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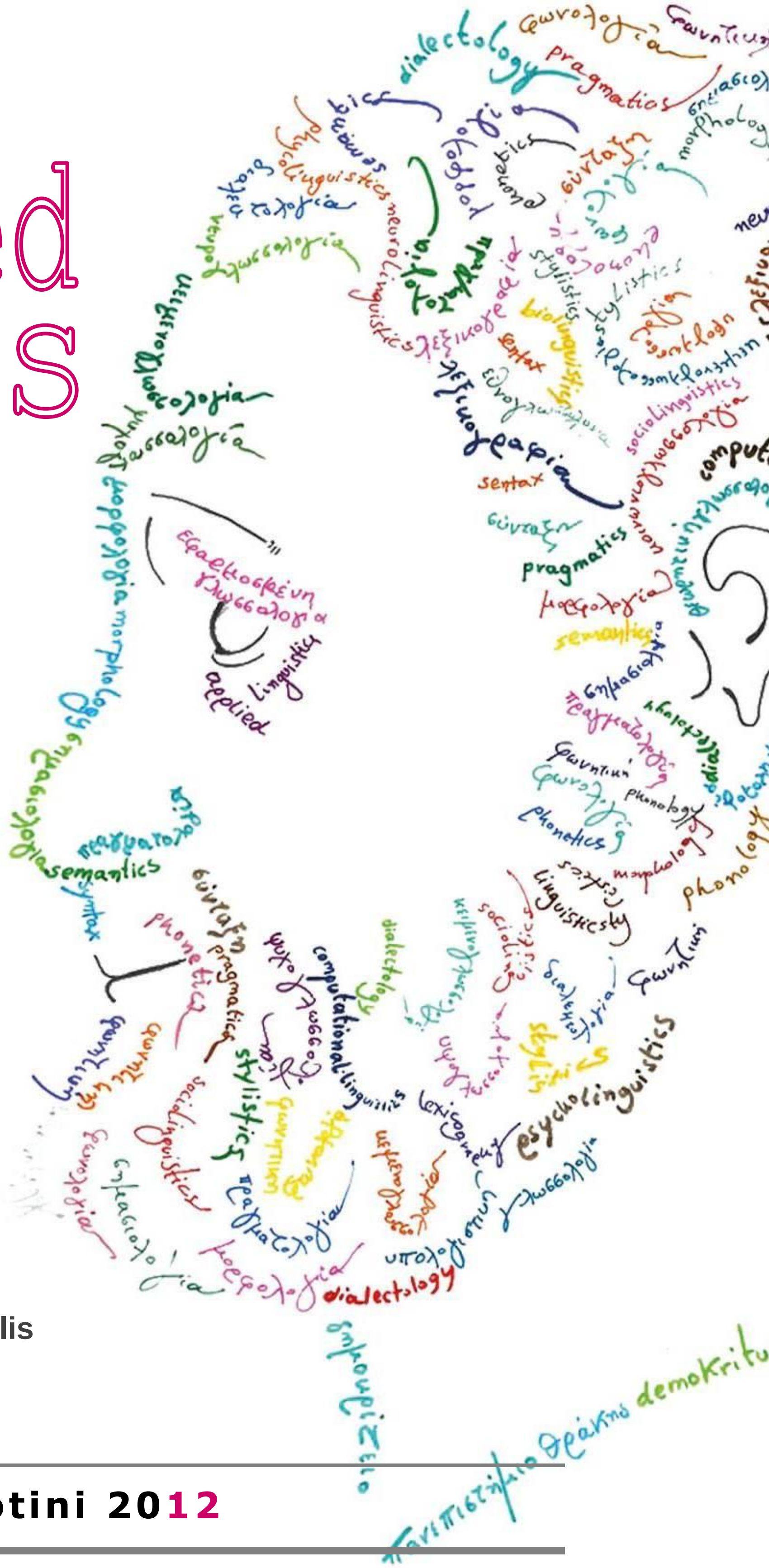

Edited by

Zoe Gavriilidou
Angeliki Efthymiou
Evangelia Thomadaki
Penelope Kambakis-Vougiouklis

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THE REALISATION OF VOICELESS GREEK VOWELS

Marianna Kaimaki
University of York, UK
marianna.kaimaki@york.ac.uk

ABSTRACT

Previous studies of the acoustic properties of Greek vowels have indicated that they may be voiceless in certain phonological contexts. Researchers (e.g. Dauer, R. M. 1980, Mennen & Okalidou 2006) have suggested that devoicing is restricted to the high vowels /i/ and /u/. I propose that the whole range of vowels can be produced voiceless in the appropriate phonological environment which is utterance-finally after voiceless consonants,under two conditions: (1) the vowel must be unstressed and (2) the intonation contour associated with the word in which the vowel occurs must fall (utterance-final voiceless vowels do not co-occur with rising contours).

