Acoustic model of stress in standard Greek and Greek dialects

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Abstract

The paper compares acoustic models which predict the position of stress in bisyllabic words in Greek varieties. It is shown that while in Thessalian Greek ratios of peak amplitude and F1 are the best predictors of stress, in Athenian and Cypriot Greek these are ratios of durations and f_0. Furthermore in Cypriot Greek morphological category of the token affects the acoustic prominence of the stressed vowel.

Key words: phonetics, vowels, stress, Modern Greek, Greek dialects

Introduction and Background

Traditionally languages with lexical stress have been divided into languages where prominence is cued primarily by fundamental frequency and languages where prominence was mainly linked to loudness. This division was later re-evaluated as a distinction between languages where pitch is the only acoustic correlate of stress ("non-stress") vs. languages where as well as fundamental frequency other acoustic properties may also be used to achieve prominence ("stress") (Beckman, 1986). However, even within the category of "stress" languages, there exists great variation in the acoustic means used to mark the prominence of a stressed vowel. The hierarchies of acoustic correlates of stress may differ not only between different languages, but also across several regional varieties of the same language. Thus variation in the acoustic correlates of stress has recently been reported for British English (Kochanski et al., 2005) and Dutch (Fournier et al., 2006).

The accentuation systems of Standard Modern Greek and Modern Greek dialects are very similar and are traditionally described as "stress accent". Nevertheless, there is certain evidence that the acoustic correlates of stress in Greek dialects may differ from Standard Greek. Recent experimental studies have shown that stressed and unstressed vowels in Standard Modern Greek show consistent differences not only in amplitude, but also in duration. (Botinis, 1989, Arvaniti, 2000, Fourakis et al., 1999). Contrary to these results, Pernot (1907) found that in Chios Greek rising tone was more consistent correlate of stress than duration or amplitude. For Northern Greek dialects, Chatzidakis (1892) observed that stressed syllables become longer and the difference in duration is greater than in the Southern dialects. Northern Greek dialects also show reduction of unstressed mid vowels (cf.

Newton, 1972). Although in Athenian and Cypriot Greek, the distribution of vowels is not dependent on stress, acoustic studies showed that unstressed vowel in Standard Greek tend to have lower F1 than stressed vowels (Nicolaidis, 2003, Fourakis et al., 1999, Loukina, in press).

In this study I will attempt to explore the contribution of each of these parameters to the prominence of stressed vowels in Athenian, Thessalian and Cypriot Greek. The study is based on multiple occurrences of disyllabic words with the same vowel phonemes in both syllables (341 tokens). The tokens were extracted from spontaneous monologues recorded from speakers of the corresponding dialects in Athens, Thessaly and Cyprus and analyzed with speech-processing software.

Results

In *Athenian Greek* words with stress on the first syllable, stressed vowels were often distinguished by a higher peak f_0, higher amplitude and also longer duration than the unstressed vowel, but sometimes by only two or one of these parameters. In words with stress on the second syllable in most cases, acoustic prominence of the stressed vowels was achieved by all three of these parameters, that is a difference in duration usually co-occurred with a difference in f_0 and with a difference in amplitude. Stressed and unstressed vowels of the same phonemic category in some cases also differed in F1 although this depended on the vowel and phonetic context.

Binary logistic regression analyses showed that in Athenian Greek ratios of durations, f_0 and amplitude between first and second vowel each allowed the position of the stress to be predicted correctly in about 80% of cases. The effect of F1 was also significant, although the prediction rate was smaller than for other measures (64%). For models based on combinations of different measures, the forward stepwise analysis showed that a combination of ratios of amplitude integral and f_0 achieves better prediction rate (89.7%) than a combination of duration and f_0 or amplitude and f_0. This agrees with results by Arvaniti (2000), who suggested that amplitude integral is a better indicator of stress in Greek than duration or peak amplitude. Further contribution of F1 was found to be insignificant.

In *Thessalian Greek* words with stress on the first syllable, the stressed vowel was in most cases distinguished by a higher amplitude than the unstressed vowel, usually accompanied by higher peak f_0 and sometimes longer duration. In words with stress on the second syllable stressed vowels were most frequently distinguished by greater amplitude and longer duration, often accompanied by higher peak f_0. Stressed and unstressed /e/, /o/ and /a/ also showed consistent difference in F1.

Models based on ratios of peak amplitude, F1 and duration separately correctly predict the number of correct syllables at above the chance level.

The model based only on ratios of f_0 performed at the chance level. The forward stepwise method showed that only the ratio of peak amplitudes and the ratio of F1 are good predictors (91.3%), while ratio of durations and ratio of f_0 do not improve the model. This provides experimental support for the numerous impressionistic observations that stress in Northern dialects may be "stronger" or "more dynamic" than in Athenian Greek (Chatzidakis, 1892, Tzartzanos, 1909). Unlike Athenian Greek, in Thessalian Greek substitution of the ratio of peak amplitudes by the ratio of amplitude integrals did not lead to any major changes in the model and the effect of peak amplitude still remained significant.

In *Cypriot Greek* words with stress on the first syllable, the stressed vowel usually had a higher amplitude and a higher peak f_0, but it was often shorter than the unstressed vowel. In words with stress on the second syllable the stressed vowel was longer than the unstressed vowel but there was no difference between amplitudes or peak f_0 of the vowels. There was no consistent difference in F1 between stressed and unstressed vowels.

Models based on ratios of amplitude, duration or f_0 separately correctly predict the position of stress in about 65% of cases. The model based on ratios of F1 failed to predict correct position of stress above the chance level. For models based on a combination of parameters, the model based on f_0 and amplitude integral achieved a similar result to the model based on amplitude, duration and f_0 and correctly classified 73.6% of cases.

The relatively poor performance of the classifier is due to the fact that words in Cypriot Greek in general showed similar acoustic patterns regardless of stress location: peak amplitude and peak f_0 on the first vowel and maximum duration on the second vowel. Changes to this pattern would usually indicate that this vowel is stressed.

There were also a number of cases where the stressed vowels probably were not assigned acoustic prominence or acoustic prominence was expressed by other means not considered in this analysis. Analysis of Cypriot Greek data showed stressed vowels in nouns were more likely to be acoustically prominent than the stressed vowels in adjectives or adverbs. As a result, the predictive power of the model in Cypriot Greek could be substantially increased by introducing morphological category ("noun vs. other") as one of the parameters. This model correctly predicted the location of stress in 79.3% of cases. The introduction of morphological category did not improve the model in the other two varieties.

Further observations refer to the overall success rate of the models. In Thessalian Greek even less successful models achieved prediction rate of 80% if they included peak amplitude or amplitude integral. This suggests that amplitude is a very robust acoustic correlate of stress in this variety. In Cypriot Greek even the best performing model correctly predicted only 80%

of the data. These results corroborate previous impressionistic observations by Menardos (1894) that Cypriot Greek allows several words to be combined into one phrase with one main stress.

Conclusion

Analysis of Modern Greek dialects also provides further evidence for heterogeneity within the traditional category of "stress" languages. The comparison between the acoustic correlates of stress in three varieties of Modern Greek confirmed that lexical stress is not always associated with acoustic prominence and the acoustic stability of stress may differ across the varieties. These varieties present very few differences in the position of stress, which suggests that the acoustic correlates of stress are not necessarily related to the phonological function of stress.

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