Changing formant values: Synthesis of four regions of Turkey

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1. Introduction

Even there are small differences; each human being has a special form of larynx, oral cavity and vocal cord length. Stevens (2000) indicates that such differences resulting in natural frequencies about 200 Hz for adult female vocal fold and about 120 Hz for adult male vocal fold.

This pilot study aims at identifying establishment of formants and their regional variability for Turkish. For phonologic reasons, synthesis of formant values is limited to F_0, F_1, F_2 frequencies for to evaluate realization of phoneme combinations. Regional variations of 8 vowels (a, e, ı, i, u, ü, o, ö) of Turkish were correlated for phonologic purposes. In this study, under phonological purposes, formant variations of four regions of Turkey are correlated as Eastern Anatolia, Black Sea, Central Anatolia, Mediterrian regions.

2. Formant synthesis

Some phonologic characteristics of speakers may be identified via F_0, duration, source and resonance values (Marasek 2005; Schötz 2005). Moreover, as well known, anatomic perspective of understanding relationship of formants and acquisition process may display appearance of distinctive features of speakers.

2.1 F_0, F_1 and F_2 formant frequencies

Formant synthesis of acoustic diagrams consists of three formant frequency. This frequency may identify distinctive features of speakers; as some acoustic cues to speaker's age or gender. F_0 is not only predictable from vocal tract shape, but also it may determine by stiffness and mass of vocal folds as in Stevens (2000). Vocal tract shapes are related to F_0 frequency. Stevens states that the shape of tract is one of the main factors may affect F_0 and quality of speech.

The frequencies of next two formants are mostly characterized as back and front vowels. F_1 regarded as representing differences between back and front vowels. This signal is limited to 1000-2000 Hz. Crystal (2003) indicates that when angle of jaw becomes to narrow, tongue rises up through oral cavity and F_1 becomes to fall down. Again, Crystal states that when tongue becomes to closer to front or back in oral cavity, F_2 rises up. Ergenç (1989) states that F_2 not only determines back and front vowels, but also determines shape of lips[1].

2.2 Previous studies

In previous, this phoneme has been mostly studied for English related to speech discrimination analyses. For English, while McDougall (2004) and McDougall (2005) correlated vowel discrimination of speaker's F_1, F_2, F_3; McDougall and Nolan (2007) and Jong et al. (2007) correlated vowel discrimination of speaker's F_1 and F_2. For French and German, Gendrot and Adda-Decker (2005) examined cumulative values of F_1 and F_2 frequencies in a pool of 15 male-female speakers. In that study, common and contrast features of vowels as (/i/, /y/, /e/, /Y/) are exhibited. Also, for Swedish, Lindh (2006) correlated spontaneous speech performances of speakers.

This phoneme is also studied for Turkish related to phonologic analyses. In first formant analysis study, Ergenç (1989) examined spontaneous speech performances of speakers. Then, Kılıç (2000) and Türk et al. (2003) correlated statistical values of three formants within non-regional perspectives. Bozkurt et al. (2004) improved different formant tracking algorithms. Recently, Çiyiltepe and Orberk (2008) examined phonologic bases of three formants for two regions of Turkey as Eastern Anatolia and Central Anatolia.

3. Method

70 male and female subjects aged 20-35 were included to study. Corpus of study is 925 vowel and consonant combinations as VC, CVC and CV. Data were recorded in a quite room with Cool Edit Pro 2.0. For to phonologic synthesis of acoustic diagrams, Praat 5.0 was used. For to statistical synthesis, ± standard deviations, %95 confidence intervals were analyzed with SPSS 15.00. Anova, Bonferroni, Mann-Whitney U Tukey Hsd post-hoc tests were applied as to define formant variations by region to region. In statistical reasons, $p \leq 0.05$ level was accepted. By this analysis, cumulative distributions and regional variations of 8 vowels of Turkish were correlated under phonologic purposes.

4. Results

In next section, correlation results of three formant frequencies as F_0, F_1, and F_2 are examined phonologically by four regions of Turkey.

4.1 F_0 Correlations

As stated above, F_0 is significant for to detect phonologic cues to speaker's characteristics. In light of our data results, F_0 correlations of front vowels have one distinctive value (see Fig. 1)[2].

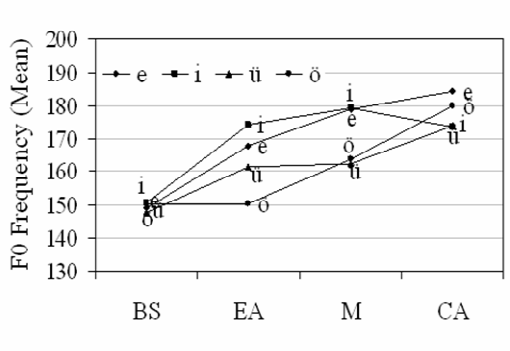


Figure 1. F_0 correlations of front vowels

In Fig. 1, vowel /i/ has a drop between Mediterrian and Central Anatolia regions. Except this vowel, all other front vowels in graphic seem to have an equal interval rise between each other.

