Vowel Length and Pitch in Yavapai

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Introduction

As early as 1970 (published in *Hokan Studies*, 1976), Shaterian claimed that there are three distinctive vowel lengths in Yavapai, a Native American Indian language of the Yuman family. He reiterated these claims in his 1983 dissertation. Shaterian does not limit his remarks to Yavapai, but rather suggests a three-vowel-length distinction as a phenomenon within the Pai (Northern Yuman) subgroup. He cites Joel's work (1966) in further support of this claim.

Joel (1966) describes a similar situation in Paipai, a Yuman language of Lower California with suggested strong affinities to Northern Yuman (Havasupai, Hualapai, and Yavapai): She finds three vowel lengths, one short, one long, and one of varying quantity. A cursory comparison of her recordings with those of Yavapai reveals definite correspondences in the three vowel lengths, although the matter of how systematic these correspondences may be has yet to be thoroughly explored. (Shaterian, 1976:88)

Shaterian also noted that Yavapai, a predominantly intonational language, makes limited use of tone:

I have found, in addition, distinctive pitch in both . . . [Northeastern Yavapai] and . . . [Western Yavapai], the two dialects with which I have worked most closely, although I have not yet been able to take precise acoustic measurements of the relationship between pitch and length; nevertheless, this is, I am certain, going to prove a very interesting area of research; and it is quite likely that the results of these investigations will . . . shed new light on Proto-Yuman vocalism. (Shaterian, 1976: 88, 89)

The following study will address two primary points. First it will determine whether the existence of three lengths is statistically verifiable. Secondly, it will address the relationship between vowel length, pitch, and syntactic category—the last in an attempt to find a morphosyntactic connection.

Shaterian's claim is of general interest because few languages of the world boast three contrastive vowel lengths. In an article entitled "Vowels of the World's Languages," Ladefoged and Maddieson (1990) discuss three languages—Estonian, Mixe, and Kamba—that use three and four contrastive vowel lengths.

Estonian, cited by Lehiste (1970), has been shown to have three vowel lengths. However, the third degree of length is dependent on syllable structure and word
patterning. Hoogshagen (1959) describes Mixe as a language which uses three contrastive vowel lengths. Unlike Estonian, Mixe does not seem to be influenced by word patterning or syllable structure. Whiteley and Muli distinguish four contrastive vowel lengths in the Bantu language Kamba (Ladefoagad and Maddieson, 1990). The third and fourth lengths, however, may be morphologically derived.

Methods

The data in this study are from tape recordings Shaterian made in 1981 and 1989 of a Northeastern Yavapai speaker named Clara Starr. In Yavapai, the two sets of minimal triplets that constitute the main data set are shown below:

<table>
<thead>
<tr>
<th>Set 1</th>
<th>Set 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>/θə/ 'water'</td>
<td>/ηə/ 'road'</td>
</tr>
<tr>
<td>/θəɾ/ 'be bitter'</td>
<td>/ηəɾ/ 'be black'</td>
</tr>
<tr>
<td>/θəɾi/ 'cottonwood'</td>
<td>/ηəɾi/ 'sun'</td>
</tr>
<tr>
<td></td>
<td>/ηəɾi/ 'me'</td>
</tr>
</tbody>
</table>

The lengths will be referred to as short, long, and extra-long. The term duration will only be used to refer to measured quantities of length in milliseconds. Note that Set 2 contains a fourth word with a short vowel and a glottal stop. This point will become relevant when examining vowel durations.

All forms were elicited several times during the recordings. Samples in which Ms. Starr was cued improperly or in which she hesitated or seemed to be thinking out loud were excluded. Once the proper samples were identified, vowel durations and their corresponding pitch measurements were made using a digital spectrograph machine (Kay Speech, DSP, Model #5500).

The general difficulty in measuring duration is consistency. The measurement techniques described below were used in an attempt to control as many variables as possible.

The technique involves locating the vowel, demarcating it between two time cursors, and noting the duration in milliseconds. The vowel is measured from its onset, defined as the end of the preceding consonant to the end of the voice-excited formant for the vowel. Because word-final vowels trail off into voicelessness, the major difficulty is demarcating the end of the vowel. The end of voicing for the vowel is determined by visually inspecting the spectrograph display as well as by a listening method, described below.

The listening method involves positioning one cursor near the end of the vowel and a second cursor just beyond the end of the word. The portion between the cursors was then played to detect whether it included perceptible voicing. If some voiced vowel was heard, then the first cursor was moved further toward the second cursor (i.e., toward the end of the vowel). The process continued until no voicing was heard. The position of the first cursor was then judged to be the end of
the vowel, and it always corresponded closely with the location chosen by examining formants.

