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Lengeris, Angelos and Kainada, Evia and Baltazani, Mary and Iverson, Paul (2015) Dialectal effects on the perception of Greek vowels. In: 18th International Congress of Phonetic Sciences, 10-14 Aug 2015, SECC Glasgow, The University of Glasgow, Scotland, UK.

### DOI

Paper number 0925.1-4

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# DIALECTAL EFFECTS ON THE PERCEPTION OF GREEK VOWELS

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## ABSTRACT

This study examined cross-dialectal differences on the perception of Greek vowels. Speakers of Standard Modern Greek (SMG) and two dialectal areas (Crete, Kozani), all with five vowels in their systems, chose best exemplar locations (prototypes) for Greek vowels embedded in a carrier sentence spoken by a speaker of their dialect. The results showed that SMG, Cretan and Kozani vowels were well separated in the perceptual space. At the same time, there were dialect-induced differences in the positioning and distances between vowels as well as in the total space area covered by each dialect. The organisation of perceived vowel space therefore seems to be dialect-specific, a finding which is consistent with production studies examining the organisation of the acoustic vowel space.

**Keywords:** Perceptual vowel space, Greek dialects.

## 1. INTRODUCTION

Many production studies have documented the existence of extensive differences in the acoustic characteristics of vowels across dialects [e.g., 5, 6, 11, 15, 23]. Such differences have questioned the original Theory of Adaptive Dispersion according to which vowels should be maximally dispersed and evenly spaced [20] and, instead, support a less stringent version of the theory whereby vowels are sufficiently dispersed [21, 22]. Research on cross-dialectal perception, however, is more limited and mainly examines how dialectal experience affects the classification of dialect variation [e.g., 4, 7, 19, 24]. Previous work on Greek has only examined the perception of SMG vowels showing that vowels are well separated from one another [3, 12].

This study examines the perceptual spaces of SMG and two regional dialects, namely Cretan Greek and Kozani Greek, all having five vowels /i, e, a, o, u/ in their systems, with the goals of (a) comparing the perceptual organisation of dialectal systems in a single language and (b) providing data on the perception of Greek vowels that are currently lacking in the literature (see [1] for a comprehensive review of research on Greek phonetics).

Perceptual data were collected as part of a larger project investigating the phonetics and phonology of

vowels across Greek dialects. Participants chose best exemplar locations for vowels in a 5-dimensional space ranging in F1 and F2 formant movement (i.e. onset and offset of the F1 and F2 formant frequencies) and duration (not analyzed in this paper). As mentioned above, production studies often report asymmetries in the way acoustic vowel spaces are organised cross-dialectally. However, since listeners prefer vowel prototypes that maximize perceptual contrasts when compared to their vowel productions [16, 17], it is possible that the perceived vowel space may be less affected by dialect than the acoustic vowel space.

## 2. METHOD

### 2.1. Participants

The total number of participants that were tested was 30 (ten for each dialect). Here, initial results are presented for seven speakers from each dialect (4 male, 3 female) with a mean age of 62 years (range = 51 - 73 years). Participants were from Athens (SMG), Crete (a Southern dialect) and Kozani (a Northern dialect). With the exception of the SMG speakers, all participants had distinctive regional accents. None reported any hearing or language impairment.

### 2.2. Perceptual stimuli

The stimuli were synthesized vowels in a naturally produced /pVta/ context (stressed on the first syllable) embedded in a carrier sentence *pes \_\_\_ ksana* 'say \_\_\_ again'. The sentence was uttered by a male native speaker of each dialect. The synthesized vowels were created using a Klatt synthesizer [18] in cascade/parallel configuration and matched the vowels spoken by the corresponding speaker for each dialect in terms of F0 and amplitude. The rest of the synthesis parameters were kept the same across vowels and dialects. These were the F4 and F5 frequencies (3500 and 4500 Hz respectively), the formant bandwidths (B1=100, B2=180, B3=250, B4=300, B5=550), the tilt (TL=0 dB slope) and the open quotient (OQ=60%). The F1 and F2 frequencies changed in a linear way from the beginning to the end of the vowel. F1 formant frequency ranged between 5 and 15 Equal Rectangular Bandwidth

(ERB) [10]. F2 formant frequency started from 10 ERB, was at least 1 ERB higher than F1 and reached a limit that was defined by the equation  $F2 = 25 - (F1-5) / 2$ . The synthesized vowels were 1 ERB apart from each other. Overall, 109,375 vowels were synthesized in each dialect.