1. Introduction

Linguistic studies on the interface of Phonetics/Phonology regarding the acoustic characteristics of Greek vowels are limited and based on data from read speech (see also Nikolaidis 2002, 2003who investigated spontaneous speech data). Despite the fact that vowels are voiced by nature, some studies report that under certain phonological circumstances (e.g. in an unstressed position) some vowels get lenited or lose some of their characteristics (e.g. from peripheral they become central (Baltazani 2007)). Research so far (e.g.Dauer, R. M. 1980, Charalambopoulos, Alvanoudi, Didaskalou, Lambropoulou, & Poulli, 2003, Mennen & Okalidou 2006) suggests that the vowels which undergo lenition or deletion are /i/ and /u/. We propose that the process of lenition or deletion is not limited to high vowels but that in certain phonological environments all Greek vowels may undergo changes in their distinctive characteristics and more specifically their voicing. Determining the validity of this hypothesis is of linguistic interest as voiceless vowels are typologically ratherrare and are not always implicated with the kind of morphological functions mentioned above. The results of the study then are anticipated to contribute to both understanding the nature of Greek vowels as well as understanding the typology of natural languages.

Preliminary research conductedby the authorrevealed that voiceless vowels can occur in utterance final position. This phenomenon merits attention as reports of voiceless vowels are rare and usually found in non-Indoeuropean languages like Japanese (Tsuchida 2001; Vance 2008), South Paiute (Harms 1966) and Comanche (Canonge 1957) as well as in Finnoungarian languages like Finnish (Ogden 2001). Pilot research conductedon recorded dialogues which were collected for the purpose of the completion of the author'sPhD thesis confirmed the findings reported to date but also revealed some new interesting facts. It was noticed that the same rule that applies for the high vowels /i/ and /u/ can be applied on any of the vowels of Greek (/i, e, a , o, u/) under the following conditions:

a) the vowel to be utterance final
b) the utterance to have a final falling pitch and
c) the consonant to be voiceless.

This finding opens up a series of important questions regarding the realisation of Greek vowels. In this paper I will examine:

- the distribution of voiceless and voiced vowels with relation to the vowel quality and intonation (falling/rising)
- whether the phenomenon of all utterance-final vowels (a, e, i, o, u) being realised as voiceless is a phonetic process which may vary potentially depending on the vowel quality or whether it is a phonological rule with wide distribution and specific locus of application.
- whether the realisation of voiceless vowels is related to the idiolect of the speaker or whether it reflects a wider rule of the language which has not been noticed so far.

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As Greek is a language with rich morphophonology at the right end of the word, the possibility of voiceless final vowels not being perceived by listeners is very important as it may lead to misinterpretation of the linguistic message. For example, it could lead to the loss of distinction between the first and third person in the verbal forms of ‘έχασα’ and ‘έχασε’. The findings of thisresearch, then will have important applications in the perception/processing of messages in new technologies (e.g. recorded telephone messages) as well as in developing specialised (oral) materials for teaching Greek.

2. Material and methods

12 native speakers of Greek (6 males and 6 females with ages ranging from 20 to 65) as spoken in the city of Thessaloniki produced utterances which included words containing the vowels /i, e, a, o, u/ in unstressed final positions. The stress pattern as well as the number of syllables and the quality of immediately preceding consonants were controlled for in the stimuli but syllable complexity in the middle or beginning of the word was not considered at this stage.I varied the phonological environment for every vowel so as to cover the variety of Greek consonants. Table 1 shows the experimental data used.

	PHONOLOGICAL CONTEXT						
	PLOSIVES		FRICATIVES				
TARGET V	c, k	p	t	f	θ	s	ç, x
i	ˈɐvɐfi άβαφη unpainted	ˈkɛnɔsi κένωση void	ˈɐsiti άσιτη ungrained	ˈpsɛftiki ψεύτικη fake	ˈɛnɔhi ένοχη guilty	ˈɛfipi έφιππη on horseback	ˈɐvɐθi άβαθη shallow
ɛ	ˈɛvɐfɛ άβαφε unpainted(voc)	ˈɐfisɛ άφησε let go	ˈhɐnɛtɛ χάνετε you lose(pl)	ˈɛnikɛ ένοικε tenant(voc)	ˈɛlɐhɛ έλαχε happened	ˈɛlipɛ έλειπε was missing	ˈɐmɐθɛ άμαθε ignorant(voc)
ɐ	ˈɛɣrɐfɐ έγραφα was writing(1st)	ˈɛnɔsɐ ένωσα joined(1st sing)	ˈɐnɛtɐ άνετα relaxing	ˈpɛrðikɐ πέρδικα grouse	ˈɛvihɐ έβηχα was coughing(1st)	ˈlɛlɐpɐ λαίλαπα great destruction	ˈɛnioθɐ ένιωθα was feeling (1st)
ɔ	ˈɐkɛfɔ άκεφο sad	ˈɐnisɔ άνισο uneven	ˈɐlitɔ άλυτο unsolved	ˈɐlikɔ άλικο scarlet	ˈɛksɔhɔ έξοχο spectacular	ˈɛntipɔ έντυπο typed	ˈɐniθɔ άνιθο dill
u	ˈɐɣrɐfu άγραφου unwritten(gen)	ˈɐvisu άβυσσου abyss(gen)	ˈɛnɐtu ένατου ninth(gen)	ˈɐðiku άδικου unfair	ˈisihu ήσυχου quiet(gen)	ˈɛsɔpu Αίσωπου Aesop(gen)	ˈɐniθu άνιθου dill(gen)
TOTAL	35						

Table 1 **Target words**

Participants produced these words in 2 carrier sentences controlling for rising and falling pitch; the two carrier sentences used were:

1. Πώς σου είπε η Μαριάννα πως γράφεται το _______ ;

   How did Marianna tell you _______is spelt?