In Set 2, forms with nasals, the end of the characteristic nasal formant structure, which is also the onset of the vowel in question, is identifiable by a rapid change in amplitude and formant pattern. The amplitude is defined by the intensity of color: the nasal formant is lighter and the vowel is much darker. This difference in intensity provides a reliable method of separating the nasal from the vowel. The end of the vowel was determined as in Set 1 by the listening method as well as examination of formant structure.

Results

Figure 1 below depicts the durations for Sets 1 and 2. Note that the duration values in Set 1 appear to reflect three different vowel lengths, with a mean difference of 93 msec between short and long, and 153 msec between long and extra-long.

![Figure 1 - Duration values for Set 1 (h) and Set 2 (p).](image)

Note that in Set 2, the minimal pair /əna/ and /əna?/ have very similar durations. The final glottal stop has very little effect on the vowel. In the following
analysis the two are combined. The difference between short and long is 161 msec; the difference between long and extra-long is 115 msec. Note that for both Sets 1 and 2, the difference between lengths is about 100-150 msec.

![Duration Graph](image)

**Figure 2** - Pooled duration values.

In addition, the absolute measure for each length of one set closely corresponds to the length of the other set. For example, the mean value for the short duration in Set 1 is 217 msec. In Set 2, it is 197 msec. Long and extra-long lengths across the two sets also have similar durations, which is easily verified by comparing the vertical height of the bars (see Figure 1). These observations allow us to pool the short (including ηai), long, and extra-long samples. This data is represented in Figure 2. The difference between the short and long duration is 119 msec; between long and extra-long it is 142 msec. The 100 msec difference between length categories persists, which is what we expect from looking at individual data sets.

At this point, we would like to know whether the differences observed in length represent a reliable distinction between different categories or whether they are due to random variation. Analysis of variance (ANOVA) was carried out on these measurements. There was a highly significant main effect of the hypothesized length categories (p< .0001). Post hoc analysis on the means using the Scheffé F-test
for multiple simultaneous comparison of means showed that all pairs of lengths are significant at better than the .01 level.

The data clearly show that there are three phonetic vowel lengths. It must next be determined whether these phonetic length differences in isolated words are related to other conditioning factors.

Vowel Length and Pitch Interaction

Lehiste (1970) notes that the third degree of vowel length in Estonian is accompanied by a falling F0 contour. Woo (1969), working with Mandarin, discovered that more complex pitch patterns were correlated with extra-long vowel lengths. Given that in both tonal and non-tonal languages vowel length and pitch may be correlated, and the fact that Shaterian has recorded varying pitch patterns for the forms cited in Sets 1 and 2, it is necessary to determine how pitch and vowel length interact in Yavapai.

SET 1

![Pitch contour data showing similarity of pitch points for each length category for Set 1.](image)

Figure 3a - Pitch contour data showing similarity of pitch points for each length category for Set 1.
SET 2

Figure 3b - Pitch contour data showing similarity of pitch points for each length category for Set 2.

In order to establish the relationship between vowel length and pitch, pitch contours of the same sets of words were also examined.

Pitch contours were measured by looking at a narrow-band spectrogram in which the harmonics are displayed. Fundamental frequency was calculated from the harmonic most clearly visible throughout the vowel. To represent the moving pitch contour, measurements were taken at the onset, the midpoint, and the offset of the harmonic. Figures 3a and 3b depict the pitch contour data for Sets 1 and 2 respectively.

In Set 1, the onset ranges from 185 to 187 Hertz, the midpoint ranges from 195 to 199, and the offset ranges from 194 to 230. Set 2 shows an onset range from 180 to 211 Hertz, with a midpoint range of 188 to 224 and an offset pitch range from 202 to 217. The pitch contours look very similar in all sets.

The numbers were pooled to determine the overall average of the pitch contours for each length category. Figure 4 represents these data. By comparing the vertical height of the bars, it becomes evident that the general contour for each length category are virtually identical. Analysis of variance confirms this observation. No significant main effect of length was observed. All comparisons of
short/long and long/extra-long were not significant. Note that the general pitch contour for words of each group is a rising pattern, and that the long and extra-long contours are virtually identical. The shape of the short syllable differs slightly from the long and extra-long contours, but this difference is not statistically significant.

We noted that typically pitch rises throughout the syllable. We might therefore expect that as a vowel becomes longer, the offset of the pitch becomes higher. The most important rise with respect to a Yavapai speaker would probably be the rise from the onset to the midpoint, not the actual landing site of the offset. This observation would also explain why the offsets of short vowels are not as high as long and extra-long vowels.

We can conclude that these three phonetic vowel lengths are not related to pitch, at least not in the context of isolated utterances.

