—ballistic stress and controlled stress.[10] The perceptible differences between ballistically and controlled-stressed syllables were described as including "intensity," duration, pitch, voicing, and vowel height. Vowel height will not be discussed here, but all the others will to some degree. In this study, however, we particularly address the so-called intensity element, as well as duration, drawing upon the newly recorded oral airflow data of the type presented in figures 4 and 5. The relevant 1963 statement on this subject is as follows (Merrifield 1963:3): "[Ballistic syllables] are characterized by:

- an initial surge and rapid decay of intensity
- with a resultant fortis articulation of the consonantal syllable onset
- and [a] tendency to loss of voicing of postvocalic elements

---

[10] A PC phonological word has only one stressed syllable—which carries a ballistic or controlled stress—to which as many as four unstressed pretonic or posttonic syllables have been observed to be added (Merrifield 1968:14). Ballistic word stress is indicated by an acute accent (´) over the vowel of the stressed syllable of the phonological word; controlled word stress is unmarked. The stressed syllable is always the last syllable of the word which carries contrastive tone; some phonological words end in syllables that lack contrastive tone. These "untoned" syllables usually represent grammatical elements which, in other contexts, may be realized phonologically as separate phonological words which carry both their own stress and contrastive tone.

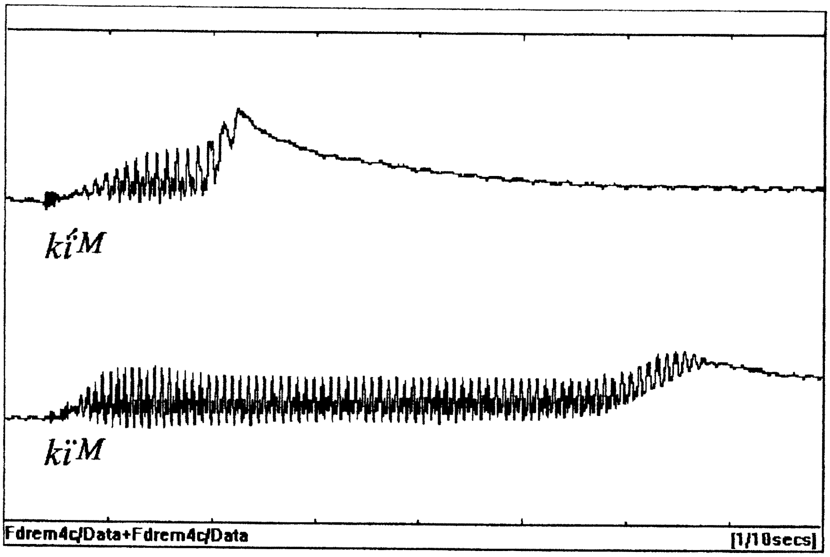

FIG. 4.—Comparison of oral airflow for PC ballistic and controlled syllables *kí*^{M} 'it ceased (raining)' and *kï*^{M} 'we are dreaming about it'.

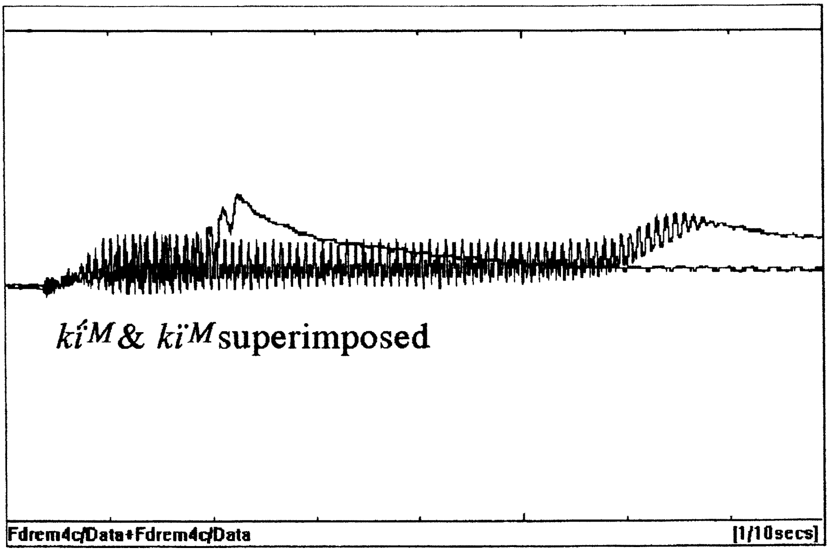

FIG. 5.—Composite plot of oral airflow for PC ballistic and controlled syllables *kí*^{M} 'it ceased (raining)' and *kï*^{M} 'we are dreaming about it'.

