The Effects of f0 and Position-in-utterance on Phonation in Santa Ana Del Valle Zapotec

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ABSTRACT

This study examines the effects of f0 and position on phonation in Santa Ana del Valle Zapotec, a language that contrasts modal, breathy and creaky voice on vowels. The first part of this experiment determined that f0, and not position-in-utterance, influenced phonation. In the second experiment, the effects of f0 on phonation were examined in more detail. Speakers were asked to produce words from each phonation in four prosodic positions: in isolation (high f0), focused sentence-initially (high f0), sentence-medially (mid f0) and sentence-finally (lower f0). In medial position, a contrast between breathy, modal and creaky voice was found. In sentence-final position, when the tokens had a lower f0, the contrast between modal, breathy and creaky voice was preserved, but with modal and breathy words both breathier. In both isolation and sentence-initial position, when tokens had higher f0, the contrast between phonations was minimized.

1. INTRODUCTION

This study examines the effects of f0 and position-in-utterance on phonation in Santa Ana del Valle Zapotec (SADVZ), a Zapotec language spoken in Oaxaca, Mexico. This language contrasts modal, breathy and creaky phonation on vowels, and on modal vowels, high versus rising tones. Breathy phonation is associated with a small fall in f0, and creaky phonation with a large fall in f0. [1].

Previous studies of other languages have shown that phonation is sensitive to changes in f0 and position-in-utterance. For example, [2] showed that, in English, position can effect phonation, independent of changes in f0. In English, words at phrase boundaries and accented words display a more non-modal phonation than their non-prominent and non-phrase-initial counterparts [2]. Changes in f0 are also likely to create changes in phonation since there is a correlation between phonation, vocal fold vibration and f0. A high f0 is associated with vocal folds that have an increased length and tension; a low f0 is linked to decrease length and tension in the vocal folds. Thus, one would expect breathy voice to be correlated with a low f0 and tenser voice qualities to have a higher f0. This is true of languages such as Hindi, where breathy voice is associated with lowered f0 [2].

Studies on the interaction between f0 and voice quality have been restricted to languages with non-contrastive phonation. SADVZ provides an opportunity to study the effects of f0 and position-in-utterance on contrastive phonations, independently. SADVZ has relatively free word order and no phrase-final fall in f0. Thus, it is possible to study the effects of position without a strong influence of f0. In addition, it is possible to examine the potential influence of f0 on phonation, independent of position, through the examination of a variety of intonational contours.

2. EXPERIMENT I: EFFECTS OF F0 AND POSITION-IN-UTTERANCE

First, it is necessary to determine whether f0, position –in-utterance, or both, has an effect on phonation in SADVZ.

2.1 METHOD

2.1.1 SPEAKERS

Three native speakers of SADVZ (two male, one female), ranging from 40-50 years of age, were recorded for this study.

2.1.2 SPEECH MATERIALS

The wordlist, which illustrated the three-way contrast in phonation, was composed of 44 monosyllabic words, all with the vowel [a] and a range of consonants.

2.1.3 PROCEDURE

Speakers were asked to produce sentences that exhibited various intonational contours. Each sentence included target words from each of the three phonations. The sentences comprised of two sets. Set I (Table 1) was composed of sentences where the target words had different positions across the utterances, but had the same f0.

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When the position is ...	The f0 is...	Sentence	Gloss
sentence-initial (focused)	High	[__guna Len]	'Elena saw the __
sentence-final (in a negative question)	High	[Teka guna̤ Len __]	'Didn't Elena see the __?'

Table 1: Set I: Target words had different position across utterances, but had the same f0.

Set II was composed of sentences where the target words had the same position within the utterance, but a different f0.

When the position is ...	The f0 is...	Sentence	Gloss
sentence-final (non-focused, statement)	Low	[guna Len __]	'Elena saw __'
sentence-final (in a negative question)	high	[Teka guna Len __]	'Didn't Elena see __?'

