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THE GREEK VOWELS

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PURPOSE

The purpose of this paper is to investigate the phonetic quality of the Greek vowels. Apart from the value of presenting a phonetic description of the Greek vowels, this will also provide a test of the Liljencrantz-Lindblom model of maximal dispersion of vowels.

GENERAL

Some investigators have supported the view that perception of sounds is related to articulation (Liberman et al., 1967). Ladefoged et al. (1972) argue in favor of acoustics in relation to vowel perception and propose "An auditory-motor theory of speech production". Distinctive features for vowels have been reviewed by Lindau (1978).

Phoneticians have realized that the first two or three spectral peaks, i.e. the formants, suffice to distinguish between different vowels. It is tempting to see the dimension height of traditional vowel diagrams inversely related to the frequency of the first formant and the dimension backness directly related to the frequency of the second formant. But the relationship between vowel formants and tongue height or backing is more complicated than this (Stevens and House 1975, Fant 1960, Lindblom and Sundberg 1971, Stevens 1972, Wood 1975a, 1975b, 1978, 1979). Ladefoged (1975) has proposed relating backness to the difference between the two formants rather than to the second formant alone. This procedure will be adopted here.

It has been shown by Peterson and Barney (1952) that two speakers may produce perceptually the same vowels with overlapping formant frequencies because of the differences in vocal tract dimensions. A desirable requirement for the comparison of vowels in languages or dialects is the elimination of the particular speaker characteristics, leaving only the phonetic

	[i]		[e]		[a]		[o]		[u]	
S	F1	F2	F1	F2	F1	F2	F1	F2	F1	F2
1	290	2000	430	1750	710	1290	430	1110	325	1000
2	360	2215	500	1835	820	1605	500	1000	390	930
3	360	2390	465	1820	785	1570	465	1070	430	1000
4	430	2285	430	1785	785	1355	430	1105	390	890
5	320	2265	500	1570	785	1250	465	890	390	930

Table 1. Formant frequency values (Hz) of 5 speakers representing Athenian Greek.

quality common to all speakers of the language. Thus, it becomes necessary to investigate the vowels of several speakers to represent the system of a language. The speech of 5 subjects will be analysed here.

Liljencrantz and Lindblom (1972) provide a quantified theory of the principle of maximal contrast as the major factor influencing the acoustic vowel space according to which the vowels in a system will tend to be maximally dispersed from a center of gravitiy in the available formant space. Wood (1975a), Papçun (1976) and Disner (1978) looked at formant data in real languages and their results indicate that some vowel spaces are not determined completely by a principle of maximal separation. The Greek data analysed here will be viewed in the light of this theory.

VOWEL		[i]	[e]	[a]	[o]	[u]
F1	$\bar{X}$	350	465	775	460	385
	S	45	35	35	25	35
F2-F1	$\bar{X}$	1880	1285	635	575	565
	S	45	110	100	100	35

Table 2. Mean values ($\bar{X}$) and standard deviations (S) of formant frequencies of 5 speakers representing Athenian Greek.

EXPERIMENTAL PROCEDURE

Formant frequency data of the five monophthongal Greek vowels /i e a o u/ were obtained from five speakers producing short utterances containing the vowels to be analysed.

Subjects

Five male Greek students in their twenties, brought up and educated in Athens, served as informants. They all speak what is considered to be standard Athenian. Apart from subject 5 (the investigator) , the subjects have never had any phonetic training.

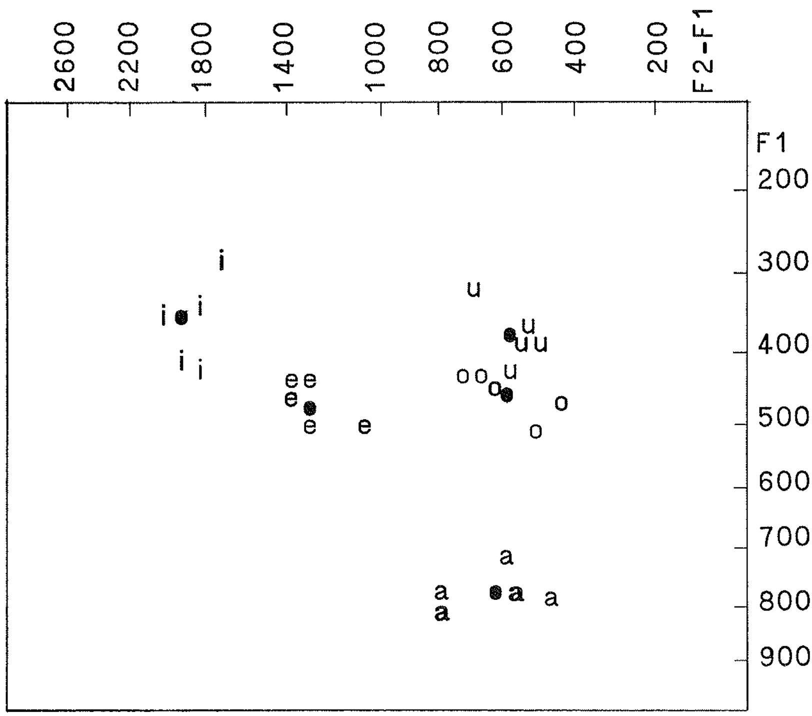

Fig.1. The formant frequencies from Table 2 with the average for each vowel indicated.