[Controlled syllables] exhibit no such initial surge of intensity and display a more evenly controlled decrease of intensity." With respect to timing, the relevant statement is "Ballistic syllables are shorter in duration than controlled syllables" (1963:3).

The term "intensity" was not defined in 1963 but was used in relation to the terms "ballistic" and "controlled" (borrowed from Pike 1957 and Stetson 1951) in informal reference to the results of energy expended by the lungs to produce particular air pressure characteristics in the vocal tract.[11] Oral airflow data collected for this study from the PC speaker Agustín are, therefore, of direct relevance to providing further insight into the nature of this phenomenon, although they give no direct evidence in regard to the source of the air pressure.

In general, oral airflow can be decomposed into two components, a relatively steady-state, egressive, DC component and a varying, AC component that reflects glottal vibration.[12] The DC component is indicated by the long-term slope or "trend line" of the signal, whereas the AC component is seen in the oscillating short-term variation of the signal.

Several differences in airflow characteristics are readily seen in figures 4 and 5. In the controlled syllable (the lower signal of figure 4), the 1963 interpretation was that there was no "initial surge of intensity" but an "evenly controlled decrease of intensity." The instrumental analysis shows that:

(*a*) The AC component of the controlled syllable airflow quickly attains a maximum level of amplitude and then continues, with very gradual loss of amplitude to a point just beyond the maximum level of DC flow, before it collapses into voicelessness.

(*b*) The DC component of the controlled syllable airflow remains steady across at least 75% of the syllable and then rises moderately through the final portion of the syllable to a level significantly above that of the first portion.

The "evenly controlled decrease of intensity" of 1963 appears to be reflected in the "very gradual loss of amplitude" in the AC component of these data; but while the lack of an "initial surge of intensity" does seem to

---

[11] It was specifically not meant to reference differences in the intensity of the acoustical signal (loudness).

[12] AC and DC are not commonly used in phonetic work but are used here on analogy to electrical waves. DC corresponds to steady-state airflow, that which remains more or less constant over a syllable; AC corresponds to oscillating airflow values that are responding to vibrating objects in the throat, viz., true vocal folds, false vocal folds, and aryepiglottal folds as found in some Tibeto-Burman languages, some kinds of Chinese, and !Xong of South Africa.

be correct relative to the ballistic syllable, a moderate "surge" in the DC component late in the controlled syllable was unnoticed in 1963.

In the ballistic syllable (the upper signal of figure 4):

(*a*) The relatively steady-state portion of the DC component of the ballistic syllable airflow is much shorter, and the upward slope of the surge which follows it is much more rapid and achieves a slightly higher maximum than in the corresponding controlled syllable, after which the airflow declines gradually. The peak is achieved at a point corresponding to 25% of the position of the peak in the controlled syllable.

(*b*) The AC component of the ballistic syllable airflow, on the other hand, increases more slowly at the onset, attaining maximum amplitude as the DC component begins its more rapid upward surge. At this juncture the AC component rapidly declines in amplitude, abruptly ending at the peak of the DC surge, after which voicelessness follows to the end of the syllable.

With respect to overall timing, both syllables may be of nearly the same length when one includes the time it takes for airflow to dissipate, but the ballistic syllable is unvoiced for much of its duration. The timing of the ballistic surge of pressure varies in other recorded examples studied, from a position of 25% to 45% of the duration of the syllable, but the general configuration of figures 4 and 5 is typical for all tones.[13]

Having identified PC stress contrasts and described some of their phonetic characteristics, it is easy enough to mark contrasting pairs using any of several orthographic conventions, whether by an accent or, say, a postvocalic consonant (such as *h*), but questions remain concerning the underlying phonetic gestures that produce these characteristics and what is required in a phonological theory to account for them.

This experiment provides no direct evidence concerning the specific mechanism responsible for ballistic stress in PC, but features exhibited by the ballistic syllable suggest an aerodynamic event in which air pressure is increasing rapidly under maintenance of glottal vibration. These findings would appear to accord with Mugele's (1982) contention, based on spectrographic evidence from Lalana Chinantec, that ballistic stress is phonologically characterized by an increase in subglottal pressure. It is not clear to us how they might support an account based on the alteration of glottalic settings (abduction) of the kind suggested by Silverman for Comaltepec Chinantec (1994; 1995), who proposes that "a laryngeal abduction is the primary articulatory gesture" (Silverman et al. 1995:78).

---

[13] It is possible that the decline in pressure after the surge is only an artifact, in which case the ballistic syllables may, in fact, be shorter than controlled syllables.

