AN ACOUSTIC STUDY OF VOWEL HARMONY IN WASHO

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ABSTRACT

Washo, a severely moribund language spoken around Lake Tahoe in California and Nevada, is reported to exhibit a case of diagonal vowel harmony where a prefixal vowel alternates between [a] when the following vowel is /a/ or /o/ and [e] when the following vowel is /e/, /i/, /ɨ/, or /u/. Drawn from archival recordings from the 1950s and recent fieldwork from the 2000s, this study reports the results of a cross-generational analysis of two Washo speakers, showing that the speaker from the 2000s does not exhibit the same prefixal vowel patterns as the speaker from the 1950s. The prefixal vowels for the speaker from the 2000s seem to diverge according to the height of the following stressed vowel, suggesting a potential reanalysis of the harmony pattern.

Keywords: Washo, vowel harmony, cross-generational.

1. INTRODUCTION

Washo, a highly moribund language spoken in the Lake Tahoe region of California and Nevada, has a six vowel system (/i/, /e/, /a/, /ɨ/, /o/, /u/), and these vowels also contrast in length. The language is described as having a regressive vowel harmony system that operates within certain morphological contexts, such as the 3p.NOM/3p.POSS *dE-* and the imperative/3p.OBJ *gE-* [3]. This prefixal vowel is the low vowel [a] when followed by stressed /a/ or /o/ (e.g., *da-hálŋa* "his/her mouth", *da-tóʔo* "his/her throat") but the mid-front vowel [e] when followed by stressed /e/, /i/, /ɨ/, or /u/ (e.g., *de-k'étep* "his/her bottle", *de-gúʔu* "his mother's mother").

Recent field investigations suggest that data from today's speakers do not consistently reflect the pattern described in [3]. The harmony pattern is typologically unusual as the sets of conditioning vowels do not form natural classes according to any canonical harmonizing features. Thus, this study aims to ascertain the empirical basis of Washo's vowel harmony system by reporting an acoustic analysis of the system using data from current speakers of Washo as well as data from archived recordings of William H. Jacobsen's original fieldwork. The results of this inspection do not consistently support Jacobsen's description of vowel harmony among current speakers, but the 1950s generation gives results more consistent with the described harmony pattern.

2. METHODOLOGY

2.1. Materials and speaker backgrounds

The materials for this study were drawn from existing audio recordings of spoken Washo that were recorded as part of fieldwork conducted from 2005-2008 as well as Jacobsen's original field recordings from the 1950s. The recent recordings were taken in a quiet room with a Marantz PMD670 solid-state recorder and a head-mounted microphone, at a sampling frequency of 44 kHz. Information about the equipment used by Jacobsen is not available, but the audio quality of these recordings is such that vowel formant information was readily identifiable.

Both sets of recordings consisted of elicited texts, word lists, and grammatical notes. These recordings examined in this study consist of speech from two native speakers of Washo, both female and over the age of 60 with no known speech impediment. The 2000s speaker, RD, was from Woodfords, California. The speaker recorded in the 1950s, BH, was a relative of RD. Aside from minor idiolectal variations, both speak the same variety of Washo and both seem to have the same level of fluency, given that RD has previously been found to have retained many of the same subtle phonetic alternations of the language[6].

2.2. Procedure and measurements

For this analysis, a total of 778 tokens of unstressed [a] and [e] were examined acoustically, including 535 from RD and 243 from speaker BH. All tokens are drawn from words that were (1) minimally disyllabic with (2) the pretonic vowel being either [a] or [e] and (3) an immediately following stressed vowel. Due to the small amount of data, instances of /ɨ/ as the conditioning vowel have been excluded from this analysis.

Tokens for examination were selected according to the above given criteria, then divided according to the presence (prefixal condition) or absence (stem-internal, or "stem" condition) of a morpheme boundary between the pretonic and stressed vowels. This allows for comparisons among the qualities of vowels in environments where harmony is expected and where it is not.

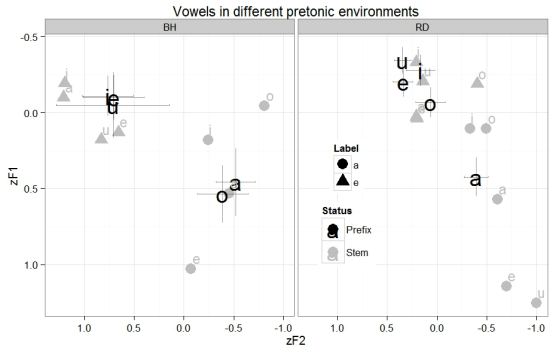
All measurements were taken using Praat [2], and initial segmentation was done using the Montreal Forced Aligner [4], which was then corrected manually for errors.