2. Η Μαριάννα μου είπε να πω _______ .

   Marianna told me to say _______ .

Carrier sentence 1 was produced once for each phonological context + target vowel giving out 35 stimuli. Carrier sentence 2 was produced twice for each phonological context + target vowel giving out 70 stimuli. The data was randomised (5 randomisations) to avoid any effects that might be brought forward by the order of the stimuli. Each speaker produced 105 target sentences in total plus 114 dummies.

The acoustic characteristics of the vowels wereexamined (duration, spectral characteristics and pitch characteristics) for all productions in order to determine their phonetic realisation. Finally, I ran regression analysis on the results in order to determine the statistical significance of the results.

3. Results/Discussion

There was considerable variability in the phonetic realisation of final vowels with falling and rising pitch. Final vowels of sentences with final falling intonation were produced as: 1) fully voiced, 2) voiceless, 3) creaky and 4) breathy while final vowels of sentences with final rising intonation were produced as 1) fully voiced, 2) creaky and 3) breathy.

Figures 1 to 8 show spectrograms and waveforms associated with the final syllables of the target words illustrating the phonetic variability encountered in the data. Figures 1 and 2 show examples of fully voiced final vowels produced with final falling (Figure 1) and final rising (Figure 2) intonation. In both figures we can see high energy in the first two formants(F1, F2) and regular glottal pulses in the spectrogram and waveform.

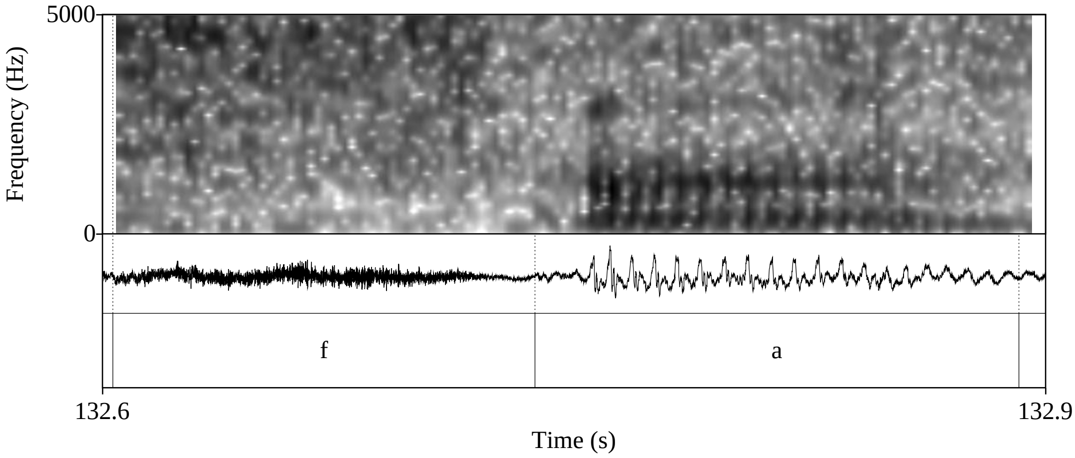

Figure 1 Voiced final falling CV

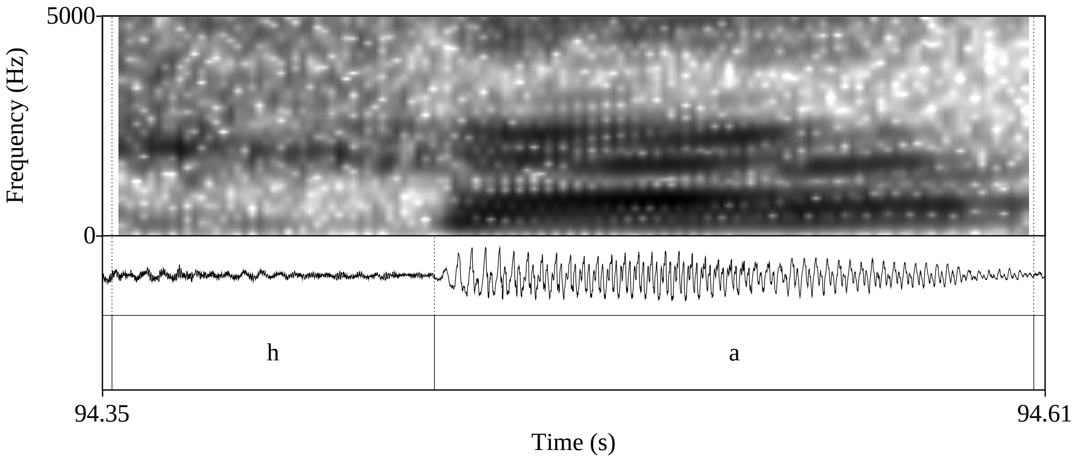

Figure 2 Voiced, final rising CV

Figures 3 and 4 show examples final creaky vowels produced with both falling and rising intonation. In both figures we can see the energy in F1 and F2 fading in and out and the glottal pulses being irregular.