4. Tone experiments. In order to determine the pitch trajectories used by the seven PC speakers, they were all requested to produce three successive tokens of each of a number of sets of lexical items that differed only by tone, from a total list of 131 items, although not all 131 were recorded for each speaker. Composite representations of some of the recorded triplets were then made using software written by Edmondson in order to compute a single, representative pitch track for each threesome.[14] The resulting composites were then plotted using Quattro® Pro for Windows v5.0 spreadsheets and graphs to produce the pitch trajectory displays presented below.

4.1. Results. Figures 6 and 7 represent composite plots of three repetitions each of the five tone categories illustrated by the forms listed in (3), as well as the sixth tone category illustrated by *tie*^{HL} 'James', borrowed from Spanish *Santiago*, all produced by the PC speaker Camilo. Figure 6 represents the five tone categories with controlled word stress, while figure 7 represents the corresponding tone categories with ballistic word stress. The sixth tone category, found only in some words borrowed from Spanish, is arbitrarily placed in figure 6 with the controlled stress forms, since the ballistic versus controlled contrast is not found with this tone category.

4.2. Discussion. Although Chinantec tone is notoriously difficult for outsiders to master because of its subtlety, its interaction with other phonological features, and because of its extensive use in verb inflection, it can be described in terms of just five contrastive categories found in native Chinantec vocabulary and one additional category found in words borrowed from Spanish. These tones were described in Merrifield (1963) as consisting of three level trajectories and three glides between those levels.

The allophonics of Chinantec tones depends on factors such as stress type, position in relation to other tones (tone sandhi), and the presence or absence of a final glottal stop. Not all of these phenomena are addressed in this short study, but a preliminary look at unchecked syllables in isolation begins to show how the acoustical data complement the original analysis.

4.2.1. PC tone in controlled syllables. Figure 6, based on acoustic recordings, presents the trajectories of the five controlled words listed in (3)

---

[14] The compositing software compensates for differences of duration and of pitch height between the various tokens of a particular word and computes a value that is representative of all three. Each of the three tokens is adjusted for duration by adding or subtracting an amount equal to each 5-msec subinterval equal to the difference between the mean value of all the tokens and an individual token. Then it adjusts the register by adjusting the pitch value at each 5 msec up or down as that token is higher or lower in mean frequency than the overall mean of the three tokens. Only after all adjustments are made to all tokens can a mean be calculated. These mean values are calculated at each 5 msec, thus preserving from the three all they have in common and discarding all that is idiosyncratic. This program is packaged with the CECIL speech analysis software.

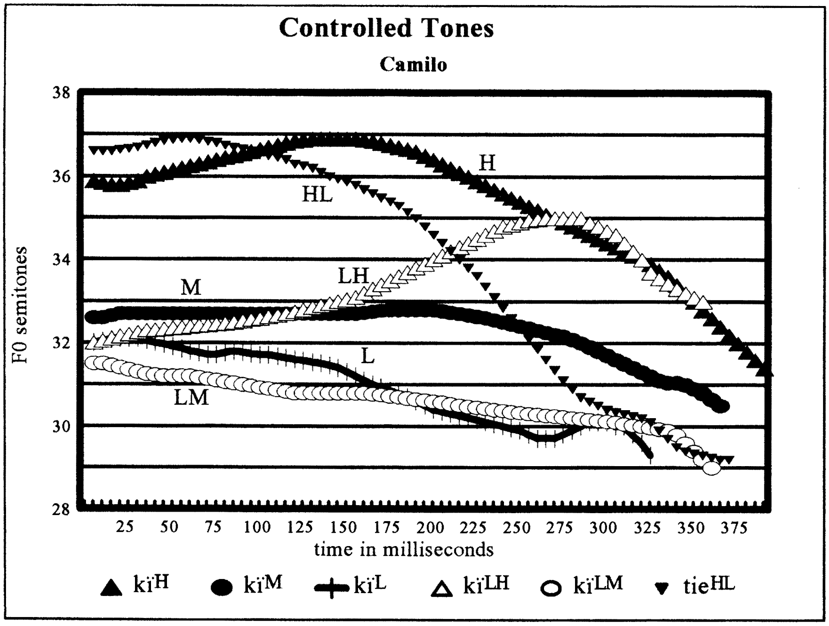

FIG. 6.—Six tone trajectories for PC controlled syllables based on acoustic recordings.

