Production of Greek and Turkish vowels by bilingual speakers

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Abstract
The present study examines the acoustic vowel space of Greek and Turkish vowels produced by bilingual speakers. The results are presented for both languages' vowels production by bilingual speakers, as well as compared with the vowels production by monolingual speakers. It is revealed that the acoustic space of the Greek vowels produced by bilingual speakers is larger than the acoustic space of their Turkish vowels, mainly due to the lower and more front position of the point vowels [a] and [i], respectively. Moreover, the acoustic space of the Greek vowels produced by bilingual speakers is smaller than the one of the Greek vowels produced by monolingual speakers. On the contrary, the acoustic space of the Turkish vowels produced by bilingual speakers is larger than the one of the Turkish vowels produced by monolinguals.

Key words: Greek, Turkish, bilinguals, vowels, formants

Introduction
A number of acoustic studies on Greek vowels have been carried out in the past (i.e. Jongman et al, 1989; Hawks et al, 1995; Fourakis et al, 1999) and there are also a few studies examining the acoustics of Turkish vowels (e.g. Türk et al, 2004; Kiliç, 2003). However, there have been no published results on vowels produced by bilingual speakers of Greek and Turkish. This study examines the vowel space of Greek and Turkish vowels produced by bilingual speakers, and compares these findings with respective results from monolingual Greek and Turkish speakers.

Methodology
Four speakers, two females and two males, recorded the experimental material. All are bilingual speakers of standard Greek and Turkish, who live in Greece, and none of them has any history of speech or hearing disorders. The five Greek vowels [a], [e], [o], [i], and [u] and the eight Turkish vowels [a], [e], [ɯ], [i], [o], [œ], [u], and [y] were recorded in real, two-syllable words (CVCV). Each vowel was in initial, stressed syllable of the word and the previous and following consonants were stops (except for the Turkish [a] and [y], which were preceded by [m] and [f] and followed by [s] and [z], respectively). The carrier phrase for Greek was 'i ˈleksi _ ˈine eliniˈci" (The word _ is Greek) and for Turkish "biɾ taˈne … alˈmak iˈstijorum" (I want one _ to buy). Each token was repeated once, yielding a total of 52 tokens.

For the comparison between the Greek vowels' production by bilingual and monolingual speakers, four Greek monolingual speakers, two females and two males, recorded the same Greek experimental material. For the comparison between the Turkish vowels' production by bilingual and monolingual speakers, the data from Türk et al (2004) has been used (the averaged *F*1 and *F*2 values of the Turkish vowels produced by 15 male and 14 female speakers in words and sentences).

*F*1 and *F*2 were measured by hand marking from wideband spectrogram, in the middle of each vowel. The statistical analysis was carried out in Excel.

Results

Table 1 and table 2 present the *F*1 and *F*2 values for the Greek and Turkish vowels, respectively, produced by the bilingual speakers.

Table 1. Mean *F*1 and *F*2 values (in Hz) for Greek vowels, as a function of speaker gender.

Vowel	Male		Female		Mean	
	*F*1	*F*2	*F*1	*F*2	*F*1	*F*2
[a]	809	1387	836	1333	822	1360
[e]	574	1713	619	2210	596	1962
[i]	411	2002	474	2590	443	2296
[o]	520	1044	610	1180	565	1112
[u]	411	981	574	1125	492	1053

Table 2. Mean *F*1 and *F*2 values (in Hz) for Turkish vowels, as a function of speaker gender.

Vowel	Male		Female		Mean	
	*F*1	*F*2	*F*1	*F*2	*F*1	*F*2
[a]	673	1234	701	1469	687	1351
[e]	493	1777	545	2201	519	1989
[ɯ]	483	1369	492	1731	488	1550
[i]	420	1849	465	2219	443	2034
[o]	502	836	664	1035	583	935
[œ]	538	1397	538	1821	538	1609
[u]	438	990	456	1179	447	1085
[y]	411	1623	447	1948	429	1785

Regarding the formant values of the five vowels that are common in Greek and Turkish, it is worth to mention that the Greek [a] has around 20% higher *F*1 than the Turkish [a] and the Greek [i] and [o] have around 11.5% and 16%, respectively, higher *F*2 than the Turkish ones.