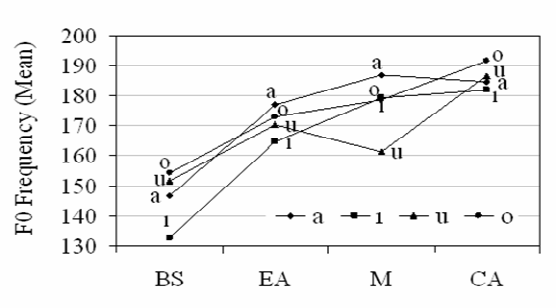


Figure 2. F_0 correlations of back vowels

In back vowels of F_0 correlations (see Fig. 2), there is a high jump of /ı/ and /a/ vowels between Black Sea and Eastern Anatolia regions. Also, there is a drop of /u/ vowel between Eastern Anatolia and Mediterrian regions. In this second graphic, the rest seem to have an equal rise.

4.2 F_1 Correlations

As highlighted above, the differences between back and front vowels might be identified by F_1 values. So, (see Fig. 3), vowel /i/ seems to have a distinctive value among all regions within a high rise from Black Sea and Eastern Anatolia; yet a high drop between Eastern Anatolia and Mediterrian. Moreover, this vowel has a further drop in Mediterrian to Central Anatolia. Another distinctive vowel appears to be /ü/ in Central Anatolia and Eastern Anatolia with the lowest F_1 values.

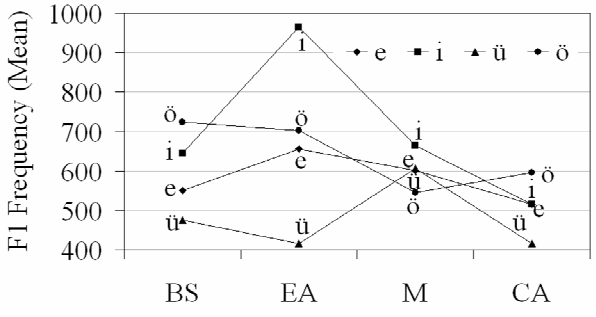


Figure 3. F_1 correlations of front vowels

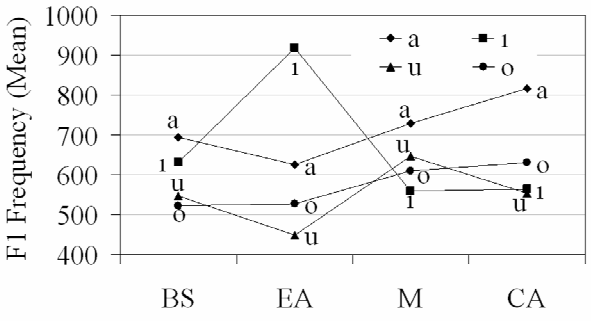


Figure 4. F_1 correlations of back vowels

For back vowels, (see Fig. 4), as regions, Eastern Anatolia seems to have its own vowel system, especially when compared with other regions. As vowels, the vowel /ı/ has a remarkable drop between Eastern Anatolia and Mediterrian. Also, vowel /a/ displays speed rise after Eastern Anatolia.

4.3 F_2 Correlations

F_2 frequency, as stated for F_1, not only may determine back and front vowels, but also F_2 may determine language shape, movements, and lips. In (5), there is a similar rise and fall relationship among all front vowels. Only vowel /i/ displays little drop in Mediterrian, and vowel /ö/ displays little drop in Central Anatolia (see Fig. 5). However, these variations indicate no significance for our data results.

