Standard Modern Greek and Cypriot Greek vowels: a sociophonetic study

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1. Introduction

The vowels of the southern Greek varieties,[1] including Standard Modern Greek (SMG) and Cypriot Greek (CG), i.e. the standard variety of Greek and the local variety of Greek spoken in Cyprus respectively, are considered fairly similar (Newton 1967, 1972a, 1972b; Kontosopoulos 1981). However, all previous attempts to compare the vowels of these two varieties have been largely impressionistic. What is more, besides SMG vowels that received a fair amount of attention, other Greek varieties -including CG- lack systematic acoustic studies (Newton 1972b). Since variation and change often lie below the level of speakers' awareness (Labov 1994), these studies do not account for the subtle acoustic differences of vowels between speakers. By comparing the acoustic structure of SMG and CG vowels, this study aims to examine the specific characteristics of SMG and CG vowels. To this purpose, we have constructed a large speech corpus recorded in Athens and Nicosia. These urban areas constitute the capital cities of Greece and Cyprus, respectively.

The importance of the first two spectral peaks, known as formants has been demonstrated in a number of studies in the 1960s and onwards. By plotting the first two vowel formants, namely the $F1$ and the $F2$, with the $F1$ along the ordinate and the $F2$ along the abscissa, linguists were able to (a) represent vowels within their vowel space, (b) demonstrate the within and between speakers variation, and (c) account for various phenomena, such as mergers, near mergers, splits, chain shifts, etc., that take place across large geographic areas (Labov 2006; Labov, Ash, & Boberg 2006; Mesthrie 2010).

Despite important cross-dialectal differences between SMG and CG in their segmental and supresegmental structures, the two varieties' vowel system consists of the same five vowels (see Figure 1): the two high vowels /i/ and /u/, the two non-high and non-low vowels /e/ and /o/ and the low vowel /a/. From these vowels /u/ and /o/ are back vowels and /i/ and /e/ are front vowels; /u/ and /o/ are rounded whereas /i/ and /e/ are not (Newton 1967, 1972b; Arvaniti 2006, 2007, 2010; Themistocleous 2008, 2011).

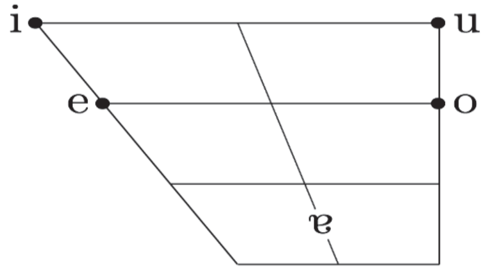

Figure 1: *Impressionistic representation of Greek vowel space.*

[1] In 1905, after taking part in various struggles (1866, 1897) that led to Crete's unification with Greece, Georgios N. Hatzidakis, a preeminent Greek linguist, provides the first and most influential description of Greek vowels (Hatzidakis 1905). In his account, the high vowel loss and raising group Greek varieties into two major dialect areas: the northern and the southern varieties (Hatzidakis 1905; Kontosopoulos 1981). In northern varieties, unstressed vowels /e/ and /o/ are often raised into /i/, e.g., /peˈði/ 'child' → [piˈði], and /u/, e.g., /ˈnikos/ 'Nick' → [ˈnikus], respectively, and word final unstressed /i/ is deleted, e.g., /ˈçeri/ → [ˈçer]. By contrast, in the southern varieties this phenomenon is not attested (Newton 1972b; Kontosopoulos 1981).

To our knowledge, the oldest acoustic study on SMG vowels' spectral characteristics is Jongman, Fourakis and Sereno (1989). In this study, male speakers read SMG vowels in keywords (p[i]ta 'pie', p[e]ta 'fly!', p[a]ta 'step!', p[o]te 'when', and p[u]se 'where are you?') uttered in the carrier phrase [θa po <keyword> ksaˈna] 'I will say <keyword> again' and in standard pace. In another study, Fourakis, Botinis and Katsaiti (1999) examined the effects of tempo (slow tempo *vs* fast tempo) and stress (unstressed, stressed and stressed/accented) on $F1 \times F2$, $F0$, vowel duration, and vowel root mean square (RMS) amplitude. Fourakis et al. (1999) showed that unstressed vowels had lower $F1$ than stressed vowels; this resulted in the raising of the unstressed vowel space. In addition, unstressed vowels were more central than stressed and stressed & pitch accented vowels. Also, Fourakis et al. (1999) showed significant effects of stress and tempo on vowel $F1 \times F2$ space.