Vowel Length and Syntactic Category
Another hypothesis, expressed in personal communication by Yumanists over the past two decades (Langdon, Munro, and others) suggests that syntactic category plays a role in predicting vowel length. Looking at the main data set again,
we see that in both Sets 1 and 2, the long-length syllable is verbal (as in 'be bitter' and 'be black') and the short and extra-long lengths are nouns (as in 'water,' 'cottonwood,' 'road,' 'sun,' and 'me'). However, this hypothesis does not hold in an additional minimal triplet measured.

Set 3, shown below, is an example of a near-minimal triplet of all nouns.

Set 3

/\yu/ 'my eye'
/\yu'/' 'owl'
/\urt/ 'nose'

Statistics cannot be calculated on this triplet because only one token was available. However, we can still look at duration and pitch as a preliminary examination of a minimal triplet of only nouns. Figure 5 is a comparison of the duration /u/ in Set 3 with the means for /a/ in Sets 1 and 2.

Figure 5 - Comparison of the duration values of /u/ and /a/. The duration values for each length category are nearly equal.
The difference in duration between the short /u/ and short /a/ is 22 msec, between long /u/ and /a/ it is 36 msec, and between extra-long /u/ and /a/ it is 1 msec. The durations of /u/ correlate well with the durations of /a/.

The pitch data correlate as well. The comparison can best be seen in a line graph, as shown in Figure 6 below. Since we saw in Sets 1 and 2 that the contours have a similar shape for each length, we have pooled the three length categories to obtain one pitch contour for /a/. The onsets, midpoints, and offsets were also pooled to obtain one representative pitch contour for /u/. The contours have more or less the same shape, with /u/ showing the same contour as /a/ but transposed a little higher, as is expected for a high vowel (Hombert et al.).

![Figure 6 - Comparison of pitch contours for /u/ and /a/.](image)

In this minimal triplet of three nouns, the vowel lengths and pitch contours correlate well with minimal triplets of two nouns and a verb. From this we conclude that syntactic category does not enable us to predict the difference between the two longer vowel lengths. More minimal triplets of various noun and verb combinations must be measured to substantiate this claim.
Conclusion

We conclude that there are three phonetic vowel lengths operating in Yavapai. These lengths are not conditioned by pitch factors or syntactic category in the data we have examined. Therefore, the boldest conclusion is that Yavapai has three distinctive vowel lengths.

Unlike Estonian and Kamba, Yavapai length does not seem to be predictable from other phenomena present in the language. In this respect it is more like Mixe. Thus, Yavapai can be added to the sparse list of languages which utilize three contrastive vowel lengths.

Acknowledgments

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Department of Linguistics
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The 1990 meeting was the twentieth anniversary of the First Hokan conference, which met at the University of California, San Diego. From time to time, the conference has met with other groups such as the Penutian conference and the Uto-Aztecan conference. It now regularly meets with the Penutian conference.

The conference is again indebted to Margaret Langdon and the Department of Linguistics at the University of California, San Diego, for hosting the conference. Our thanks are also due to the various graduate students who took care of the numerous details such as supplying the endless coffee.

The papers in this volume appear in the same order as they did on the program at the conference. Unfortunately, a few of the presenters were not able to send in a paper for publication. All of the papers in the volume except the last one were presented at the 1990 meeting.

In 1983, 1984, and 1985, very few of the presenters sent in their papers for publication. In 1986, a few papers from each of these years were assembled into a single volume. Werner Winter sent his 1983 paper in so early that the editor lost it in the files, and Winter's paper was omitted from the 1986 volume. It is now egg-on-the-face time for the editor. Winter's paper is included in this volume as the last paper. Mea culpa.

Arrangements have been made with Coyote Press, P.O.B. 3377, Salinas, CA 93912, 408-422-4912, to reprint the various Hokan and Hokan-Penutian conference volumes. Dr. Gary S. Brechin of Coyote Press has told me that he will try to keep all the volumes in print. I have just sent him part of the original manuscripts and will be sending him the rest of the manuscripts very shortly. Only a very few of the original publications are still available. Please see the list at the end of the volume for details on the few remaining original volumes. I do not know how long it will be until Coyote Press will begin issuing reprints of the backissues.

James E. Redden
Carbondale, December 1990

Historical Note: The proceedings of the First Hokan conference were edited by Margaret Langdon and published by Mouton. I have edited all the other volumes of proceedings except those of 1988 and 1989, when I was in Africa. The 1988 and 1989 volumes of proceedings were edited by Scott Delancey in the series published by the Department of Linguistics at the University of Oregon. Please do not request these two volumes from me. Please address orders for the 1988 and 1989 volumes to: Department of Linguistics, University of Oregon, Eugene, OR 97403. I hope that Scott will be willing to publish the Hokan-Penutian volumes regularly, when I retire in a few years.

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