Table 2: Set II: Target words had the same position across utterances, but different f0.

Each sentence was repeated five times. Tokens were digitized and analyzed in PCQuirer at sampling rate of 22050 Hz. A Fast Fourier Transform was calculated over a 30 ms window starting 50 ms before the end of the vowel (since creak is only apparent at the end of the vowel). Spectrograms were used to position the 30 ms window. To calculate phonation for the male speakers, the amplitude of H1 and the amplitude of the highest harmonic near F3 was taken from the FFT; for the female speaker, the amplitude of H1 and H2 was taken. (H1-F3 and H1-H2 were determined to be the best measures of phonation for the male and female speakers, respectively.) The measure of phonation is the difference between these two measurements in dB.

3. RESULTS

Figures 1-4 represent the results of H1-F3 (male speakers). The difference between H1-F3 in dB is presented on the y-axis. (The female speaker showed the same results.)

3.1 DIFFERENT POSITION, SAME F0

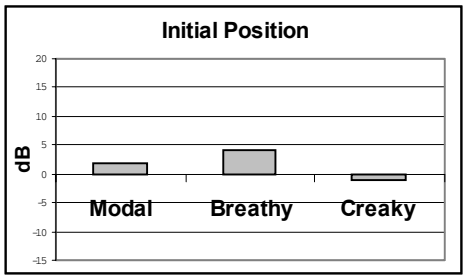

Figure 1: Results of H1-F3 for Set I. The graph represents tokens read with a high f0 in sentence-initial position.

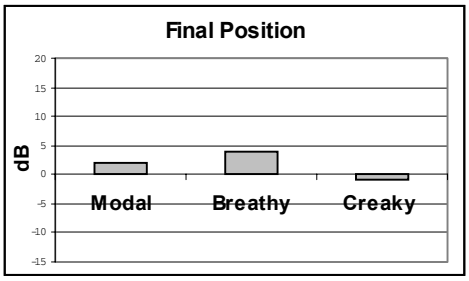

Figure 2: Results of H1-F3 for Set I. The graph represents tokens read with a high f0 in sentence-final position.

3.2 SAME POSITION, DIFFERENT F0

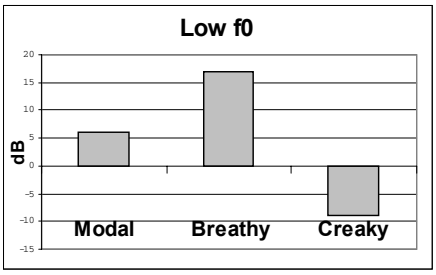

Figure 3: Results of H1-F3 for Set II: The graph represents tokens read with a low f0 in sentence-final position.

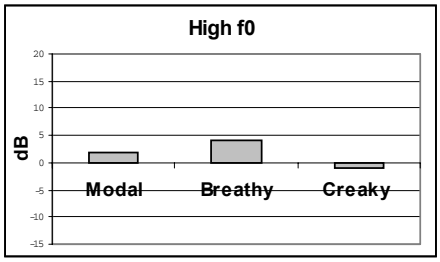

Figure 4: Results of H1-F3 for Set II: The graph represents tokens read with a high f0 in sentence-final position.

The graphs show that there is an effect of f0 on phonation, but not an effect of position. While the three phonation categories are distinguished at low f0s, the three categories are not well distinguished at high f0s, regardless of position.

4. EXPERIMENT II: EFFECTS OF F0 ON PHONATION IN SADVZ

4.1 METHOD

In the second part of the experiment, the effects of f0 on phonation were examined more closely. Speakers were asked to produce words from each of the phonation categories. Each token was read in four prosodic positions: isolation, sentence-initially (and focused), sentence-medially, and sentence-finally. Sentence-medially, in the frame [Guniʔ __ pɾimeɾ] "Say __ first," tokens had a mid-ranged f0. In isolation, tokens had an overall higher f0 than sentence-medial position. In sentence-initial (focused position) tokens also had a higher f0 than sentence-medial position. These tokens were uttered in the frame [___guniʔ] "__say (it)." Sentence finally, in the frame [Guniʔ __] "Say __", tokens had a lower f0 than sentence-medial position. Each token was repeated five times. Tokens were digitized and analyzed in PCQuirer at a sampling rate of 22050 Hz.