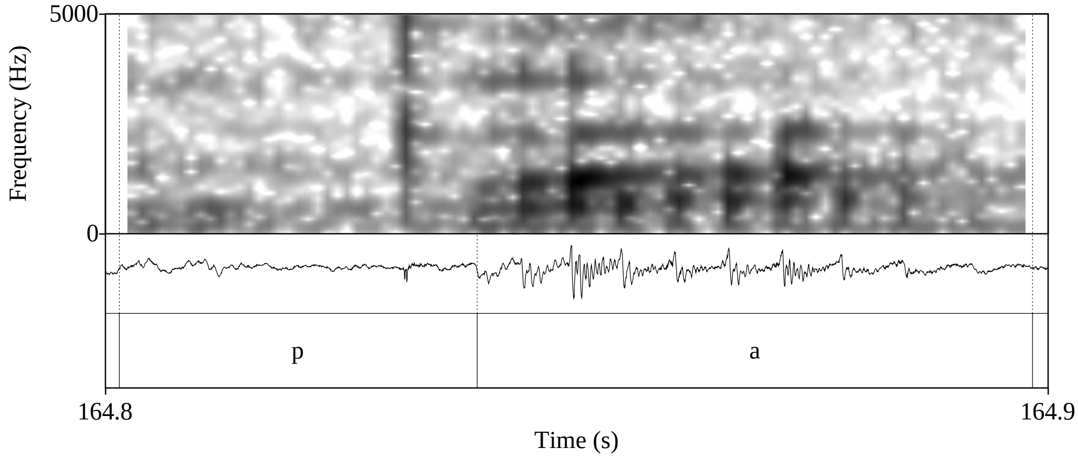

Figure 3 Creaky, final falling CV

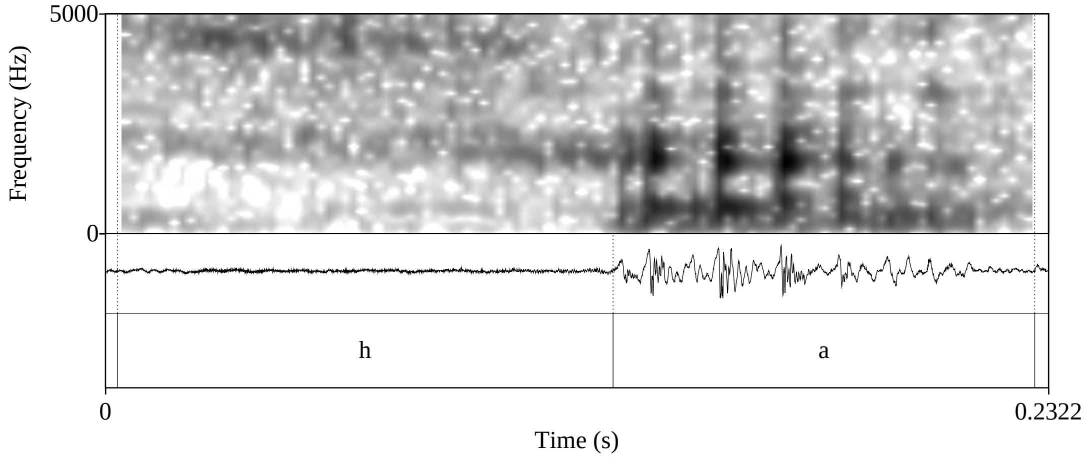

Figure 4 Creaky, final rising CV

Figures 5 and 6 show cases of final vowels produced with breathy voice. We can see there is regular vocal fold vibration which is accompanied by frication giving out the percept of breathy voice.

