THE ACOUSTIC CORRELATES OF TONGUE ROOT VOWEL HARMONY IN EVEN (TUNGUSIC)

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ABSTRACT

In this production study on the endangered Tungusic language Even, we investigate the acoustic correlates of the tongue root contrast that participates in Even vowel harmony. We investigate F1, F2, F3, A1-A2 and durational differences between "advanced" and "retracted" vowels. We found that F1 was consistently increased for "retracted" vowels, and F2 and A1-A2 were consistently decreased. For the Sebian dialect, F3 was lowered. Moreover, we found that some vowels exhibited durational differences that might be considered an enhancing feature of the tongue root contrast. The high vowels /i/ and /u/ of Sebian dialect had smaller F1, F2 and A1-A2 differences than the low vowels, suggesting that the tongue root contrast is less expressed for high vowels.

Keywords: ATR, pharyngealization, vowel harmony, Even, Tungusic

1. INTRODUCTION

Even is an endangered Tungusic language spoken by approximately 7000 speakers on a large territory of north-eastern Siberia and fragmented into a considerable number of dialects. In recent decades, Even played a central role in discussions about the main phonological phenomenon that unites the Tungusic languages: vowel harmony. Researchers were interested in whether there is a shared feature that participates in all of the Tungusic vowel harmony systems [1, 8, 11] and whether a particular language is best characterized as having a system based on pharyngealization [10] or on advanced tongue root position (ATR) [8]. However, acoustic data have rarely been used to substantiate the claims that have been made in these discussions. In this paper, we present data on the acoustic characteristics of vowels in two dialects of Even.

How an ATR contrast or a pharyngeal contrast can best be characterized in phonetic terms is a matter of continuous debate and there have been numerous proposals for different languages. A pronounced difference in F1 has come to be taken as a main indicator for the presence of an ATR contrast [9], [7] p. 300-306, [5]): It was shown for several West African languages (Akan, Igbo, Degema etc.), that [+ATR] vowels have lower F1 values than [-ATR] vowels. As for F2, there is no unanimity about the role it plays in distinguishing between [+ATR] and [-ATR] vowels. Ladefoged and Maddieson ([7] p. 304) claim that [+ATR] vowels appear "to be raised and advanced in the acoustic space", which would imply higher F2 values for [+ATR] vowels. But as discussed in Guion, et al. [6], differences of F2 between [+ATR] and [-ATR] vowels do not have to be the same for all vowel qualities. So far, no consistent cross-linguistic pattern with respect to F2 has emerged.

Another acoustic feature that is now widely considered characteristic of [+ATR] vowels is spectral slope (or flatness in terms of [5]). For [+ATR] vowels spectral slope is thought to be steeper than for [-ATR] vowels, but cross-linguistically, a regular pattern is revealed only for some of the vowel pairs [5, 6].

As for pharyngealization, Ladefoged and Maddieson [7] p. 307 consider a markedly lowered F3 to be a noticeable feature of pharyngealized vowels. At the same time pharyngealization also leads to a slight raising of F1.

2. VOWEL HARMONY IN EVEN

The vowel system of Even consists of two sets of vowels (see Table 1). For the ease of discussion we can call set I vowels "advanced" and set II vowels "retracted", however the evidence for [ATR] will be investigated in this paper.

Table 1: Two sets of vowels in Even.

Set I "advanced"	i	iː	u	uː	o	oː	e	eː	ie
Set II "retracted"	i̹	i̹ː	u̹	u̹ː	o̹	o̹ː	a	aː	i̹a

The dots under the vowels in the lower row are used in this paper to indicate that the vowels belong to the “retracted” set II.

The evidence for a division into two sets comes primarily from vowel harmony: all vowels within a phonological word have to be of the same set, which is determined by the vowels inside the stem. Example (1) exemplifies this process, where the suffix vowel is chosen depending on the stem.