3. RESULTS

3.1. Qualitative analysis

Fig. 1 shows the (Lobanov) normalized F1 and F2 measurements of pretonic stem-internal /a/ and /e/ vowels ("Stem") and prefixal vowels. The following stressed vowel is indicated by the label. The different shapes represent pretonic stem-internal /a/ (circles) and /e/ (triangles).

Figure 1: Vowels in different pretonic environments by BH and RD. Prefixal vowels (that is, vowels in the harmonizing condition) are in black, while stem vowels are in gray. Stem vowels /e/ are indicated by triangles while /a/ are circles. Labels indicate the phonemic value of the following stressed vowel, while error bars indicate 95% confidence intervals.



The figure shows that speaker BH exhibited the harmony pattern as described in earlier accounts. The prefixal vowels for this speaker cluster into two distinct groups. The cluster near stem-internal /a/ are prefixal vowels before /a/ and /o/, while the one near stem-internal /e/ are prefixal vowels before /i/, /e/, and /u/. Speaker RD also exhibited clustering, but her prefixal realizations before /i/, /e/, /o/, and /u/ clustered together (near lexical /e/), while realizations before /a/ are off in the space of the stem-internal /a/, suggesting that the speaker may have reanalyzed the pattern.

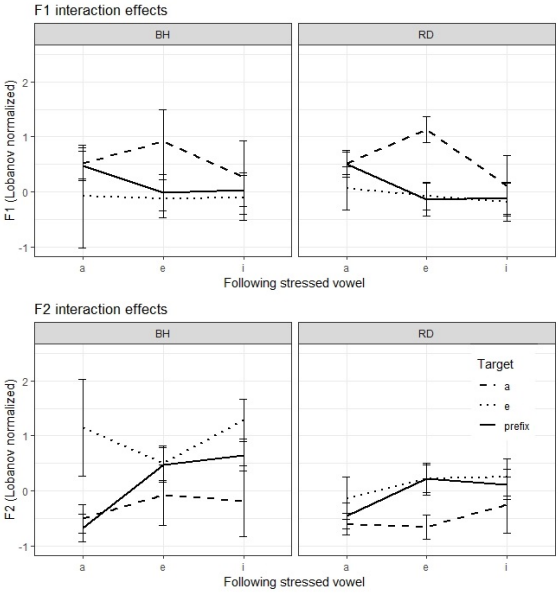
3.2. Regression analysis of data from RD and BH together

Two linear mixed-effect regressions were constructed (one for each formant), examining the effect of the harmonizing condition (the Target*Stress Vowel interaction) on the normalized F1 and F2 (zF1/zF2) for the two speakers. The full models were constructed using the lme4 package [1] in R [5] and were of the form: formant value $\sim$ TARGET*STRESSED VOWEL*SPEAKER + (1|WORD) + (1|PRECONS) + (1|FOCONS). TARGET refers to the status of the pretonic vowel as being a stem /a/, stem /e/, or a prefix vowel; STRESSED VOWEL refers to the quality of the following stressed vowel as /a/, /e/, or /i/ (not enough tokens involving stressed /o/ or /u/ could be found for speaker BH in the stem-internal contexts); WORD controls for potential bias introduced by repeated instances of the same word within the data; and PRECONS and FOCONS control for potential coarticulatory effects introduced by preceding and following consonants respectively.

Focusing first on the main effects, there is a significant influence of the tonic vowels on the pretonic ones along the F1 dimension (prefixal vowel vs. stem /a/: β = -0.568, p $<$ 0.001; prefixal vowel vs. stem /e/: β = -0.529, p $<$ 0.001) as well as the F2 dimension (prefixal vowel vs. stem /a/: β = 0.911, p $<$ 0.001; prefixal vowel vs. stem /e/: β = 0.95, p $<$ 0.001). There are significant two-way interactions between TARGET and STRESSED VOWEL, as well as their interaction with SPEAKER along the F2 dimension. Fig 2 summarizes the three-way interaction between TARGET and STRESSED VOWEL across both speakers, using the 'effects' package in R. The figure shows the model-predicted vowel formants for the target vowels (lexical /a/ (dashed line), lexical /e/ (dotted line), or a prefixal vowel (solid line)) before the stressed vowels.

