Velar softening: An acoustic study in Modern Greek

Asimina Syrika[a], *Eun Jong Kong*[b], *& Jan Edwards*[b]

[a]Callier Center for Communication Disorders, UT-Dallas & [b]Waisman Center, UW-Madison
syrika.asimina@utdallas.edu, {ekong|jedwards2}@wisc.edu

ABSTRACT

In (Modern) Greek, velar consonants become palatalized before front vowels following an allophonic rule. In many southern dialects, the variants that result from palatalization further undergo softening in this same position. While velar softening is well-documented in Greek dialectology studies, most previous work is based on impressionistic data. In the present study, several acoustic and psychoacoustic measures were applied to examine the characteristics of velar palatalization/softening in voiceless plosives of two regional varieties of the language: a 'non-softening' dialect spoken in Thessaloniki and a 'softening' dialect spoken in Crete. The effects of speaker's sex, word position, and stress placement on velar palatalization/softening were also examined. The results provided acoustic evidence of velar softening in the Cretan dialect. We also found an influence of sex, word position, and stress on the extent of velar softening.

Keywords: velar softening, Cretan dialect, Greek plosives, palatalization

1. INTRODUCTION

In Modern Greek (henceforth Greek), voiceless velar stops become palatalized before front vowels following an allophonic rule (e.g., /kipos/ "garden"→ ['kʲipos] /_ [i, e]) [1]. Velar palatalization is a common phonological process of all Greek dialects, including standard Greek. A well-known feature associated with many southern dialects is that in addition to palatalization, front velar stops further undergo softening in this same position, i.e. a change in manner of articulation, from stop to an affricate [2, 3]. For example, /k/ is realized as [kʲ] before front vowels in standard Greek, but as [t͡ɕ] in many varieties of Cretan Greek and as [t͡ʃ] in Cypriot Greek [4]. Moreover, the presence of these dialectal affricate types co-occurs with realizations of target /ts/, which is described phonetically as a voiceless alveolar or dental affricate in standard Greek [1, 2]. However, studies on the exact nature (and distribution) of these (velar, fronted velar, and affricate) variants in the different dialects of Greek are scarce and mainly impressionistic [3, 5, 6].

Velar softening is a particularly interesting dialect feature because it is also a common sound change in the world's languages [7, 8, 9]. Two explanatory hypotheses for velar softening have been proposed. First, the articulation-based hypothesis claims that the sound change from velar to an affricate is triggered by particular anterior, (alveolo) palatal realizations of the velar stop in several contextual and positional conditions. Thus, velar softening (a change in manner) is necessarily preceded by velar palatalization (a change in place of articulation) [7, 8]. Second, the acoustic-equivalence hypothesis claims that velar softening is due to the acoustic similarity and subsequent perceptual confusability between the spectral cues for a velar stop and a palato-alveolar affricate before front vowels, especially under conditions of fast speech [9].

The goal of the present paper is to examine the acoustic characteristics of velar softening in Greek. We recorded speakers of two dialects: a 'non-softening' dialect, spoken in Thessaloniki (northern Greece) and a 'softening' dialect spoken in the district of Ierapetra, in Crete (southeastern Greece). We additionally explored the effects of speaker's sex (male vs. female), prosodic environment (word-initial vs. word-medial), and stress placement (e.g., following a stressed or unstressed vowel) on the acoustic characteristics of velar softening.

2. EXPERIMENT

2.1. Methodology

2.1.1. Participants

Twelve monolingual native speakers of Greek between the ages of 21 and 61 years participated in

the study. There were six speakers (three male and three female) from each dialect area who were born and raised in either Thessaloniki or Crete. The two participant populations were generally similar in terms of age (mean = 40.2 years, range = 21 to 61 years for Thessalonikans; mean = 37.9, range = 23 to 58 for Cretans) and level of education (mean = 14.3 years of schooling, range = 12 to 16 years for Thessalonikans; mean = 14.2 years of schooling, range = 12 to 17 years for Cretans).