A number of studies provide evidence on the effects of segmental structure (see also Nicolaidis 2003), age (see Sfakianaki 2002), and regional variety (see Christou & Baltazani 2010) on vowels. Others compare SMG vowels with the vowels of other languages (see Jongman et al. 1989; Hawks & Fourakis 1995). Finally, there are studies that examine the effects of SMG vowel structure on L2 acquisition (see Lengeris 2009a, 2009b; Lengeris & Hazan 2010). Despite this research on SMG and other varieties, CG vowels remain largely unstudied (Arvaniti 2010).

2. Methodology

2.1 Speakers

45 female speakers between the age of 19 and 29 years old participated in the study. There were 25 CG speakers and 20 SMG speakers. Participants were born and raised in Nicosia and Athens, respectively. Based on information from a demographic questionnaire, the participants from each dialect constituted sociolinguistically homogeneous groups: they originated from approximately the same socio-economic status and they were university students, namely CG speakers were students at the University of Cyprus and SMG speakers were students at the University of Athens. All participants were bilingual in Greek and English (as a second language); four SMG participants knew French as a third language. None reported a speech or hearing disorder.

2.2 Speech materials

Stimulus materials consisted of a set of nonsense words, each containing one of the five Greek vowels (/e i a o u/) in both stressed and unstressed position, word initially and word medially. The nonsense words had the structure ˈVsa, e.g., /ˈesa, ˈisa, ˈasa, ˈosa, ˈusa/, or Vˈsa, e.g. /eˈsa, iˈsa, aˈsa, ˈosa, ˈusa/. The SMG carrier phrase was: 'ˈipes < keyword > ˈpali' (You told < keyword > again) and the CG carrier phrase was: '/ˈipes <keyword> ˈpale/' (You told <keyword> again). The utterances were read in random order; filler words were added to the carrier sentences to provide variation within the experimental material and to minimise speaker's attention on the experimental words. Each subject produced 80 utterances (i.e., 5 (vowels) × 2 (stress placement) × 2 (word placement) × 4 repetitions).

2.3 Acoustic Measurements

Vowels were segmented as follows: Vowel onsets and offsets were located manually by employing simultaneous inspections of the waveform and spectrogram, and the overall duration was calculated. Vowel onset was located at the zero crossing before the first peak in the periodic waveform and vowel offset was defined as the beginning of the fricative consonant [s]. In addition, the leftmost onset of the $F1$ was employed to set their left edge and its rightmost offset the right edge of the vowel. Segmental boundaries were aligned with zero crossings. An additional cue employed for the segmentation of vowels measured at the last syllable of the word was the lowering of the second formant.

We measured formant frequencies $F1$ and $F2$, vowel duration, and $F0$ measurements. Formant frequency values were then extracted automatically using a Praat script. To avoid measurement errors the automatically extracted values were double-checked by the first author.

2.4 Statistics

Independent Variables: Vowel (/e i a o u/), Stress (stress *vs* unstress), and Variety (SMG *vs* CG). Elicitation: Speakers read the target sentences in standard pace in random order. The utterances were part of a larger experiment, which included similar contexts, but different keywords. Repetitions: 4x

- Formant Values $F1$, $F2$ measured at 50% (midpoint);
- Vowel Duration;
- F_0.

A mixed ANOVA has been conducted with Stress × Vowel as the independent variables and the Variety as the between groups predictor. The statistical analysis was carried out in R 3.1.0 (R Core Team, 2012). For the ANOVA, the ezANOVA function from the ez package was employed (Lawrence 2011). Before running the ANOVA, Mauchlys tests for sphericity violation were performed. If the assumption of sphericity was violated, the degrees of freedom were corrected by using Greenhouse-Geisser estimates. The *a* level for determining statistical significance was 0.05.

3. Results

The vowel spaces of SMG and CG display great similarities in their $F1 \times F2$ vowel space. Overall, vowels are more centralised when unstressed and more peripheral when stressed. Vowel duration differs significantly in the two varieties. In the following, we discuss the main results in more detail.

3.1 Formants

The vowel $F1 \times F2$ is shown in Figure 2. Stressed vowels are more peripheral than unstressed vowels in both varieties. Unstressed vowels are more central and raised than stressed vowels. Overall, stressed vowels $F1 \times F2$ position is similar in both varieties. CG unstressed vowels are lower than the SMG unstressed vowels.