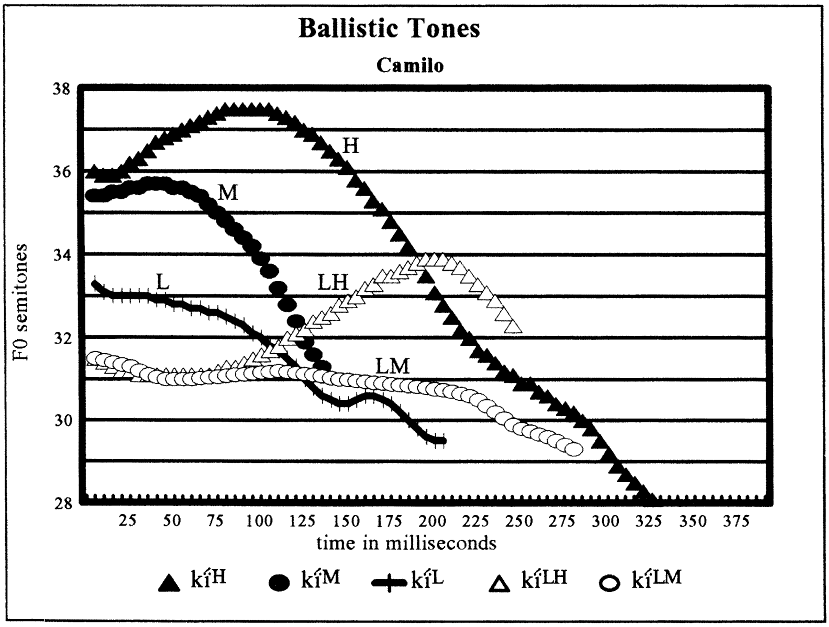

FIG. 7.—Five tone trajectories for PC ballistic syllables based on acoustic recordings.

plus the loanword *tie*^{HL} 'James' from Spanish *Santiago.* Looking at these trajectories, note that:

- High-tone *kï*^{H} 'dream!' begins just below 36 semitones,[15] rising gradually to 36.9 semitones, and then falls gradually to below 32 semitones.
- Mid-tone *kï*^{M} 'we are dreaming' begins at 32.6 semitones and rises only very slightly to 32.8 semitones before falling off to below 31 semitones.
- Low-tone *kï*^{L} 'I dreamed' begins at 32 semitones and falls to almost 29 semitones, with only a short shallow opening rise and minimal change of direction during the fall until near the end of the trajectory, where there is a brief reversal of direction before finally falling to its lowest point.
- Low–mid-tone *kï*^{LM} 'I am dreaming' begins at 31.5 semitones and falls along a very gradual and steady course to 29.9 semitones, where it begins a faster fall to 29 semitones.
- Low–high-tone *kï*^{LH} 'I will dream' begins at 32 semitones and rises gradually to 35 semitones before falling off to 33 semitones.
- High–low-tone *tie*^{HL} 'James' begins at 36.6 semitones, peaks quickly at 36.9 semitones, and falls moderately fast to almost 29 semitones.

The 1963 analysis was based on both spoken and whistled speech. Chinantec men communicate to one another by whistling, and whistled renditions of speech were utilized by Merrifield as a tool for learning to recognize the spoken forms. The results of the early analysis were then described using a highly schematic rendition of the supposed pitch trajectories of the whistled forms. This schema is reproduced here, in part, as figure 8.

High and mid tones, in controlled syllables, were perceived by Merrifield as essentially level tones, whereas low tone was perceived as a low-falling tone. Low–mid tone was perceived as an extremely shallow rising tone—almost level but characteristically different from mid and high tones. Low–high tone was perceived as a more sharply rising tone. The high–low tone was not included in the schematic presentation but was described as a

---

[15] On semitones. This study relies on measuring and comparing pitch intervals that occur around different mean frequencies. Because the psychological magnitude of pitch intervals is not represented by a constant span of Hertz with increasing pitch (Stevens, Volkman, and Newman 1937 and Borden and Harris 1980), another metric is needed. The Hertz-scale may be converted into a useful *interval-preserving* pitch scale according to the following transformation (Fairbanks and Pronovost 1939): $N = 39.86\ (\log 10\ (Fa/Fb))$, where Fa and Fb are frequencies in Hertz and Fb represents the zero point standard. We use the Equal Tempered chromatic (musical) scale (Hodgman 1961), where $A4 = 440\ Hz$ and $C0 = 16.35$ or zero semitones. Thus the relation becomes: $Fst = 39.86\ (\log 10(Fhz/16.35))$, Fhz = frequency in Hz. For a full discussion of semitones, see Ross, Edmonson, and Seibert (1986).