2.1.2. Materials and procedure

The stimuli were 67 (two-or three-syllable) real words containing /k/ or /ts/ in word-initial or word-medial (intervocalic) position before the vowels /i/, /e/, or /a/ (e.g., κύμα /kima/ ['k^{j}ima] "wave"; φάτσες /fatses/ ['fatses] "faces"; κάππα /kapa/ ['kapa] "letter k"). Three repetitions of each stimulus were elicited. The syllable containing the target /k/ or /ts/ sound was stressed in 29 words and unstressed in 38 words. For example, target /k/ in the vowel /i/ context was elicited in the Greek words κύμα /kima/ ['k^{j}ima] "wave" and κινά /kina/ [k^{j}i'na] "he/she puts something in motion" in word-initial position, and in κουκί /kuki/ [ku'k^{j}i] "broad bean" and κόκκοι /koki/ ['kok^{j}i] "seeds, grains" in word-medial position.

Recordings were made at a 44.1 kHz sampling rate. Stimuli were first elicited in citation form, then at the end of the carrier phrase τώρα είπα _____ ['tora 'ipa] "I've just said"_____ (*target word)*. For the Cretan speakers we replaced the standard form τώρα (['tora], "now") with the dialectal form εδά ([e'ða], "now") to facilitate elicitation of the dialectal features. Participants were asked to read each sentence out loud, at a comfortable rate of speech. Only the words elicited in citation form were included in the present study.

2.1.3. Acoustic analysis

We examined: 1) the burst of the plosives to characterize the fronted constriction of velar stops and 2) the release (or frication) of the plosives to measure the strength of constriction. For the burst analysis, the power spectrum of a 10 ms Hamming window centered at the burst was computed to obtain the highest spectral peak. The peak location was identified after transforming the linear frequency domain (i.e., Hz) into ERB (Equivalent Rectangular Bandwidth) to better capture the acoustic cues crucial to the auditory system [10]. This peak location will be referred to as peak ERB. Another advantage of this method is that it reduces the risk of spectral misidentification that has been reported in previous studies [11]. Higher peak ERB values indicate a shorter front cavity (or a more anterior place of articulation).

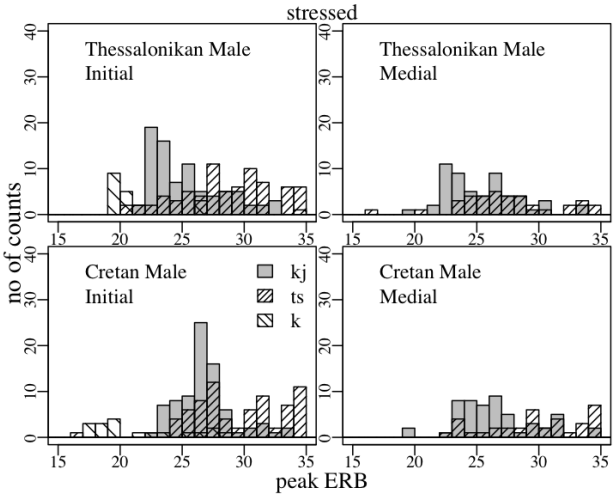
To compare the strength of the constriction between affricates and stops, we measured the relative intensity of release duration (25 ms centered at the midpoint of the plosive release duration) with reference to the intensity of the following vowel. The temporal interval between the burst and the voice onset was also measured to compare velar stops and affricates in both dialects.

2.2. Results

2.2.1. Perceived burst spectral peak

Figure 1 shows peak ERB values of each target sound for male speakers in word-initial and word-medial position when the vowel following the target sound was stressed. The patterns of the Thessalonikan-Greek speakers are shown on the two top panels and the ones of the Cretan-Greek speakers are shown on the bottom panels. Clearly, both dialect groups showed some evidence of velar palatalization, with [k^{j}] (the allophone of /k/ before front vowels) having higher peak ERB values than [k] (the allophone of /k/ before non-front vowels) in both dialects.

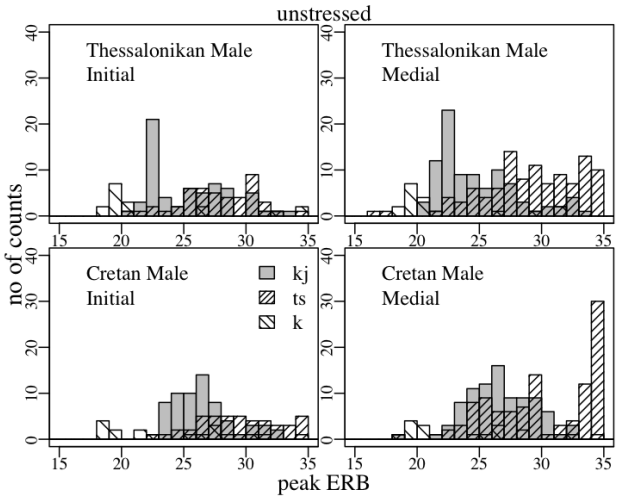
Figure 1: Histograms of peak ERB values of the target sounds before stressed vowels in male speakers. Panels are separated by dialect and prosodic position (Note: Tokens containing /k/ before a stressed /a/ vowel were not elicited in word-medial position).