H1-F3 (for the male speakers) and H1-H2 (for the female speakers) were measured following the same procedure established in Experiment I. In addition, f0 was measured from the frequency of H1 at the beginning, middle and end of the vowel.

4.2 RESULTS

Figures 5, 7, 9, 11 represent the results of H1-F3 (male speakers). The difference between H1-F3 in dB is presented on the y-axis. Figure 6, 8, 10, and 12 represent f0 at three timepoints within a vowel. (The female speaker's results were similar.) In the graphs of f0, H equals the f0 of modal vowels with a high tone, R equals modal vowels with a rising tone, B represents the f0 of breathy vowels and C, of creaky ones.

4.2.1 MEDIAL

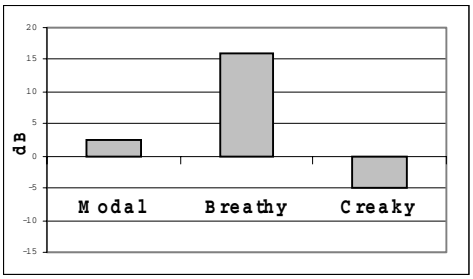

Figure 5: H1-F3, Medial Position

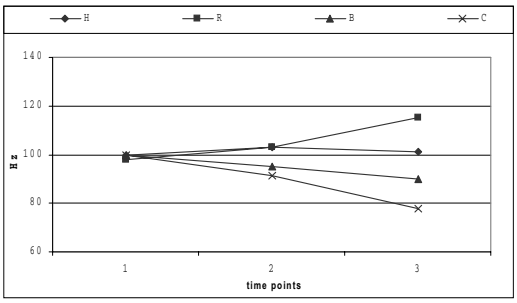

Figure 6: F0 for tokens read in sentence-medial position.

In sentence-medial position, there is a three-way contrast between modal, breathy and creaky phonation. Each of these phonation is associated with one or more tonal patterns. Modal phonation can have either a high or a high rising tone, breathy phonation has a slightly falling tone and creaky phonation has a largely falling tone. (This result is very similar to the cases with low f0 in Experiment I (Figure 3).)

4.2.2 ISOLATION

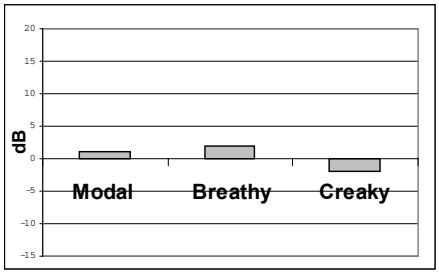

Figure 7: H1-F3, Isolation

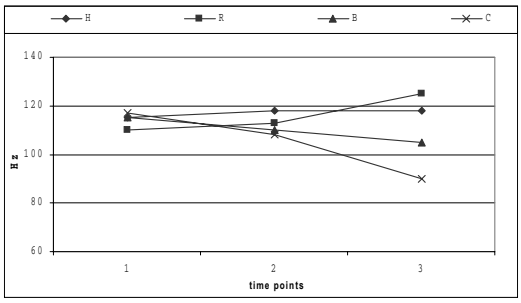

Figure 8: F0 for tokens read in isolation.

In isolation, where the f0 is higher than in medial position, the three-way contrast is phonation is minimized. Tokens which had breathy or creaky phonation in sentence-medial position had a more modal phonation in isolation. Modal phonation remained relatively the same. While the three-way contrast in phonation is minimized, the four-way contrast in tone is preserved. (This is similar to high f0 cases in Experiment I (Figures 1,2,4.)