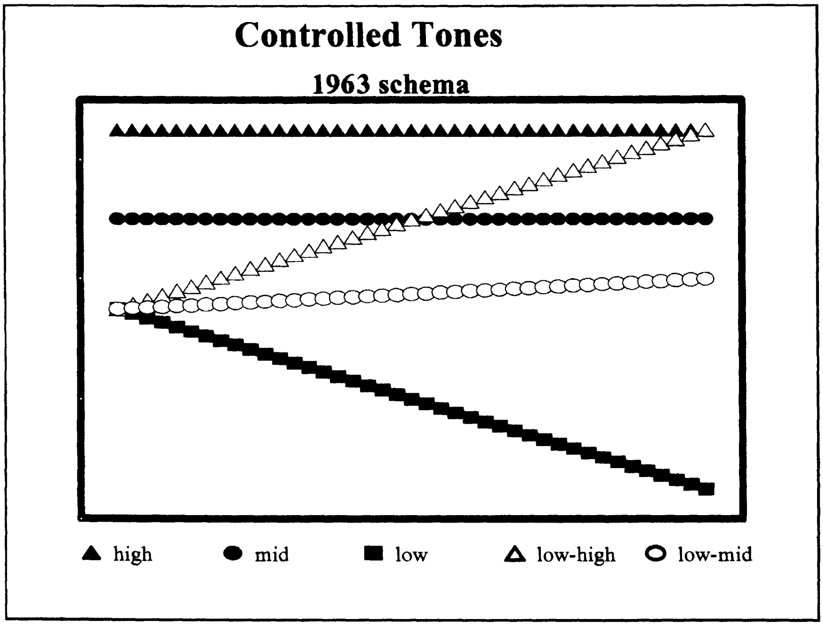

FIG. 8.—The 1963 schematic representation of PC tone trajectories in controlled syllables.

"high falling glide which occurs only on a very limited list off words all of which are borrowed from Spanish" (Merrifield 1963:10).

The pitch trajectories of figure 6 are clearly different from those of figure 8. In the first place, there is a clear tendency for ALL TONES to fall, especially during the latter portion of their trajectories. Second, an inspection of numerous recorded tokens of high, mid, and low tones indicates that the most distinctive element of their trajectories is the relative height of their apexes, rather than the height of their initial or final portions.

The heights of even particular tones are, of course, relative, changing from speaker to speaker and within the speech of the same speaker (Pike 1948:4). It is beyond the scope of this paper to investigate the extent of such variation, but figure 9 is offered, to show something of the difference in trajectories of two tokens each of the two high-tone words *kï*^{H} 'dream!' and *teg*^{H} 'blind', as spoken by four different adult male speakers.[16]

The first portion of the trajectories of high, mid, and low tones involves movement from what appear to be nondistinctive starting points, some-

---

[16] In figure 9, the word *kï*^{H} 'dream!' is represented for Aniceto and Camilo, and the word *teg*^{H} 'blind' is represented for Florentino and Mario.

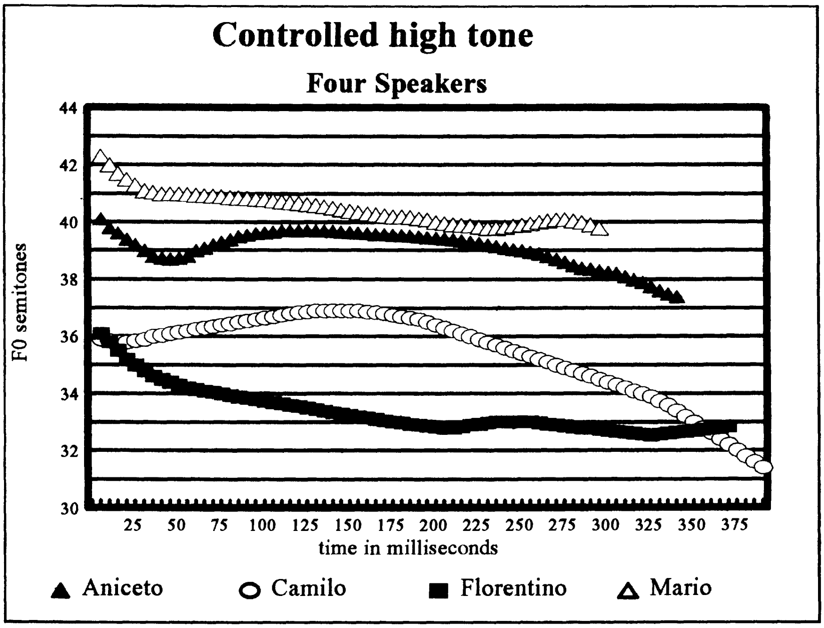

FIG. 9.—Examples of controlled high tone by four PC speakers.

times involving brief changes in direction, into the more distinctive portion of the trajectory which usually rises to an apex. Neither the length of the downturn nor minor changes in direction after reaching the apex appear to be distinctive.

Low–mid tone is a gradual downglide in figure 6, rather than the upglide predicted in figure 8, but other recorded tokens of this tone have been found to vary from a gradual downglide, to primarily level, to a gradual upglide. Its distinctiveness appears to be in a tendency to hold to a steady, unidirectional track for a prolonged period which lacks any obvious apex of the sort seen in high, mid, and low tones.