Moreover, a clear dialectal difference can be observed. In word-initial position, Thessalonikan-Greek speakers produced the affricate /ts/ with a larger range of peak ERB values, as compared to Cretan male speakers. Also, the peak ERB values of [k^{j}] in Cretan Greek showed considerably more overlap with those of /ts/, suggesting a more anterior realization of [k^{j}] or a larger acoustic similarity in terms of perceived spectral peak between [k^{j}] and /ts/ in this dialect. This was the case for both word-initial and word-medial position, but was more prevalent in word-medial position.

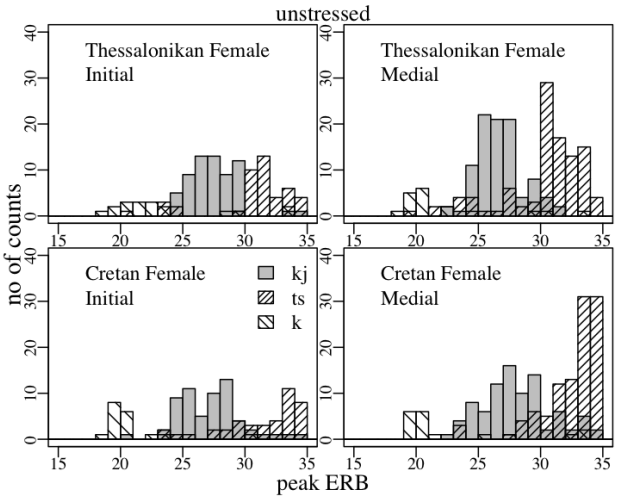
Figure 2 shows peak ERB values of each target sound for male speakers in the two prosodic positions when the vowel following the target sound was unstressed. Results were similar, but more extreme in the unstressed condition, especially for the word-medial tokens produced by Cretan male speakers.

Figure 2: Histograms of peak ERB values of the target sounds before unstressed vowels in male speakers. Panels are separated by dialect and prosodic position.



This dialectal difference in distribution of peak ERB values was not as prevalent in females' productions. As we can see in Figure 3, both Thessalonikan-and Cretan-Greek female speakers produced three distinct categories of velar, palatalized stops, and affricates. Below we show the results for the unstressed condition only. Results were similar in the stressed condition.

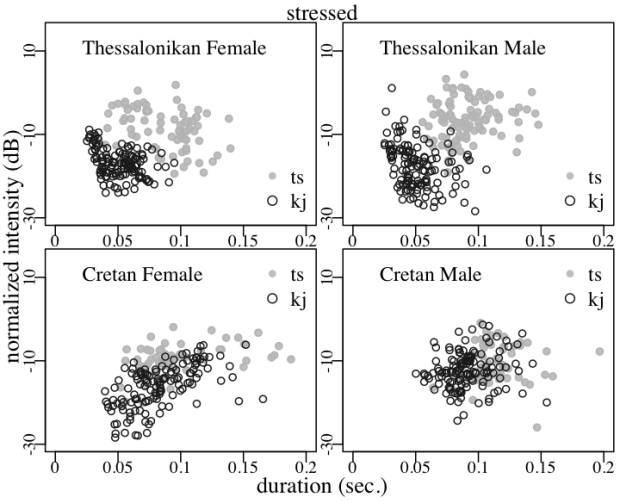
Figure 3: Histograms of peak ERB values of the target sounds before unstressed vowels in female speakers. Panels are separated by dialect and prosodic position.



2.2.2. Burst intensity and duration

Figure 4 shows the distribution of normalized intensity by duration for [k^{j}] and /ts/ in Thessalonikan-and Cretan-Greek speakers in the stressed vowel condition. Word-initial and medial tokens were collapsed, due to their similarity.

Figure 4: Scatterplots of normalized intensity against duration between velar stops and affricates before front vowels in the stressed condition. Panels are separated by speaker sex and dialect.