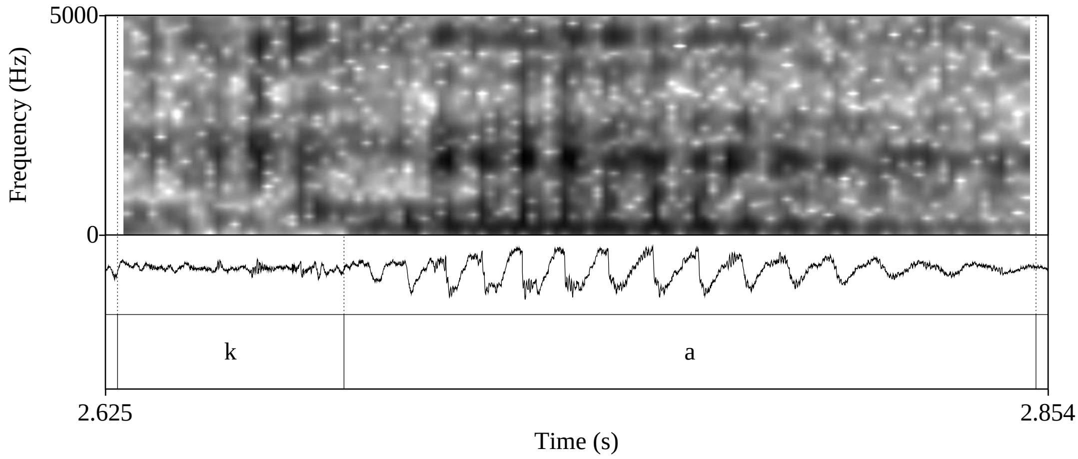

Figure 5 Breathy, final falling CV

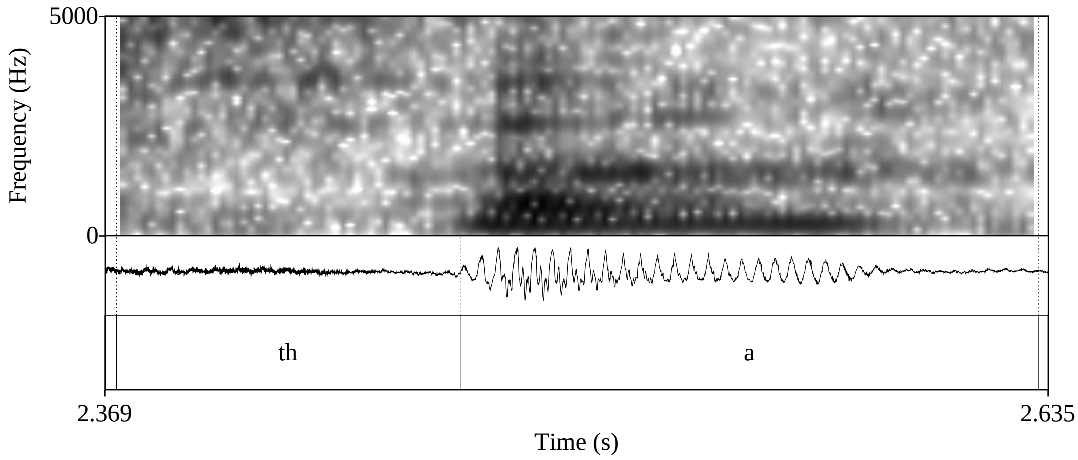

Figure 6 Breathy, final rising CV

Figures 7 and 8 show two examples of final voiceless vowels. In both cases we can see that there is no voice bar associated with the vowels. In figure 7 we can see the onset of the voiceless vowel right after the release of the plosive.There is some energy at the low frequencies but there is no regular vocal fold vibration associated with the vowel.

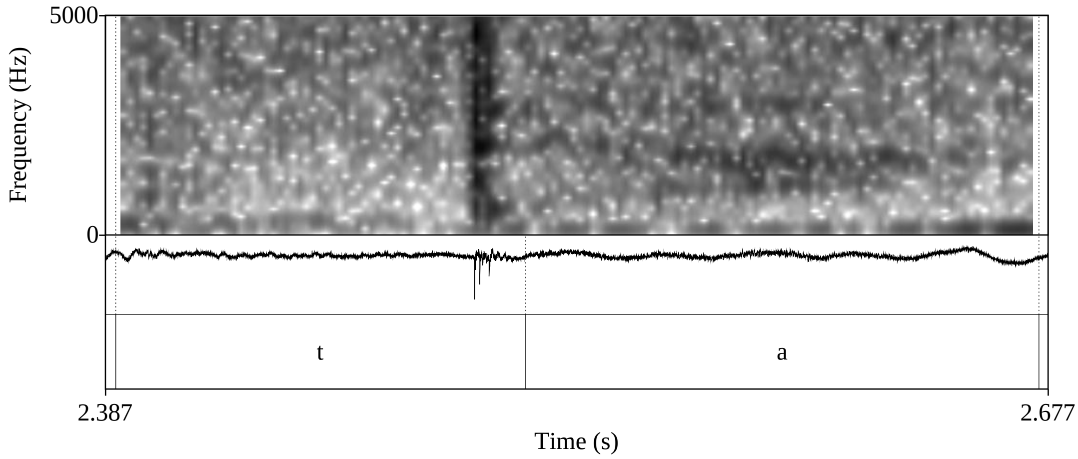

Figure 7 Voiceless V

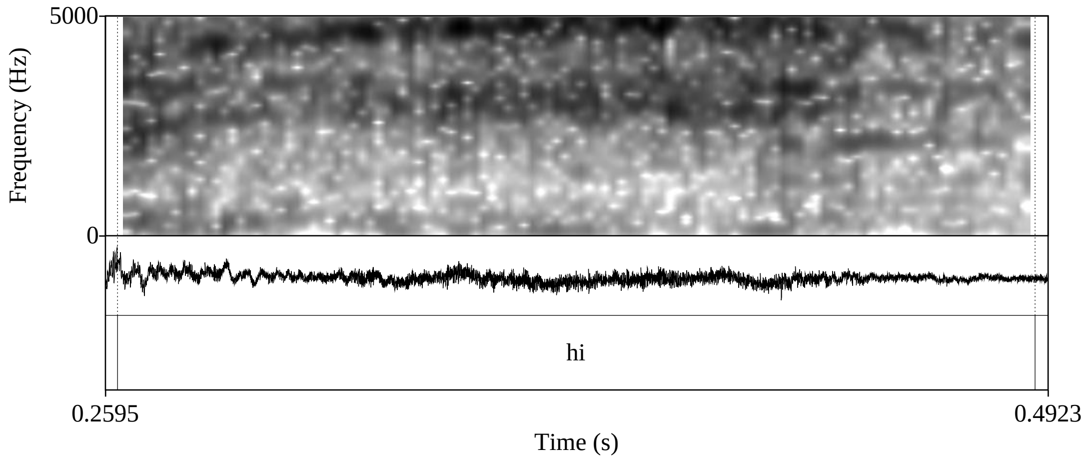

Figure 8 Voiceless V

In figure 8, we can see a high close voicelessvowel, which is produced right after the production of a voiceless palatal fricative. We can see that there is no voicing associated with the vowelbut there is more energy concentration in the higher frequencies than for the fricative preceding the vowel.