Low–high tone is not unlike its 1963 description, except that even this rising tone ends in a downglide, which was not detected in the 1963 treatment.

The difference between high tone and high–low tone is that the latter attains its apex much more quickly and falls thereafter at a greater speed than does high tone.

4.2.2. PC tones in ballistic syllables. Now if we look at the five ballistic forms represented in figure 7, in comparison to the controlled forms of figure 6, we can begin to gather clues concerning the effect of ballistic stress on tone.

- High-tone *kí*^{H} 'we will dream' begins at 36 semitones, rising quickly to 37.5 semitones, and falls again quickly to 28 semitones (although not all recorded tokens of ballistic high tone are this long or fall so far).
- Mid-tone *kí*^{M} '(the rain) stopped' begins at 35.4 semitones, rises to 35.7 semitones, and falls, again sharply, to 31.2 semitones.
- Low-tone *kí*^{L} 'I paid' begins at 33.3 semitones and drops slightly to what may be considered its "apex" at 33 semitones, before falling to 29.5 semitones at a less precipitous rate than high and mid tones. The brief reversal of direction before falling to its lowest point is exhibited by many tokens of several of the tones and does not seem to be distinctive.
- Low–mid-tone *kí*^{LM} 'I am paying' falls quickly from an initial 31.5 semitones to 31 semitones, where it holds almost steady, dropping only .10 of a semitone throughout most of its trajectory, before falling almost 2 semitones at the end.
- Low–high-tone *kí*^{LH} 'I will pay' also begins at 31.5 semitones and rises rapidly to 34 semitones before falling off, again rapidly, to 32.1 semitones.

The most obvious distinctive characteristics of the ballistic trajectories, as opposed to the corresponding controlled trajectories, are their relatively shorter duration and the relative speed of pitch changes before and after they reach their apexes.

The 1963 schema for representing ballistic tones is presented in figure 10 in two parts. Trajectories on the left represent how tones are realized in ballistic syllables occurring medially in an utterance; trajectories on the right represent how they are realized in syllables occurring finally in an utterance. These trajectories differ from the controlled syllable tones of figure 8 in several ways. First, ballistic syllables were claimed to begin higher in pitch than corresponding controlled syllables (although this is not shown here since the relative height of trajectories between figure 8 and 10 is not calibrated). Second, ballistic syllables were said to be shorter. This is reflected in figure 10, although in our discussion of stress we mentioned that ballistic syllables may, in fact, be longer than they seem to be if we take into account the time it takes for air pressure to dissipate. Finally, ballistic syllables were said to fall in pitch utterance-medially when unchecked by glottal but to be level otherwise.

What can we learn from comparing the representations of ballistic syllables in figure 7 to those in figure 10? First, we find for ballistic syllables, as we did for controlled syllables, that the trajectories of even so-called level tones tend to fall at some point during their trajectories, even when

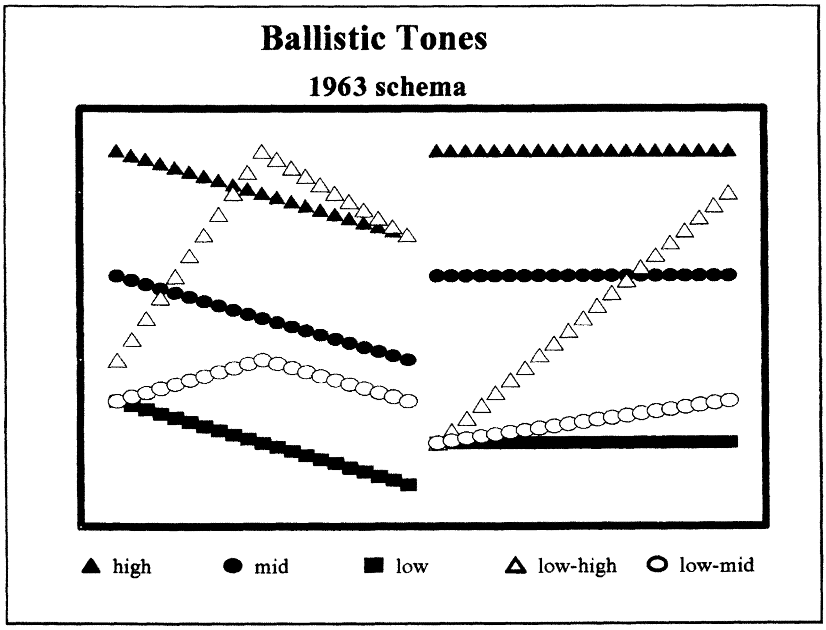

FIG. 10.—The 1963 schematic representation of PC tone trajectories in ballistic syllables.

final in the utterance. All of the data reported upon here so far are of forms given in isolation, or as items in a list, so that they are all, for all practical purposes, utterance-final forms.