(1)	moː-le water-LOC ‘in the water’	(2)	mọː-la tree-LOC ‘on the tree’

Several researchers provided descriptions of these vowel sets. Relying on static x-ray data, Novikova [10] reported pharyngealization to be the main distinctive feature between the two sets of vowels in the Even dialect of the Ola district. Later, her data were reinterpreted as providing evidence for “retracted tongue root” contrast [1]. In recent work, the contrast between the two vowel sets in Even is described as an [ATR] contrast [11].

3. DATA AND METHODS

3.1. Stimuli and procedure

The data discussed in this paper were recorded during two fieldtrips in the Bystraia district (Kamchatka) and the village of Sebian-Küöl, (Yakutia), the Eastern- and Westernmost periphery of the Even area. We recorded two male (age: 55, 50) and two female (age: 54, 69) speakers of the Bystraia dialect and two male (age: 17, 23) and two female (age: 38, 46) speakers of the Sebian dialect with a Zoom H4n audio recorder (44.1 kHz/16 bit).

The stimuli list consists of 63 words for the Bystraia dialect and 76 words for the Sebian dialect. We recorded data for all of the monophthong vowels in Table 1. For each vowel, there were about five words, which were repeated by the speaker three times in isolation and three times within a carrier phrase. Only some of the words on the word list are minimal pairs; the differences between non-minimal pairs can be handled by linear mixed effects analyses.

3.2. Acoustic analyses

All annotations and measurements were performed with Praat [4]. The first author manually annotated vowels and their steady state portions. The onset and offset of F2 were taken to be the beginning and end of a vowel. Based on the vowel steady state portions, we measured and visually checked F1, F2, F3, A1 and A2 (the amplitudes of F1 and F2 measured in dB). In addition, we measured the overall duration of the vowel.

3.3. Statistics

All data were analyzed using R with the packages *lme4* [3] and *languageR* [2]. For each acoustic measure we constructed linear mixed effects models with Subjects and Items as random effects. Set (“Set I” vs. “Set II”) was the primary fixed effect of interest, together with the factors vowel “fronting” (i.e. /e, i/ vs. /u, o/) and “height” (i.e. /i, u/ vs. /e, o/). In addition, we included the fixed effects Dialect (“Sebian” vs. “Bystraia”), Gender, Repetition (1, 2, 3) and sentence position (“isolated” vs. “within-phrase”), as well as the interactions of these effects with the factor Set.

We checked for normality and homogeneity by visual inspection of plots of residuals against fitted values. In order to meet the normality assumption, we had to exclude F1 values whose residuals differed 2SDs from the mean (~4%). We present p-values (estimated using Markov chain Monte Carlo simulations).

4. RESULTS

4.1. Overall F1/F2 distribution

Fig. 1 shows the acoustic space of Even vowels for each of the 8 speakers. The median values of F1 and F2 were taken to represent a vowel. Some observations can be made just at first glance. First, the location of set I and set II vowel pairs resembles a vowel system with an ATR contrast in that set I vowels (“advanced”) have lower F1 and higher F2 values. Secondly, there is a tendency for high vowels of the different sets to overlap with each other – especially in the Sebian dialect.

4.2. Formant differences

We found that the F1 of “advanced” set I vowels was about 85 Hz lower than the “retracted” set II vowels ($p=0.0034$) (see Fig. 2). While the difference between set I and set II vowels is fairly consistent in the Bystraia dialect, the high vowels /i/ and /u/ of different sets in Sebian are almost exactly equal with respect to F1 (interaction Height*Dialect, $p=0.0492$; Height*Set, $p=0.0001$). Separate models for high and low vowels show that the change in F1 between set I and set II is larger for low vowels (150 Hz) than for high vowels (52 Hz). This effect seems to be mainly driven by the Sebian dialect.

Figure 1: F1/F2 vowel plots for eight speakers of Even (i, u, o stand for "advanced" set I vowels; I, U O stand for "retracted" set II vowels).