From the examples presented so far we can see that there is considerable variability in the production of final vowels in terms of their acoustic features. The variability does not **depend** on the prosodic design of the carrier sentence for the fully voiced, breathy and creaky productions of final vowels. The voiceless cases of final vowels though only occur in carrier sentences with final falling intonation, which means that there is an association between final falling intonation and the realisation of vowels as voiceless. This constraint is particularly interesting as one of the reviewers pointed out voiced obstruents are usually associated with low pitch (Bradshaw 1999). Possible explanations for this constraint are examined in section 4.

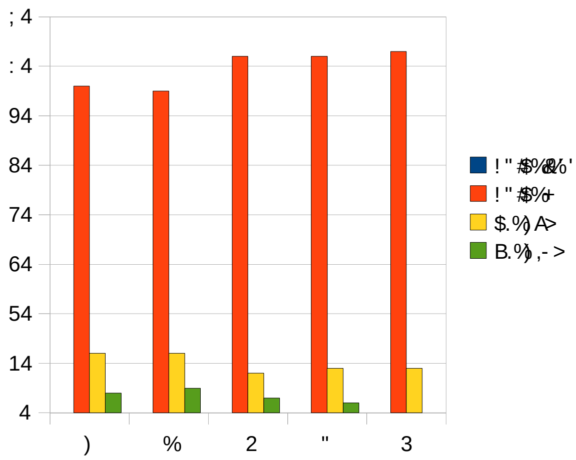

Figure 9 Voice quality of final rising vowels

Figure 9 shows a bar chart showing the distribution of voice quality associated with each kind of final vowel produced with a final rising intonation. As we can see there are no instances of voiceless tokens. /a, e, i, o/ have similar distributions with most their instances being produced fully voiced, with regular vocal fold vibration; creaky voiced instances of final vowels follow in number and there are also some small numbers of breathy voiced instances. Note that /u/ is never found produced with breathy voice in any of the final rising carrier sentences.

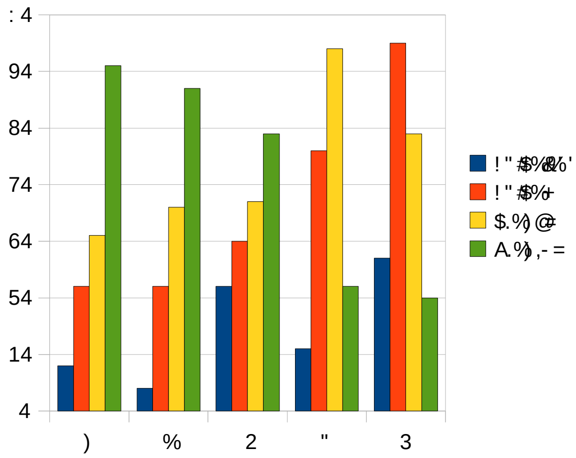

Figure 10 Voice quality of final falling vowels

Figure 10 shows a very different picture in terms of distribution of voice quality which is associated with final vowels produced in final falling carrier sentences. We can distinguish two groups in terms of voice quality distribution; /a, e, i/ and /o,u/. /a, e, i/ all have breathy manifestations for the majority of their productions. Creaky voiced instances of /a, e, i/ are also a big part of the data followed by voiced and voiceless instances. /o, u/ have a very different distribution from /a, e, i/ and partly from one another but the distribution is similar in that the majority of their productions are voiced or creaky with the numbers almost reversed for /o/ and /u/ (more creaky for /o/ more voiced for /u/), and number of instances for breathy and voiceless manifestations are similar but reversed (more breathy than voiceless cases for /o/ and more voiceless than breathy cases for /u/).What is important to note is the fact that the whole set of vowels /a, e, i, o, u/ have voiceless instances and not just the high vowels.