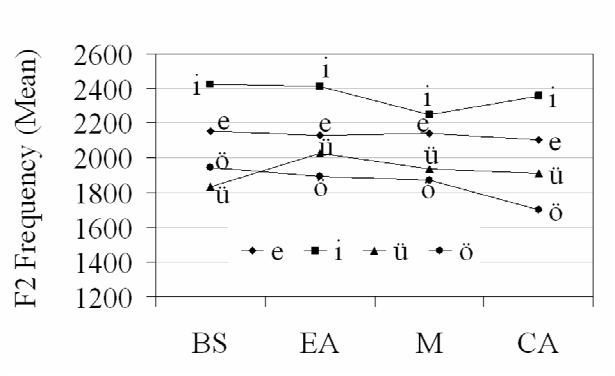


Figure 5. F_2 correlations of front vowels

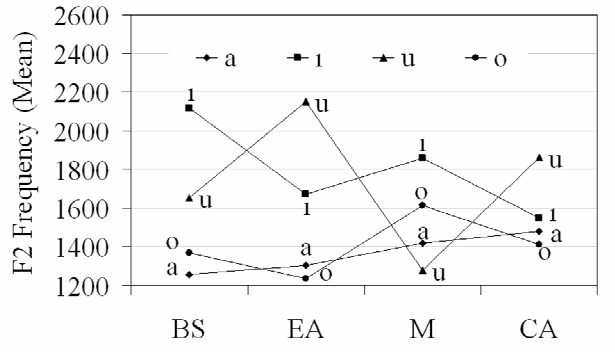


Figure 6. F_2 correlations of back vowels

For back vowels, there is a consistency of distribution (see Fig. 6). For instance, vowel /a/ is same in all regions. /o/ and /ı/ vowels have parallel rise and fall with a similar distribution among all regions. There is parallel rise between Black Sea and Eastern Anatolia; and between Mediterrian and Central Anatolia, yet there is drop between Eastern Anatolia and Mediterrian. For (6), it must be a hypothesis looking at the similarities of F_2 distribution in Mediterrian, because back vowels of this region appear to be similar to standard Turkish vowel system[3].

4.4 Cumulative distributions of speakers

In final section of our data results, there are overall distributions of F_0 (mean) variation in Hz[4]. There seems a remarkable variation between male and female speakers. For male speakers, while the range is 148.90 Hz; for female speakers, the range is 215.53 Hz. This difference may display certain effects of gender variations in formant analyses[5].

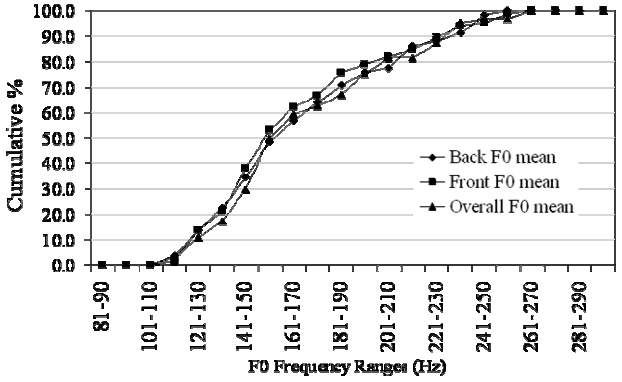


Figure 7. Cumulative distribution of speakers F_0 (means)

In this study, F_0 values of Turkish are tried to place across two languages. According to this, while for German as Wiesbaden region, mean value is determined as 81 Hz; for Swedish, mean value is 121 Hz[6]. However, for Turkish, we place mean values of Turkish as 161 Hz with differences in both male and female speakers.

5. Conclusion

This study proposed of an establishment of different formant values of Turkish by region to region. By this aim, we tried to place Turkish with mean value of 161 Hz between other languages. Also, cumulative distribution of gender variations was examined. According to these results, there was noticeable difference between male and female speakers.

Preliminary results of this study exhibited both similarities and contrasts between four regions of Turkey. Distinctive regions among all other regions were Eastern Anatolia and Mediterrian regions. In Fig. 4, Eastern Anatolia appeared to have its own quadrial across other regions. In Fig. 6, back vowels of Mediterrian appeared to have its own quadrial. These results displayed that there was a remarkable phonological contradiction and similarity in four regions of Turkey.

Notes

1 F3 and F4 formant frequencies are also significant for to determine the gender of the speaker's.

2 In figures, "BS" is used for Black Sea, "EA" is used for Eastern Anatolia, "M" is used for Mediterrian and "CA" is used for Central Anatolia regions.

3 One might consider that Fig. 6 may be related to F1 distribution, since the frequencies are lower than 2200 Hz.

4 In horizontal line, there are F0 ranges in Hz with 10 decimal intervals. In vertical line, there are cumulative percentages of speakers producing those F0 values in Hz. For instance, (see in Fig. 7) for F0 of /a/ vowel, between 191-200 Hz, there are 70 percent of speakers, or for F0 of /ö/ vowel between 130-140 Hz, there are 30 percent of speakers, either.

5 While for female speakers range of back vowels is 204.81±32.79, range of front vowels is 145.25±27.51; for male speakers range of back vowels is 147.09±28.14, range of front vowels is 210.17±29.26. So, the differences seen in overall distribution of male and female speaker's F0 (mean) are also visible for distributions of back and front vowels.

6 These studies were done with male speakers.

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