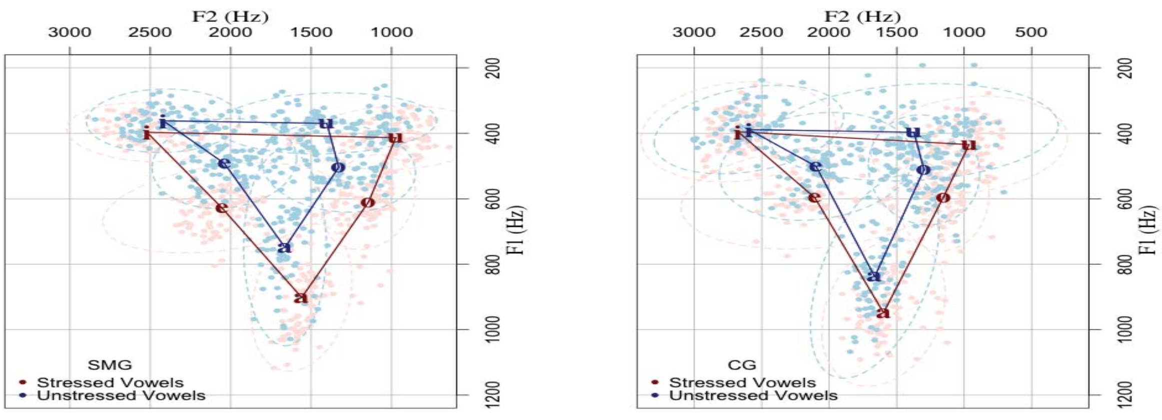

Figure 2: *Stressed and unstressed SMG (Left Panel) and CG (Right Panel) vowels with 95% confidence ellipses.*

3.2 Vowel Intrinsic f_0

High vowels have higher F_0 than middle and low vowels.

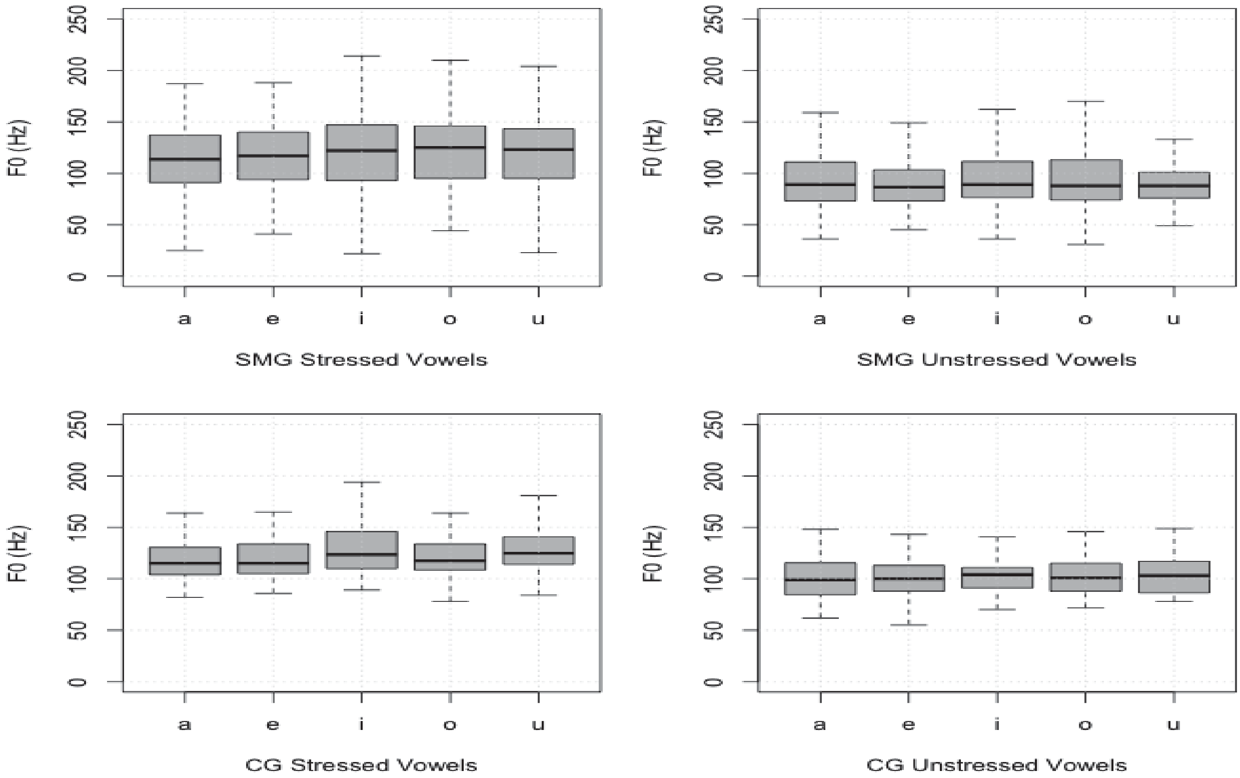

Figure 3: *Effects of Stress × Variety × Vowel on F_0 in Hertz.*

The findings show significant effects of Vowel on the f_0 ($F(0.712, 108.22)= 8.47$, $p < .05$). Moreover, Stress $F(1, 32)=48$, $p < .05$) and the interaction of Stress × Variety has significant affects on f_0 ($F(0.712, 108.22) = 3.40$, $p < .05$).