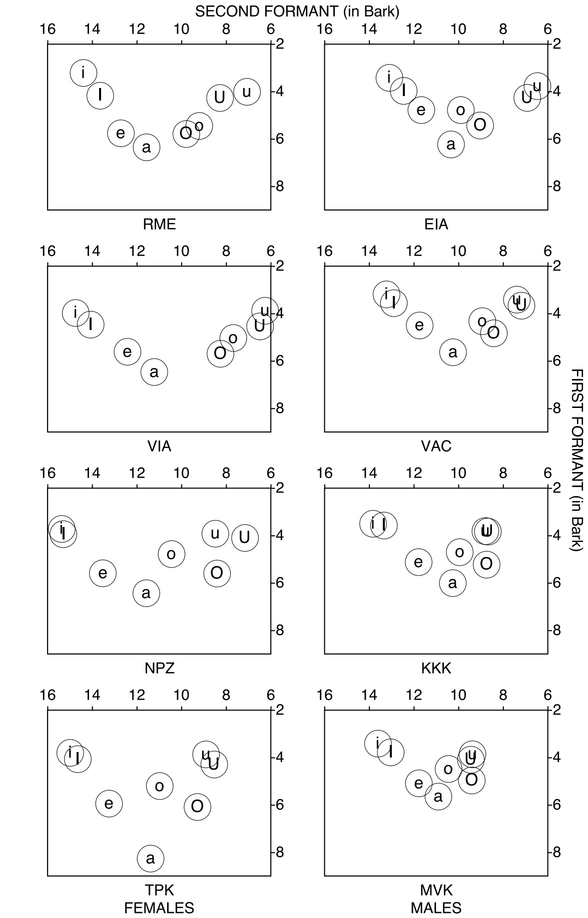
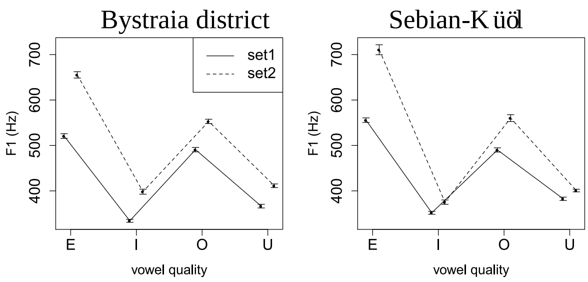
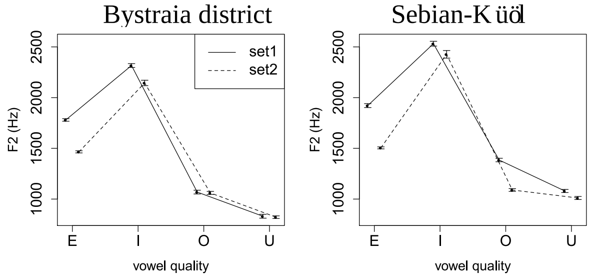


Figure 2: Mean values of F1 for vowels of different sets in different dialects. Here and throughout the following plots, the error bars represent the standard error, the pairs e/a, i/ị, o/ọ, u/ụ are labeled as E, I, O, U.



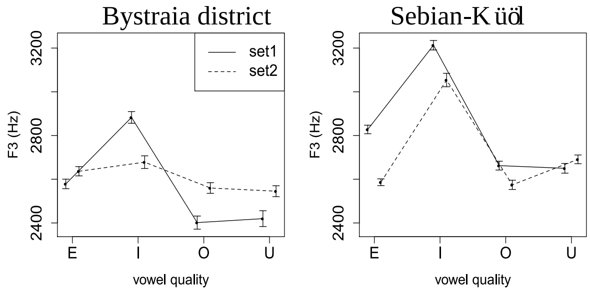
With respect to F2, set I vowels of both dialects have a higher F2 (337 Hz; main effect, p=0.0001), however, the pairs of back vowels /o/ and /ọ/, /ụ/ and /ụ/ in the Bystraia dialect are not distinguishable by F2 with respect to a difference in set 1 and set 2 (Set*Fronting*Dialect, p=0.01). In the Sebian dialect it is again high vowels where set I and set II ones are almost the same.

Figure 3: Mean values of F2 for vowels of different sets in different dialects.



With respect to F3, there seems to be a lowering by about 206 Hz in Sebian for set II vowels (p=0.0001, analysis on Sebian subset) (Fig. 4). This is reminiscent of pharyngealized vowels described by [7] p. 307.