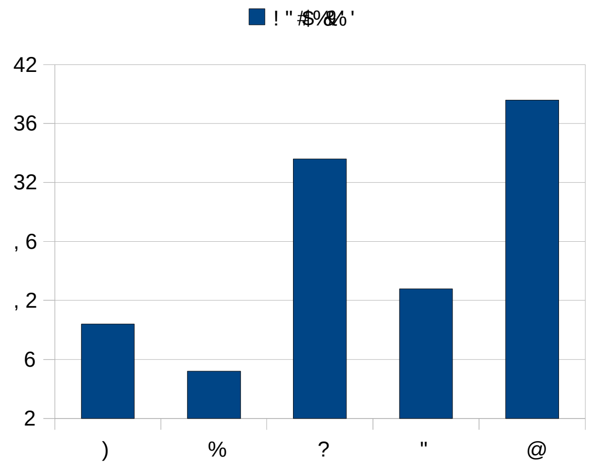

Figure 11 Number of voiceless vowels

The number of voiceless vowels encountered in the data and their distribution as to vowel quality is shown in figure 11. From the bar chart we can see that /i/ and /u/ have the highest number of voiceless instanceswhich agrees with research done so far. It is also clear from the chart though that open and mid vowels have some of their instances produced with no vocal fold vibration as well. In order to check whether there is any relation between the realisation of a vowel as voiceless and its phonological environment a bar chart (figure 12) was created that shows the breakdown of voiceless vowels to preceding consonants.

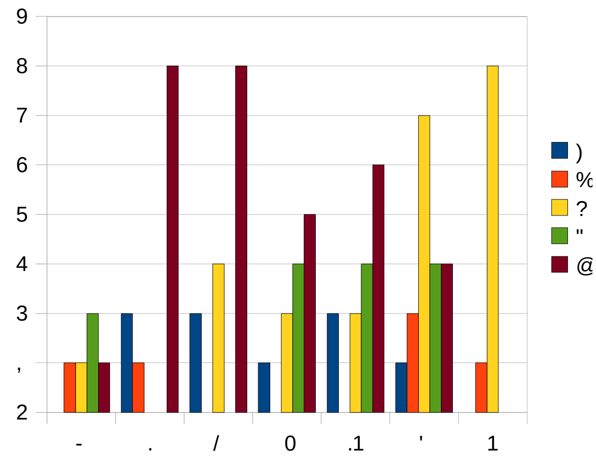

Figure 12 Vowels with individual consonants

From figure 12 we can see that all kinds of consonantal environments examined allow voiceless vowels following them. Overall,the total numbersof voiceless vowels are similar amongst consonants (p=5, t=10, k=12, f=10, th=12, s=15, h=8). The manner of articulation of the consonants though seems to play a role in the number of instances of voiceless vowels that occur after a consonant, as there are more voiceless vowels after fricatives (N=45) than plosives (N=27).Despite fricatives having more voiceless vowels occurring after them, not all fricatives have voiceless instances of the whole set of vowels; only after /s/ all vowels(/a e i o u/) were produced as voiceless. From the data examined so far there is no particular pattern as to the vowel quality of voiceless vowel and the place of articulation of the consonant.

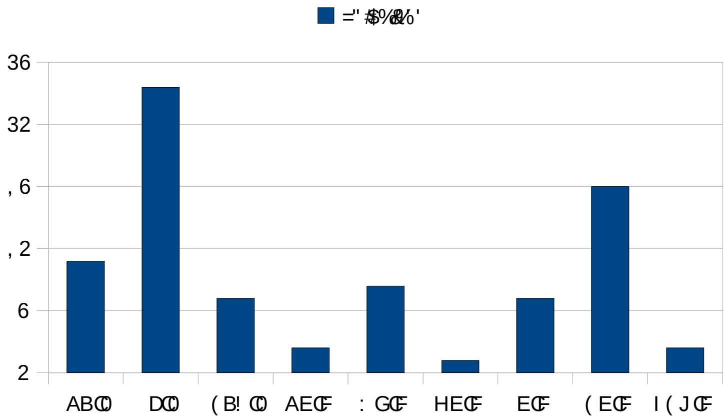

Figure 13 Breakdown of voiceless vowels to speakers

Figure 13 shows a bar chart with the breakdown of voiceless vowels to speakers. As the bar chart shows 9 out of 12 speakers produced voiceless vowels. In terms of sex, more males (n=6) produced voiceless vowels than females (n=3) but individual females produced more voiceless vowels than individual males.

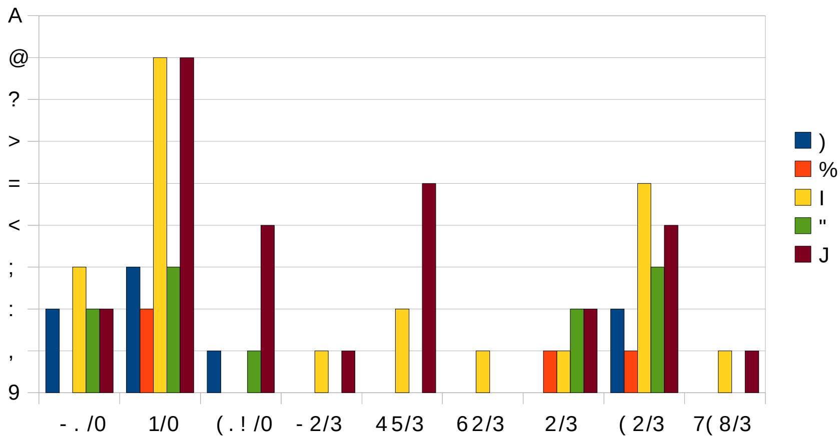

Figure 14 Voiceless vowel distribution in individual speakers

Figure 14 shows a bar chart showing the distribution of voiceless vowels to individual speakers. L (female) and PK (male) are the only speakers who have the whole set produced as voiceless and they are the ones who produce the most voiceless vowels(L=24, PK=15).From the rest of the speakers who do not have the whole set, we can see that there is a pattern as to which vowels they produce voiceless first and which vowels follow. The high close vowels /i, u/ are the first that speakers produce voiceless and only if they have voiceless instances of those vowels do theythen extend to the mid and open vowels.