Of particular interest is the behavior of the prefixal vowel (solid line). If the prefixal vowel undergoes categorical vowel harmony as traditionally described, this line is expected to reach values similar to lexical /a/ when the following stressed vowel is /a/ and to lexical /e/ when the following stressed vowel is /e/ or /i/. If there were no vowel harmony, the solid line representing the prefixal vowels may fall somewhere between the other two lines (suggesting that the prefixal vowels are somewhere between /a/ and /e/), or it may be skewed toward only one of the lines (i.e. they are either exclusively /a/ or exclusively /e/ regardless of the following stressed

Figure 2: Interaction between TARGET and STRESSED VOWEL in BH and RD along the F1 (top) and F2 (bottom) dimensions.



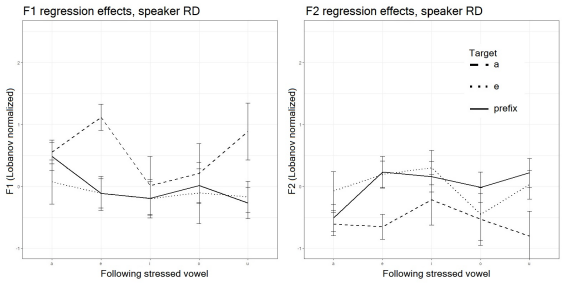
vowel).

Overall, the interaction results suggest that both speakers exhibit similar effects for this subset of vowels. Along the F1 dimension, both speakers show the prefixal vowel patterning with stem-internal /a/ before /a/, but with stem-internal /e/ before /e/ and /i/. The patterns along the F2 dimension is more complicated. The difference between stem vowels in the /i/ context is larger for BH than for RD such that the prefixal vowel is not different from either stem-internal /a/ or /e/ for RD. Nonetheless, the prefixal vowel patterns more with stem-internal /e/ in the /e/ and /i/ contexts than in the /a/ context for both speakers.

3.3. Regression analysis of speaker RD

The evidence thus far suggests that the two speakers exhibited vowel alternations that are consistent with previous descriptions. However, when a fuller set of stressed vowel contexts are considered, a more complicated pattern emerges. Two separate regression models similar to the ones above were constructed for the F1 and F2 values of RD'S pretonic vowels in five stressed vowel contexts (i.e. /i, e, a, o, u/ rather than the earlier /a, e, i/). Of particular interest is the TARGET:STRESSED VOWEL interaction. Fig 3 shows the model predictions concerning the nature of the interaction. The prefixal vowel (in solid line) patterns with stem-internal /a/ in the /a/ context (dash line), but pattern with stem-internal /e/ (dotted line) in the other stressed vowel contexts including when the following vowel is /o/. This pattern is consistent with the patterns observed in Fig 1.

Figure 3: Interaction between TARGET and STRESSED VOWEL in RD along the F1 (left) and F2 (right) dimensions.



These results suggests that RD might have reanalyzed vowel harmony as strictly height such that a stressed /a/ conditions a prefixal [a] while the other non-low vowels condition the presence of [e] in the prefixes.

4. CONCLUSION

This paper offers a preliminary cross-generational acoustic analysis of vowel harmony in Washo. The analysis found support for Jacobsen's description of the phenomenon as vowel harmony among data from a speaker consulted in the 1950s, while the system seems to have shifted for the speaker recorded in the 2000s such that the prefixal [a] was only conditioned by a following stressed /a/, while all other vowels (including /o/) conditioned [e]. These results suggest that vowel harmony existed among Jacobsen's consultants, but that it may have been reanalyzed across generations. Further analysis with a wider range of speakers is needed to determine the robustness of these effects, in particular with regards to the potential reanalysis found within speaker RD's data.

The value of acoustic corpora for analyzing understudied and endangered languages (and in fieldwork generally) is also highlighted by this study. Archival records of native speakers are valuable both for academic linguists to more fully describe phonological distinctions that are representative of the language and as records for those outside of phonetics and phonology and beyond the field of linguistics in general. Such archives can be useful to speakers within the relevant language communities as educational resources, invaluable cultural archives, or both.

5. REFERENCES

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