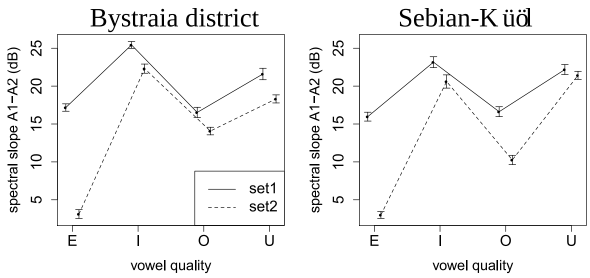
Figure 4: Mean values of F3 for vowels of different sets in different dialects.



4.3. Spectral slope

The results of the amplitude measurements (A1-A2) show a consistent difference between the "advanced" set I and "retracted" set II (marginally significant main effect of Set, p=0.0566).

Figure 5: Mean values of A1 and A2 differences for vowels of different sets in different dialects.

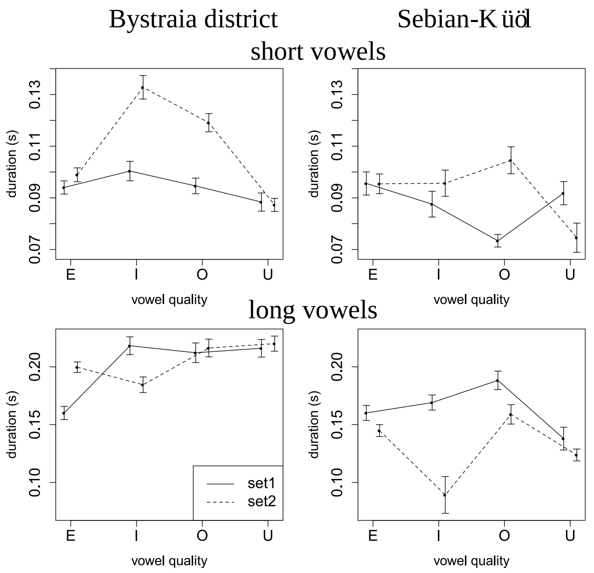


The amplitude difference is 6.8 dB larger for set I vowels in both dialects (Fig. 5, results were not normalized for different vowel qualities because the statistical model has vowel quality as fixed effect). As in the case of F1 and F2, the value of the difference is closer for high vowels in the Sebian dialect.

4.4. Duration

With respect to duration, we did not observe any general tendency for all vowel qualities. The only peculiarity which can be observed consistently is the longer duration of set II short /ọ/ in comparison with set I short /o/ (Fig. 6), as well as the longer duration of set II short /i/.

Figure 6: Mean values of the durations for the short and long vowels of different sets in different dialects



5. DISCUSSION AND CONCLUSIONS

As in other descriptions of tongue root systems, F1 differs consistently between "advanced" and "retracted" vowels. While other studies have reported no consistent differences for F2 [5, 6], we found that F2 was consistently lowered for "retracted" set II vowels, and A1-A2 was also smaller. Moreover F3 was lowered in the Sebian dialect in line what was said about pharyngealization [7] p. 307.

In Sebian dialect, the acoustic differences between "advanced" and "retracted" vowels were less expressed for high vowels than for low vowels. This seems to contradict the statement by Ladefoged and Maddieson that the difference between [+ATR] and [-ATR] vowels "is often most obvious in the case of high vowels", however, this statement appears to refer to articulatory differences. The vowel plots on p. 305 in [7] suggest that in other languages as well (e.g. Akan, Ateso, DhoLuo), advanced and retracted high vowels are less distinct in terms of F1 and F2 than advanced and retracted low vowels.

Finally, we found that for short /i/ and /o/, there are durational differences between the vowels of "advanced" and "retracted" sets, a tendency that points towards a contrast-enhancing feature. A perception study is needed to assess whether these durational differences and also the other acoustic ATR correlates serve as perceptual cues.

6. ACKNOWLEDGEMENTS

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