3.3 Vowel Intrinsic Duration

Stressed vowels are longer and unstressed vowels are shorter. In SMG, the back stressed vowels were longer than front stressed vowels and low stressed vowels were longer than high stressed vowels (/a > o >u > e > i/). In CG, stressed and unstressed vowels and SMG unstressed low vowels were longer than high vowels (/a > o > e > u > i/).

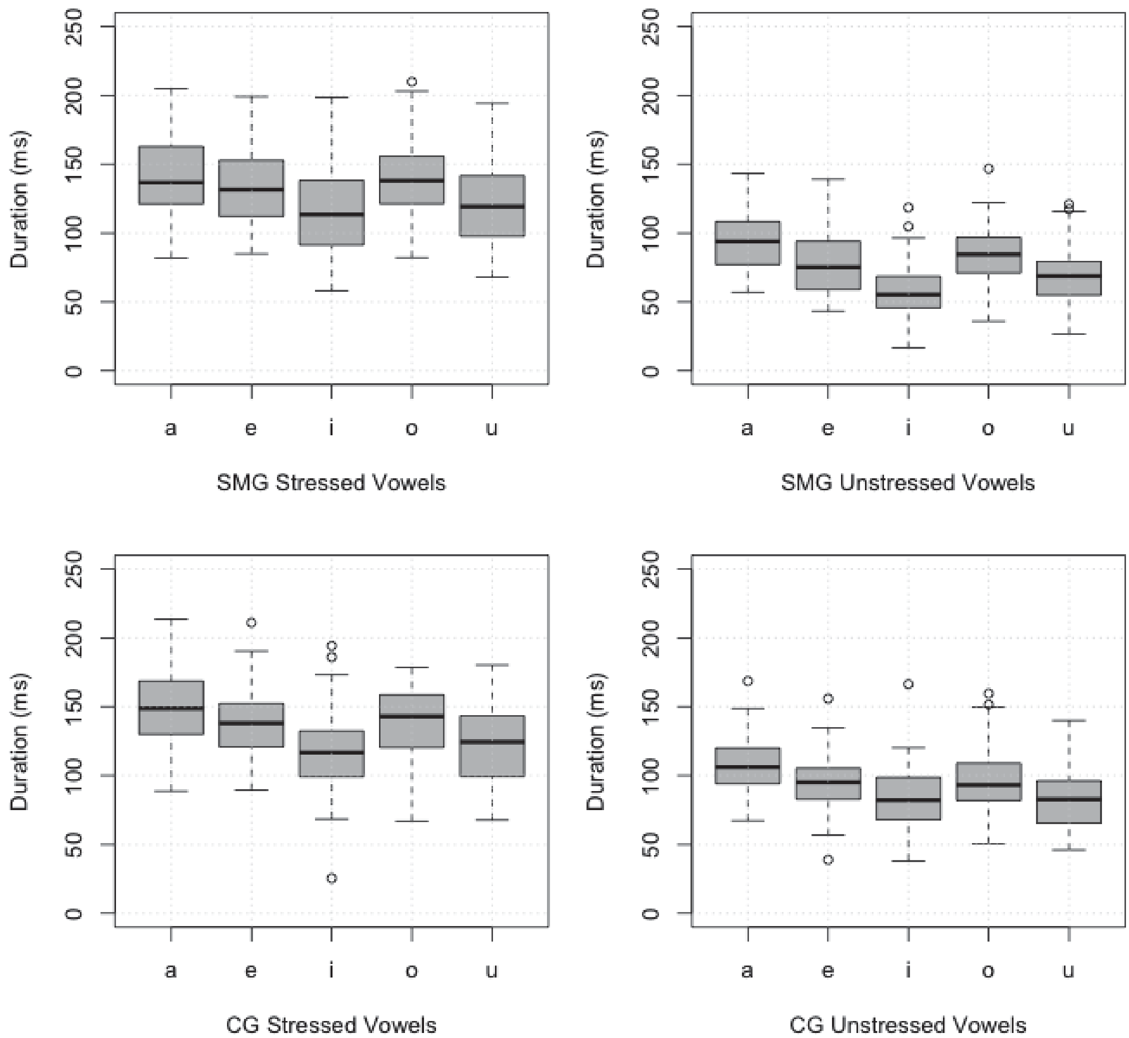

Figure 4: *SMG and CG Vowel Duration (in ms) for Stressed Vowels (Upper Panel) and Unstressed Vowels (Lower Panel).*