Before synthesizing the vowels, the sentences produced by the SMG, the Cretan and the Kozani speaker were normalized to a ‘model’ speaker in terms of their formant frequencies and median pitch using signal processing in PRAAT [2]. This was done to reduce any effect the vocal tract differences between the three speakers might have on participants’ location of best exemplars (see [8] for a detailed analysis of the procedure).

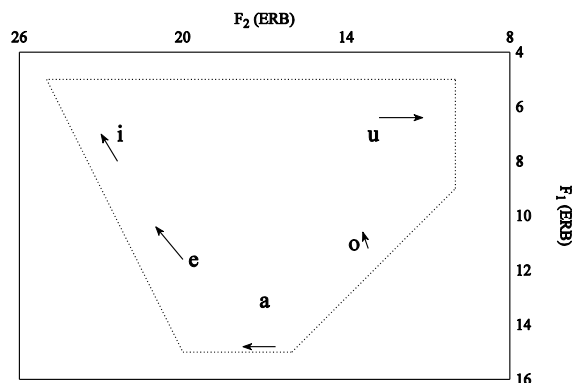
### 2.3. Procedure

Participants were tested in quiet rooms using a laptop computer and high-quality headphones (DT 770 PRO) with the help of a research assistant who was a native speaker of the tested dialect. Participants heard a synthetic vowel stimulus embedded in the carrier sentence and rated how close the vowel was to a good exemplar of the vowel displayed on the screen by clicking on a continuous bar. Based on participants’ responses, a goodness optimization method [7, 8, 13, 14] found best exemplar locations of the Greek vowels. During testing, an algorithm would search along 7 vectors (straight-line paths cutting through the five-dimensional space) so that the best exemplar on each vector would be found after 5 trials per vector. The whole process thus required just 35 trials for each vowel despite the large number of synthesized vowels available to listeners and was completed after 175 trials (5 vowels × 35 trials) in about half an hour.

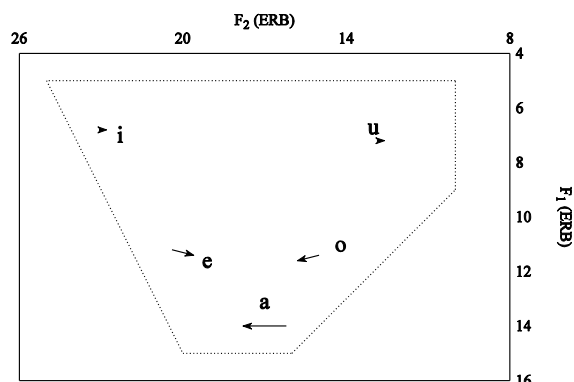
## 3. RESULTS

Figures 1-3 show the mean best exemplar locations (ERB) of Greek vowels for SMG, Cretan and Kozani speakers respectively. Instead of static vowel locations, best exemplars are shown as arrows from the onset to the offset of the F1 and F2 formant frequencies and thus indicate F1 and F2 formant movement. Although the five Greek vowels were well separated in the perceptual space with no overlap between vowels across dialects, there were cross-dialectal differences in terms of the precise positioning of vowels, the distance between vowels, and the total space area covered. The SMG system was the most symmetrical system compared to the non-standard systems of Crete and Kozani, a finding which is consistent with production studies in other languages[e.g. 6] and in Greek [25]. In Crete for

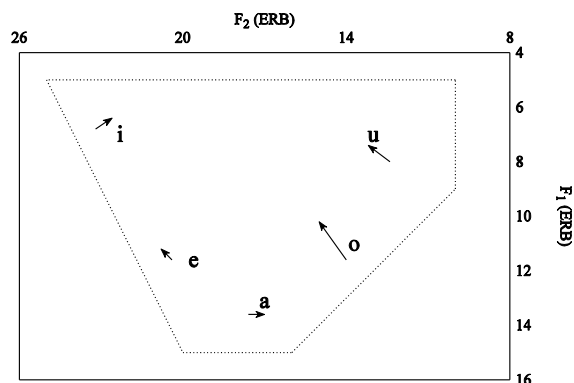
**Figure 1:** Mean best exemplar locations (ERB) of Greek vowels for SMG speakers. Vowels are represented as arrows from the onset to the offset of the F1 and F2 formant frequencies. The limits of the synthesized vowels available to listeners are indicated by the dotted line.