Summary

From the results reported so far we conclude that final rising utterances do not display much variability in the voice quality of the final vowels and they do not display any final voiceless vowels. Final falling utterances on the other hand display considerable variability in the voice quality of final vowels and they display the whole range of voiceless vowels with /i/ and /u/ being the first to get produced voiceless.

Regression analysis was performed to determine whether there is any statistical significance for the results reported. Analysis showed a significant relationship between height and closeness of the vowel and voicelessness [for /i/, p=0.017, for /u/, p=0.0017] which suggests that the presence of /i/ and /u/ increased the possibility of the vowel of a final falling utterance being produced with no voicing.

Results also showed that voiceless vowels are more likely to appear after voiceless fricatives rather than voiceless plosives and that the distribution of voiceless vowels was not even across all speakers. In terms of usage by sex, more males used voiceless vowels than females but individual females used them more than individual males.

4. Conclusions and perspectives

In this paper we extended the existing research on the production of Greek vowels. Unlike findings reported by research so far, our results showed that all Greek vowels (/a, e, i, o, u/) can be realised as voiceless.Results also showed that there is variability in the realisation of final falling Greek vowels in our data for both rising and falling conditions but the nature of variability is not the same in the two cases. In this section we will endeavour to give an account for this phenomenon and assess the implications for the phonology of the language.

Final vowels in our data were produced with either final falling or rising pitch and their acoustic characteristics varied accordingly. Final vowels produced with falling intonation were found to have four distinct phonetic qualities: 1) fully voiced, 2) voiceless, 3) creaky and 4) breathy. There are at least two potential interpretations for the variability encountered. We can try to account for this variability with reference to the physiology of the vocal tract and the articulatory mechanisms for producing speech.Following this train of thought we could start making claims about how it is not surprising that falling pitch, which is accomplished by slow rate of vocal fold vibration, is accompanied by creaky voice or breathy voice or voicelessness as this could be natural physiological consequence of the vocal folds vibrating slowly or even to stop vibrating altogether. However, our data also showed that final vowels produced with rising intonation were found to have three of those distinct phonetic qualities: 1) fully voiced, 2) creaky and 3) breathy.In this case it would not be possible to try and account for it using a physiological explanation as rising pitch is accomplished by increasing the rate of vocal fold vibrations which would make it harder to explain how we find breathy and creaky voice quality associated with rising pitch. The second possible interpretation would be to account for it phonologically. Following this interpretation we would have two phonological statements; one for rising and one for falling pitch:

1. If a vowel is associated with final falling intonation the range of variability for its production is: fully voiced, creaky, voiceless, breathy.
2. If a vowel is associated with final rising intonation the range of variability for its production is: fully voiced, creaky, breathy.

From the results reported so far we also concluded that final falling utterances display the whole range of voiceless vowels with /i/ and /u/ being the first to get produced voiceless which agrees with the outcomeof the regression analysis which showed that there is a significant relationship between height and closeness of the vowel and voicelessness. This result is of considerable importance as it complements research done on the Greek vowels so far by providing new evidence for the presence of voiceless vowels in Greek. One account explaining this phenomenon is that this is a phonetic process which may vary potentially depending on the vowel quality. However, as all vowels can be produced voiceless this cannot be a sufficient explanation for the data. Another hypothesis could be that this is a phonological rule with wide distribution and specific locus of application. The current experiment does not provide us with all the required data that would allow us to make such a generalisation. From the experiment it is clear though that all voiceless consonants seem to allow this process with one condition; the utterance has to have a final falling intonation.Results also showed that voiceless vowels are more likely to appear after voiceless fricatives rather than voiceless plosives which indicates that the phonological context may be an important factor in determining the realisation of the final vowels as voiced or voiceless.

As the experiment involved different individuals and the distribution of voiceless vowels was not even across all speakers, there is also the issue whether the realisation of voiceless vowels is related to the idiolect of the speaker. In terms of sex,more males used voiceless vowels than females but individual females used them with greater frequency than individual males. In order to determine whether this phenomenon reflects a wider rule of the language, more data (maybe of a different kind) is needed. One reviewer suggested the possibility of the presence of voiceless vowels being a dialectal effect. However, as I mentioned in section 2 all subjects were speakers of the Urban variety of Greek as spoken in Thessaloniki which does not exhibit vowel lenition processes found in Greek northern dialects.

The results of this experiment are of particular importance as final Greek vowels may carry morphosyntactic information. A production of a voiceless vowel, may result in the neutralisation of contrast between e.g. egrafa and egrafe leading to loss of morphosyntactic information.If the vowels are realised as voiceless but the linguistic message is still perceived nevertheless, then there should be some other factor contributing in the decoding of information. This could be intonation, traces of spectral information of the vowel in the preceding consonant or the overall context.

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