Some of the data were recorded by contrastive pairs, such as *ki*^{LM} *kí*^{LM} 'I am dreaming, I am paying'; but they were then recorded in reverse order as well, without significant differences in the recorded result for words in the first and words in the second position of such pairs.

If we discount the right-hand column of figure 10, then, as unrepresentative of the results obtained from our airflow recordings of ballistic syllables, we see that the representation in the left-hand column of figure 10 is not too bad. High, mid, and low tones do all fall in ballistic syllables. What is missing in the 1963 schema is the nondistinctive rise in pitch to an apex in both mid and high tone. Low–high tone in ballistic syllables, even more so than in controlled syllables, is much as indicated in 1963. And so is low–mid tone in ballistic syllables, which shows a shallow rise much more consistently than in controlled syllables.

4.2.3. Further work to be done. We have made a beginning in describing the results of tone experiments in PC, but additional space would be required to present data concerning all the features of tone presented in 1963.

- We have recordings of syllables checked by glottal but have not discussed them here.
- The tones of syllables in sequence were said to downstep in PC; this was confirmed, but we plan to present our findings on another occasion.
- Voiced consonants influence the trajectories of PC tone. We have some data on this but not enough to present an adequate report.
- The relative height of pitch trajectories for individual speakers, between different speakers, for males and females, and between ballistic and controlled syllables are all subjects worthy of additional work.
- The study of airflow recordings of whistled speech would be instructive for determining how PC speakers translate spoken language into whistle talk in terms of pitch trajectories and stress differences and how the 1963 analysis, which utilized whistled speech as an aid to analysis, was helped or hindered by it in the attempt to represent PC tone and stress systems.

There are undoubtedly other matters which can usefully be discussed concerning PC tone. We have made a start. We have found the 1963 discussion of PC tone, based on auditory impressions, to have been a reasonably good first approximation, but the introduction of airflow data into the mix has facilitated additional insights into the nature of PC tone.

REFERENCES

ANDERSON, JUDI LYNN; ISAAC H. MARTINEZ; AND WANDA PACE. 1990. Comaltepec Chinantec tone. Syllables, Tone, and Verb Paradigms: Studies in Chinantec Studies 4, ed. William R. Merrifield and Calvin R. Rensch, pp. 3–20. Dallas: Summer Institute of Linguistics and University of Texas at Arlington.

BAUERNSCHMIDT, AMY. 1965. Amugo syllable dynamics. Language 41:471–83.

BORDEN, G. J., AND K. S. HARRIS. 1980. Speech Science Primer: Physiology, Acoustics, and Perception of Speech. Baltimore: Williams and Wilkins.

CHAO, YUEN REN. 1934. The non-uniqueness of phonemic solutions to phonetic systems. Bulletin of the Institute of History and Philology (Academia Sinica) 4:363–97.

FAIRBANKS, G., AND W. PRONOVOST. 1939. An experimental study of the pitch characteristics of the voice during the expression of emotion. Speech Monograph 6:87–104.

FORIS, DAVID PAUL. 1973. Sochiapan Chinantec syllable structure. IJAL 39:232–35.

GARDNER, RICHARD, AND WILLIAM R. MERRIFIELD. 1990. Quiotepec Chinantec tone. Syllables, Tone, and Verb Paradigms: Studies in Chinantec Studies 4, ed. William R. Merrifield and Calvin R. Rensch, pp. 91–105. Dallas: Summer Institute of Linguistics and University of Texas at Arlington.

HAMP, ERIC P. 1957. A Glossary of American Technical Linguistic Usage 1925–1950. Publication of the Committee for Terminology, Permanent International Committee of Linguistics. Utrecht: Spectrum Publishers.

HODGMAN, C. D., ed. 1961. Handbook of Chemistry and Physics. 42d ed. Cleveland: Chemical Rubber Publishing.

LADEFOGED, PETER. 1971. Preliminaries to Linguistic Phonetics. Chicago: University of Chicago Press.

LADEFOGED, PETER, AND IAN MADDIESON. 1995. Sounds of the World's Languages. [In press].

MERRIFIELD, WILLIAM R. 1963. Palantla Chinantec syllable types. Anthropological Linguistics 5, no. 5:1–16.

______. 1968. Palantla Chinantec Grammar. Papeles de la Chinantla 5, Serie Científica 9. Mexico: Museo Nacional de Antropología.

______. 1993. Whither Chinantec adjectives? Paper presented at the Twenty-second Annual Meeting of the Linguistic Association of the Southwest, University of Texas at Arlington, October 22–24, 1993.