Speech samples

Five monosyllabic words of the type CV, each representing one Greek vowel, were put in the frame *γrápse...páli* "write ... once more". Below is the list of the CV-words.

ti	what
te	and (formal and archaic Greek)
ta	definite article, neuter, plural
to	definite article, neuter, singular
tu	definite article, genitive, singular

The list of "sentences" was read three times by each speaker. The subjects were instructed to read the list in a natural way.

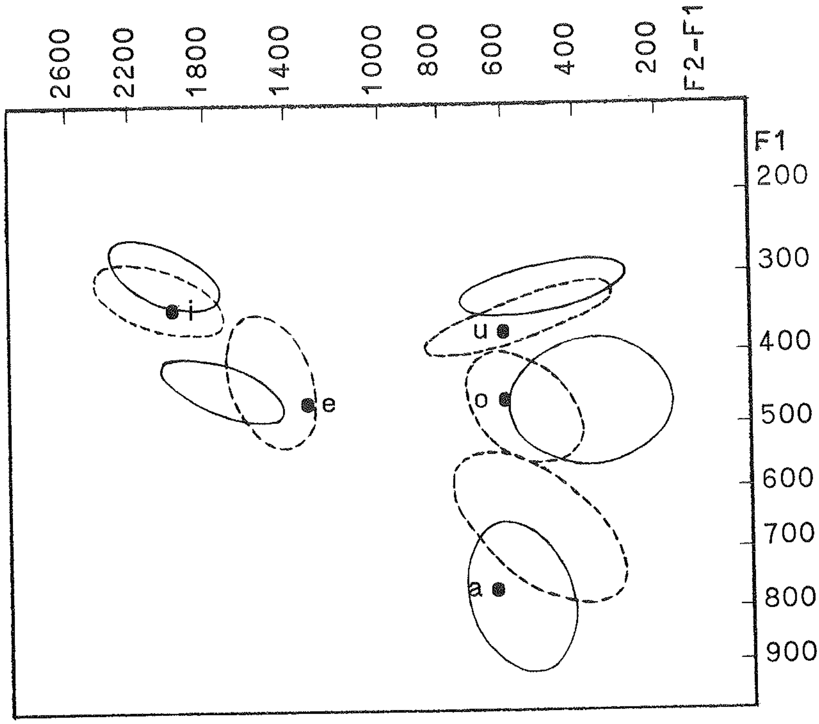

Fig.2. The formant frequencies of Mexican Spanish (solid lines) and Peninsular Spanish (broken lines) from Godinez (1978). The average formant frequencies of the Greek vowels are indicated by dots.

Experimental equipment

The recording took place in a sound-treated studio. The frequency response of the tape recorder was flat within ± 2 dB, from 30 Hz to 14 000 Hz. The signal to noise ratio was 63 dB. The microphone was unidirectional within the frequencies 30 to 17 000 Hz, and the sound spectrograph was a PV-10 voiceprint.

Acoustic analysis

Wide band spectrograms were made of the middle set of utterances and the first two formant frequencies of each of the five vowels were measured by the investigator (Table 1). Mean values and standard deviations of formant one and the difference between formant one and formant two were also calculated (Table 2).

RESULTS

Figure 1 shows the formant space of the five Greek vowels plotted with the frequency of the first formant on the ordinate and the difference between the first and second formant on the abscissa. Distances along the axes are arranged in accordance with the Mel-scale, in which perceptually equal intervals of pitch are represented as equal distances along the scale (Ladefoged 1975).

DISCUSSION

The Greek vowel space does not completely conform to a principle of maximal disperson. Some vowels do not utilise the full acoustic space. First, the vowels [u] and [o] are too close together. Second, the vowel [e] is considerably centralized.

The Greek vowel space was compared with the vowel spaces of two Spanish dialects, Mexican and Peninsular Spanish (Godínez 1978). Figure 2 shows the comparison. First, the average [i] and [u] of Greek is somewhat lower than in Spanish. This is what makes Greek [u] and [o] closer together than expected from a principle of maximal dispersion. Second, the Greek [e] is centralized in comparison with Spanish. This shrinks the Greek backness dimension.

Maximal dispersion is one factor governing the Greek vowel space. However it is clearly not the only one; examination of the historical development of the Spanish and Greek vowels may cast some light on the observed differences between the two languages. First, in modern Greek the vowel /e/ has come both from the short classical /e/ and the classical diphthong /ai/; this merger of /ai/ with /e/ may have contributed to the central value of modern Greek /e/. Spanish has never had this kind of vowel change. Second, the modern Greek /u/ has derived successively from the pre-classical diphthong [ou] via mid close [o:] to the classical [u] . On the other hand, the Spanish /u/ has come directly from the classical Latin /u:/. That the Greek /u/ is lower than Spanish /u/ indicates that the modern Greek vowel may reflect its development from classical Greek.

Thus, the current Greek vowel space may be the result of the principle of maximal dispersion and the historical development of the Greek vowel sounds; but there may be other factors involved too.

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