**Figure 2:** Mean best exemplar locations (ERB) of Greek vowels for Cretan speakers.



**Figure 3:** Mean best exemplar locations (ERB) of Greek vowels for Kozani speakers.



**Table 1:** Euclidean distance (ERB) between best exemplar locations of adjacent vowel pairs in SMG and in the Cretan and Kozani dialect.

Euclidean distance	SMG	Crete	Kozani
/i/ - /e/	4.20	5.48	5.35
/e/ - /a/	5.29	4.30	4.10
/a/ - /o/	5.67	3.04	4.09
/o/ - /u/	4.73	5.17	4.00
/u/ - /i/	10.80	10.22	10.24

example, the best exemplar locations for /e/ and /o/ were closer to /a/ than to /i/ and /u/. Similarly, the best exemplar locations for /e/ were closer to /a/ than to /i/ for Kozani speakers.

This can be better seen in Table 1 which displays the Euclidean distances between best exemplar locations of adjacent vowels (ERB) in SMG and in the Cretan and the Kozani dialect. To calculate the Euclidean distances, the four-dimensional coordinate for each vowel (i.e. onset and offset F1-F2 frequencies) was transformed to a two-dimensional coordinate by averaging the onset and offset of the F1 and F2 formant frequencies of each vowel, thus removing the F1-F2 formant movement. A repeated-measures analysis of variance (ANOVA) was conducted on Euclidean distances with vowel pair (5 levels) and dialect (3 levels) as factors. There was a significant main effect of vowel pair,  $F(4,72) = 146.8$ ,  $p < 0.001$  and a significant interaction of vowel pair and dialect,  $F(8,72) = 4.8$ ,  $p < 0.001$ , indicating that dialect did not have the same effect on Euclidean distances across adjacent vowel pairs. Simple effect tests showed that dialect significantly affected the Euclidean distances in /i/-/e/ (Crete, Kozani > SMG), /a/-/o/ (SMG > Kozani > Crete) and /o/-/u/ (Crete > Kozani),  $p < 0.05$ .

Apart from adjacent vowel distances, dialect also affected the total space areas covered by vowels. To compute vowel space areas, the Greek five-vowel space was divided into three triangles, the area of each triangle was calculated using Heron's formula and the triangles were summed. The vowel space areas were  $53.2 \text{ ERB}^2$  for the SGM speakers,  $38.7 \text{ ERB}^2$  for the Cretan speakers and  $40.1 \text{ ERB}^2$  for the Kozani speakers. An analysis of variance (ANOVA) showed that the effect of dialect on vowel space areas was significant  $F(2,20) = 5.4$ ,  $p < 0.05$ . Pairwise comparisons (Bonferroni adjusted) showed that the SMG vowel space area was the largest with no difference between the Cretan and the Kozani vowel space areas.

## 4. CONCLUSION

This study compared the perceptual organisation of vowel systems in Standard Modern Greek and two regional Greek dialects, Cretan Greek (a Southern dialect) and Kozani Greek (a Northern dialect). All dialects, including the standard variety, have five vowels in their systems. Participants selected best exemplar locations (prototypes) for vowels embedded in a carrier sentence uttered by a speaker of their dialect. The results showed that despite having well dispersed vowel systems, SMG, Cretan Greek and Kozani Greek differed in terms of the positioning/distances between adjacent vowels and the total space areas covered by their systems. The SMG vowel system was the most symmetrical system compared to those of Crete and Kozani and covered the largest perceptual area. The finding that the two non-standard dialects have less symmetrical and less expanded systems than the standard variety agrees with production studies examining the organisation of the acoustic vowel space across dialects [e.g. 6, 25]. It therefore seems that while perceptual targets are generally more extreme than vowel productions [16, 17], this perhaps reduces but does not completely remove dialect-specific trends in the perceptual organization of vowel systems.

## 5. ACKNOWLEDGMENTS

This research has been co-financed by the European Union (European Social Fund – ESF) and Greek national funds through the Operational Program "Education and Lifelong Learning" of the National Strategic Reference Framework (NSRF)-Research Funding Program: THALES Investing in knowledge society through the European Social Fund, grant number MIS 379396.

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