4.1.3 INITIAL (FOCUSED) POSITION

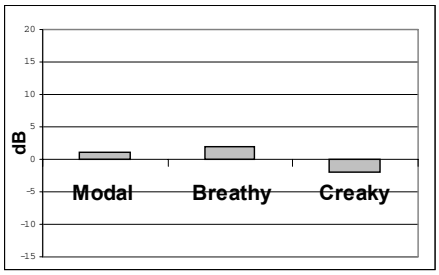

Figure 9: H1-F3, Initial (Focused) Position

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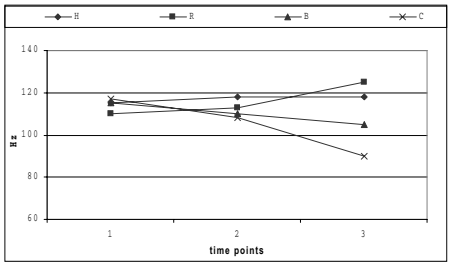

Figure 10:F0 for tokens read in sentence-initial position.

Words read in initial (focused) position were most similar to words read in isolation. In initial (focused) position, where the f0 is higher than in medial position, the three-way contrast in phonation is minimized, while the four-way contrast in tone is preserved. This is similar to Figure 6 above and to cases with high f0 in Experiment I. Words that had a breathy or creaky phonation in medial position now had a much more modal phonation. Modal phonation remained relatively the same.

4.1.4 FINAL POSITION

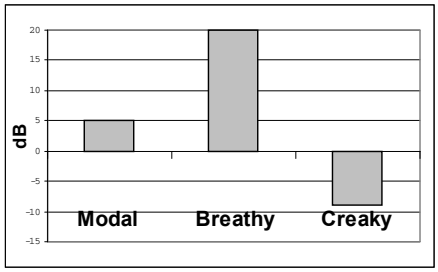

Figure 11: H1-F3, Final Position

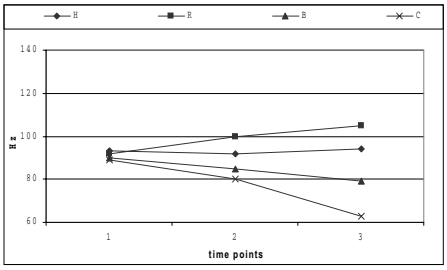

Figure 12:F0 for tokens read in sentence-final position.

In sentence-final position, where the f0 is lower than in medial position, the three-way contrast is preserved, but with modal and breathy words both breathier and creaky vowels creakier. (This is similar to the low f0 cases in Experiment I, Figure 3.) Again, the four-way tonal contrast is preserved.

5. CONCLUSIONS

In conclusion, position-in-utterance (independent of f0) does not have an effect on phonation, but changes in f0 do alter phonation. In sentence-medial position, which has a mid-ranged f0, there is a three-way contrast between modal, breathy and creaky voice. In sentence-final position in a non-focused statement, when the tokens had a lower f0, the contrast between modal, breathy and creaky voice was preserved, but with modal and breathy words both breathier. In isolation, initial position and sentence-final position in negative question, when tokens had higher f0, the contrast between phonations was minimized. The effect of f0 is so strong that the phonemic three-way contrast in phonations is not preserved when the f0 is high.

The question arises as to whether the tone or phonation is in any way more basic than the other. It seems that when the phonation is weakened, the tonal pattern remains, preserving some level of distinction. For example, in sentence-initial position, breathy phonation becomes modal, but the falling tone remains. Thus, the tonal pattern seems to be more basic; at the very least, it acts as an enhancing feature of the phonation differences.

In conclusion, this study has shown that there is a strong effect of sentence-level f0 on phonation. Further research is necessary to understand the effects of f0 in a more natural discourse context.

REFERENCES

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[3] Ohala, John.1973. The physiology of tone. *Southern California Occasional Papers in Linguistics*. 1,1-14.