Figures 1 and 2 show *F*1 X *F*2 acoustic spaces for Greek and Turkish vowels, respectively. In each space, the vowels are plotted by the mean frequencies of their formants. It is illustrated that the Greek [a] is lower than the Turkish [a] and the Greek [i] more front than the Turkish one. Both Greek and Turkish [e] and [u] lie almost in the same space, and the three Turkish vowels [ɯ], [œ] and [y] lie in the mid vowel space, more close to the front than the back vowels. The lower and more front position of the point vowels [a] and [i], respectively, define a larger acoustic space of the Greek vowels than the acoustic space of the Turkish vowels.

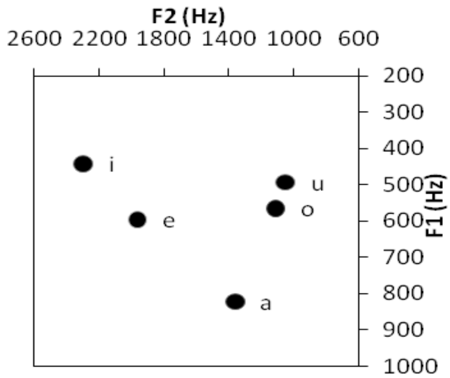


Figure 1. The Greek vowels plotted in an *F*1 X *F*2 space (mean values).

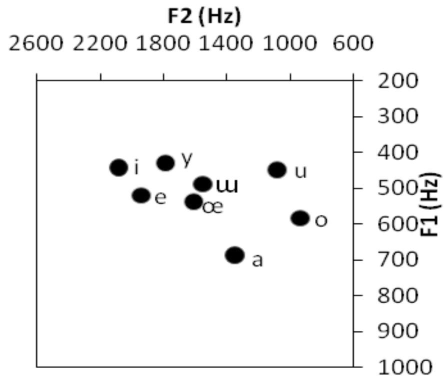
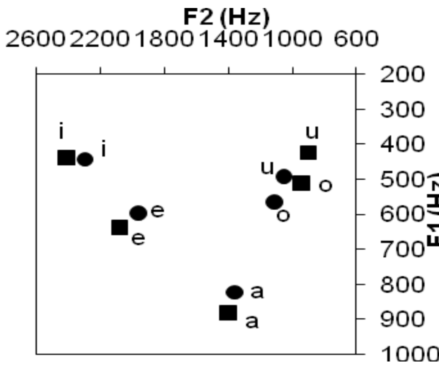
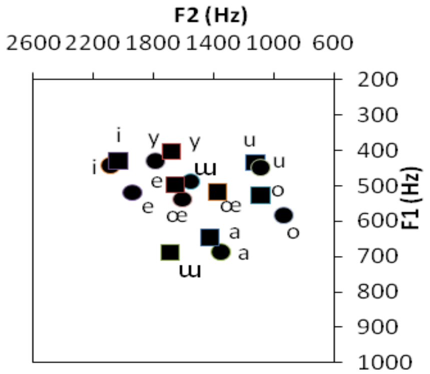


Figure 2. The Turkish vowels plotted in an *F*1 X *F*2 space (mean values).



Bilinguals● Monolinguals■

Figure 3. The Greek vowels produced by monolingual and bilingual speakers plotted in an *F*1 X *F*2 space (mean values).



Bilinguals● Monolinguals■

Figure 4. The Turkish vowels produced by monolingual and bilingual speakers plotted in an *F*1 X *F*2 space (mean values).

In Figures 3 and 4 the $F1$ and $F2$ frequencies of the Greek and Turkish vowels produced by bilingual speakers are plotted along with the results from monolingual Greek and Turkish speakers, respectively.

Regarding the Greek vowels, it is clearly shown that all vowels produced by monolingual speakers occupy more extreme positions in the acoustic space than the ones produced by bilingual speakers. On the other hand, the Turkish vowels produced by monolingual speakers lie either in about the same ([i], [u], [y]) or in more central position ([a], [o], [e], [œ]) than the ones produced by bilinguals.

Conclusions

The results of the present study provide important cues for the production of Greek and Turkish vowels by bilingual speakers.

First, the acoustic space of the Greek vowels produced by bilingual speakers is larger than the acoustic space of their Turkish vowels. This result accords with the results of Jongman et al. (1989), Hawks et al. (1995) and Fourakis et al (1999) in that the Greek vowels are well separated in an acoustic space, allowing for maximal contrast between vowel categories. In addition, the acoustic space of the Greek vowels produced by bilingual speakers is smaller than the one of the Greek vowels produced by monolingual speakers, whereas the acoustic space of the Turkish vowels produced by bilingual speakers is larger than the one of the Turkish vowels produced by monolinguals. This provides the preliminary evidence that due to the production of both vowel systems, the bilingual speakers tend to equalize the one with the other in terms of their acoustic space.

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