______. 1995. Progress in Chinantec language studies. Panorama de los estudios de las lenguas indígenas de México, ed. Doris Bartholomew, Yolanda Lastra, and Leonardo Manrique, vol. 2, pp. 187–236. Quito, Ecuado: Colección Biblioteca Abya-Yala 17.

MERRIFIELD, WILLIAM R., AND ALFRED E. ANDERSON. 1995. Issues in Chinantec bilingual lexicography. The Twenty-first LACUS Forum, 1994, ed. Mava Jo Powell, pp. 476–92. Chapel Hill, N.C.: The Linguistic Association of Canada and the United States.

______. 1999. Diccionario chinanteco de la diáspora del pueblo antiguo de San Pedro Tlatepuzco, Oaxaca. Serie de vocabularios y diccionarios indígenas Mariano Silva y Aceves 39. México, D.F.: Instituto Lingüístico de Verano, A.C.

MERRIFIELD, WILLIAM R., AND CALVIN R. RENSCH, eds. 1990. Syllables, Tone, and Verb Paradigms: Studies in Chinantec Languages 4. Dallas: Summer Institute of Linguistics and University of Texas at Arlington.

MUGELE, ROBERT L. 1982. Tone and ballistic syllable in Lalana Chinantec. Ph.D. dissertation, University of Texas.

______. 1984. The phonetics of ballistic and controlled syllables. Texas Linguistic Forum 23:1–43.

PIKE, KENNETH L. 1948. Tone Languages: A Technique for Determining the Number and Type of Pitch Contrasts in a Language, with Studies in Tonemic Substitution and Fusion. Ann Arbor: University of Michigan Press.

______. 1957. Abdominal pulse types in some Peruvian languages. Language 33:30–35.

RENSCH, CALVIN R. 1968. Proto Chinantec Phonology. Papeles de la Chinantla 6, Serie Científica 10. Mexico: Museo Nacional de Antropología.

______. 1978. Ballistic and controlled syllables in Otomanguean languages. Syllables and Segments, ed. A. Bell and J. B. Hooper, pp. 85–92. Amsterdam: North-Holland.

ROSS, ELLIOTT D.; JEROLD A. EDMONDSON; AND G. BURTON SEIBERT. 1986. The effect of affect on various acoustic measures of prosody in tone and non-tone languages: a comparison based on computer analysis of voice. Journal of Phonetics 14:283–302.

ROTHENBERG, MARTIN. 1971. The glottal volume velocity waveform during loose and tight glottal adjustments. Proceedings of the Seventh International Congress of Phonetic Sciences, pp. 380–88.

______. 1972. A new inverse-filtering technique for deriving the glottal airflow waveform during voicing. Journal of the Acoustical Society of America 53, no. 1:1632–45.

______. 1977. Measurement of airflow in speech. Journal of Speech and Hearing Research 20, no. 1:155–76.

______. 1984. Source-trace acoustic interaction in breathy voice. Vocal Fold Physiology: Biomechanics, Acoustics and Phonatory Control, ed. I. R. Titze and R. C. Scherer, pp. 465–81. Denver: The Denver Center for the Performing Arts.

RUPP, JAMES E. 1990. The Lealao Chinantec syllable. Syllables, Tone, and Verb Paradigms: Studies in Chinantec Studies 4, ed. William R. Merrifield and Calvin R. Rensch, pp. 63–73. Dallas: Summer Institute of Linguistics and University of Texas at Arlington.

SILVERMAN, DANIEL D. 1994. A case study in acoustic transparency: [spread glottis] and tone in Chinantec. Proceedings of the Northeast Linguistic Society 24:558–72. Amherst: University of Massachusetts.

______. 1995. Phasing and recoverability. Ph.D. dissertation, University of California, Los Angeles.

Silverman, Daniel D.; Barbara Blankenship; Paul Kirk; and Peter Ladefoged. 1995. Phonetic structures in Jalapa Mazatec. Anthropological Linguistics 37, no. 1:70–88.

Skinner, Leo E. 1962. Usila Chinantec syllable structure. IJAL 28:251–55.

Stevens, S. S.; J. Volkman; and E. B. Newman. 1937. A scale for the measurement of the psychological magnitude of pitch. Journal of the Acoustical Society of America 9:185–90.

Stetson, R. H. 1951. Motor Phonetics: A Study of Speech Movements in Action. 2d ed. Amsterdam.

Thelin, Anders. 1980. Tlacoatzintepec Chinantec syllable structure. SIL Mexico Workpapers 4:1–8.

Westley, David O. 1971. The Tepetotutla Chinantec stressed syllable. IJAL 37:160–63.