It is clear that both duration and normalized intensity are necessary to distinguish [k^{j}] from /ts/ in Thessalonikans' productions, regardless of speaker's sex. More specifically, affricates are longer and have higher intensity values than the

palatalized stop productions. In productions of Cretan speakers, however, [k^j] and /ts/ overlap almost completely in both duration and intensity values, with [k^j] being both longer and higher in intensity relative to the Thessalonikan [k^j]. The Cretan [k^j] is clearly affricate-like. Also interestingly enough, the affricate /ts/ in Cretan is also produced with less intensity relative to the Thessalonikan /ts/. Thus, our findings indicate a difference not only in [k^j] realizations, but also in /ts/ realizations in the two dialects. Similar patterns were observed in the unstressed vowel condition.

3. DISCUSSION AND CONCLUSION

These results provide empirical data supporting the presence of velar softening in the Cretan, but not the Thessalonikan dialect of Greek. Our measures were generally successful at capturing differences in place and manner of articulation between velar stops, allophonically palatalized stops, and affricates in the two dialects. Thessalonikans who do not have velar softening in their dialect tended to have a wider range of peak ERB values for productions of /ts/ relative to the Cretans, especially in word-initial position. Cretan-Greek speakers also showed considerable overlap in their peak ERB values for [k^j] and /ts/ tokens, suggesting that Cretan [k^j] tends to be perceived as more anterior than the Thessalonikan [k^j], and similar to the Greek affricate /ts/. This affricate-like character of the Cretan [k^j] was also widely confirmed in the intensity by duration analysis.

Our findings also revealed some interesting effects of speakers' sex, prosodic position and stress placement on velar softening. It appears that more overlap between [k^j] and /ts/ in Cretan is observed for male speakers in the word-medial context, particularly when the following vowel is unstressed. These results are in agreement with those reported in Granqvist's [5] corpus about the frequency of application of velar softening in eastern-Cretan.

To summarize, the current study presents psychoacoustic and acoustic measures to characterize velar softening in Greek. To our knowledge, this is the first systematic acoustic study of velar softening in Greek. Our results support the claims of dialectologists that velar softening is present in Cretan-, but not in Thessalonikan-Greek.

Further research is needed to determine whether listeners from softening and non-softening dialects of Greek are able to discriminate between [k^j] and /ts/ productions. Once we have these results, we may be able to use the results from the acoustic study and the perception study together to differentiate between the two hypotheses that have been proposed to explain why velar softening is such a common sound change.

4. ACKNOWLEDGMENTS

This research was supported by NSF grant BCS-0729140 to Jan Edwards. We thank the people who took part in the study and the student Katerina Derdemezis for assistance with data segmentation and analysis.

5. REFERENCES

[1] Arvaniti, A. 2007. Greek phonetics: The state of the art. *J. of Greek Ling.* 8, 97–208.

[2] Joseph, B.D., Tserdanelis, G. 2003. Modern Greek. In: Roelcke, T. (ed), *Variationstypologie/Variation Typology*. Berlin: Mouton de Gruyter, 823-836.

[3] Newton, B. 1972. *The generative interpretation of dialect: A study of Modern Greek phonology*. Cambridge: Cambridge University Press.

[4] Trudgill, P. 2003. Modern Greek dialects: A preliminary classification. *J. Greek Linguistics* 4, 45-64.

[5] Granqvist, K. 1997. *Notes on eastern Cretan phonology: A corpus-based study*. Stockholm: Almqvist & Wikksel International.

[6] Kontosopoulos, N. 1981. *Dialects and vernaculars of Modern Greek* [in Greek]. Athens: Ekdoseis Grigori.

[7] Recasens, D., Espinosa, A. 2009. Acoustics and perception of velar softening for unaspirated stops. *J. Phonetics* 37, 189-211.

[8] Zygis, M., Recasens, D., Espinosa, A. 2008. Acoustic characteristics for velar stops and velar softening in German, Polish and Catalan. *Proc. 8th International Seminar on Speech Production* Strasbourg, 97-100.

[9] Guion, S.G. 1998. The role of perception in the sound change of velar palatalization. *Phonetica* 55, 18-52.

[10] Glasberg, B.R., Moore, B.C. 1990. Derivation of auditory filter shapes from notched-noise data. *Hear. Res.* 47, 103-138.

[11] White, S.D. 2001. *Covert contrast, merger and substitution in children's productions of /k/ and /t/*. Master's thesis, Department of Speech and Hearing Science, The Ohio State University.