Vowels differ significantly in their duration $F(3.24, 123.12) = 125.09$, $p < .00001$). Stressed vowels were longer than the unstressed ones. The effect of Stress on Vowel Duration ($F(1, 38) = 350.04$, $p >$ .0001) was significant. The interaction Variety × Stress ($F(1, 38) = 9.58$, $p < .001$) and Vowel × Variety ($F(3.2, 121.6) = 3.28$, $p < .05$) were significant. However, notice that the effect sizes are extremely small; thus, the *p* values should be treated with care.

4. Discussion

As opposed to a large body of instrumental studies on SMG vowels, previous research on CG provided largely impressionistic data (see also Arvaniti 2010 for a discussion). What is more, the lack of acoustic data from CG impedes the comparison of SMG and CG vowels. Addressing this issue, this study compares the acoustic structure of SMG and CG vowels.

The study shows significant effects of stress on vowel formants, vowel intrinsic duration, and intrinsic F_0. Overall, both SMG and SG stressed vowels are more peripheral than unstressed vowels. Moreover, unstressed vowels are more central and raised than stressed vowels. Also, CG unstressed vowels are lower than SMG unstressed vowels. These findings corroborate earlier studies on SMG vowels. For instance, Fourakis et al. (1999) show that unstressed vowels are more central than stressed vowels and pitch accented vowels (see Figure 6).

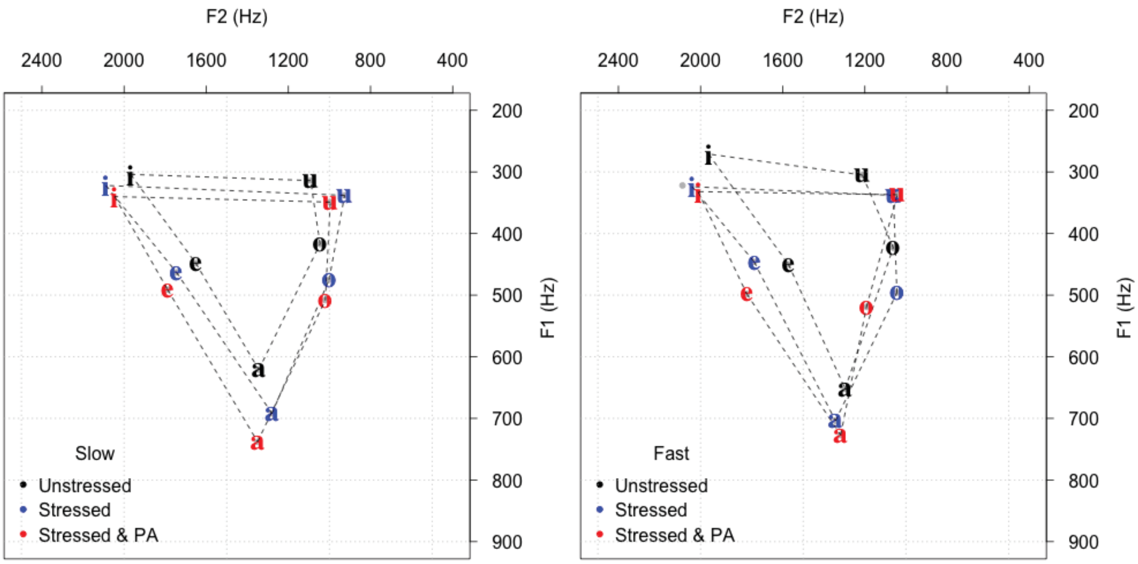

***Figure 5:** SMG Unstressed, Stressed and Stressed and Pitch Accented (Stressed & PA) vowels uttered in slow (Left Panel) and fast (Right Panel) speech rate (Fourakis et al. 1999).*

Moreover, SMG and CG vowels differ in their intrinsic duration and intrinsic f_0. Stress affects vowel duration significantly: stressed vowels are longer and unstressed vowels shorter. The differences in vowel duration were more evident in the unstressed vowels: unstressed CG vowels are significantly longer than unstressed SMG vowels (see also Botinis 1989; Themistocleous 2014). As for the F_0, high vowels have higher F_0 than middle and low vowels.

To conclude, this study confirms the findings of earlier studies on SMG vowels, provides the first report on CG vowels' acoustic structure, and constitutes the first comparative sociophonetic research on SMG and CG vowels.

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