

Prosodic Interactions on Segmental Durations in Greek

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Abstract

The present study is an experimental investigation of the effects of prosodic variables on segmental durations in Greek. Nonsense disyllabic CVCV words were produced in a carrier sentence under different conditions of stress, focus and tempo. The results indicate: (1) the intrinsic durations of vowels are rather canonical in the order /iu<eo<a/; (2) the adjacent consonant /s/ shows complementary duration tendencies; (3) stress has bigger effect on the vowel than the consonant; (4) focus has no major effects; (5) tempo has also bigger effect on the vowel than the consonant. In summary, stress has a bigger effect on both consonant and vowel durations than tempo whereas the effects of focus are in question.

1. Introduction

This study is an experimental investigation on segmental durations under different conditions of stress, focus and tempo in Greek. The following questions have been addressed: (1) what are the duration correlates of different vowel categories? (2) what is the effect of different vowels on adjacent consonants? (3) what are the effects of the prosodic categories of stress, focus and tempo on CVCV segmental durations? Finally, a general question concerns prosodic typology and language-specific characteristics of Greek.

Considerable knowledge has been accumulated on prosodic effects on segmental durations. On the one hand, vowels do have different durations which mainly depend on high-low vowel articulations, e.g. [1]. On the other hand, stress, focus and tempo may have variable effects on both consonant and vowel segmental durations, e.g. [1], [2], [3]. However, neither the effects of vowel durations on adjacent consonants nor prosodic interactions on segmental durations have drawn particular attention, which is the main contribution of the present investigation.

There are a variety of factors which determine the duration of segments in speech production. Linguistic factors are related to segmental (referred most usually as “intrinsic” or “microprosodic”) and prosodic effects. Segmental effects may involve articulation gestures such as manner and place of articulation: e.g. other prosodic effects being equal, low vowels (i.e. /a/) are

longer than mid vowels (i.e. /e/ and /o/ which, in turn, are longer than high vowels (i.e. /i/ and /u/. Prosodic effects, on the other hand, apart from stress, focus and tempo investigated in the present study, may involve syllable structure, rhythmic structure, syntactic structure and discourse structure, among other linguistic structures, which is outside the scope of this investigation.

Regardless of intrinsic durations of different segmental categories, which is a study for its own merits, a general question is the intra-language as well as the inter-language effects of different prosodic categories on segmental durations. What is, e.g. the effect of stress on vowels vs. consonants or on consonants with different voice, manner or place of articulation? How does this stress effect varies among languages with similar or different to various degrees prosodic structure? Aspects of these questions appear regularly in the international prosodic literature but, still, a deep understanding, especially on interaction effects of different prosodic categories, would contribute to prosodic and linguistic theory and pave the way for powerful prosodic models as well as diverse technological applications such as speech synthesis and speech recognition.

2. Experimental procedures

The speech material of this investigation consists of a set of nonsense key words in the carrier sentence “the club ___ plays good music” in Greek (i.e. “to 'klab ___ 'pezi ka'li musi'ki”). The key words have a CVCV syllabic structure with a constant segmental set up except for the first vowel which may be an /i/, /e/, /a/, /o/ or /u/, i.e. /s{i,e,a,o,u}sa/.

The speakers are four female adults with standard Athenian pronunciation who produced the sentences, and thus the key words, with alternative stress patterns (i.e. first or second syllable stress), two tempi (i.e. normal and fast) six times each production. The key words were also pronounced in two focus conditions, i.e. in focus and non-focus. The non-focus productions were pronounced more or less “neutrally” i.e. the speakers had no contextual information. The focus productions, on the other hand, were pronounced as a

response to a question, which elicited the key word as the information required by the question. Thus, the stereotypical (and constant) question “which club plays good music” was defining the contextual frame for a focus production of the key word, i.e. “the club {focus production of the key word} plays good music”.

The speech material was recorded in a sound-treated room and some basic instructions were provided just before the recordings. No particular difficulty was observed and very few mispronunciations were produced. Speakers varied the prosodic conditions, especially tempo, at an individual basis, in accordance with their speech habits. The speech analysis was carried out at the Phonetics Laboratory of the University of Athens.

3. Results

The results are based on measurements of all CVCV segments (the first V referring to /i, e, a, o, u/ vowels) under the conditions of stress, focus and tempo x 4 speakers x 6 productions in accordance with the experimental procedures. The results were subjected to ANOVA (analysis of variance) statistical processing with the statistical package StatView and presented in figures. The following conventions are used: C=consonant, i.e. the fricative /s/ at both first and second syllable; V=vowel, i.e. five vowels in first syllable but only /a/ in second syllable; S1=first syllable; S2=second syllable; W=word, i.e. five words corresponding to five vowels of the first syllable; +S/-S=+stress/-stress, +F/-F=+focus/-focus.

3.1. Effects of vowel category

Figure 1a shows the effects of vowel category on word durations. All five words do roughly have the same duration and thus there were no significant effects. This is an indication that intrinsic vowel differences of the first syllable are compensated at word level durations.

Figure 1b shows the effects of (first syllable) vowel category on first syllable durations. Although there are some minor differences there were no significant differences, which indicates that intrinsic vowel differences are compensated even at syllabic level.

Figure 1c shows the duration of each of four segments for each vowel in the first syllable. There were significant vowel category differences as well as significant effects on adjacent consonants, especially the prevocalic one. All five vowels had different intrinsic durations in the order /i<u<e<o<a/. Grouped along the high~mid~low articulations, differences reached a significant level ($p<0.0001$) producing the order /iu<eo<a/. The effects of vowel category were carried over on the prevocalic (intrasyllabic) consonant, in a complementary distribution pattern, with significant differences between /i/ and /e,o,a/ but also on the postvocalic (intersyllabic) consonant between /i/ and /u/

(at least at $p<0.05$ level). There were no significant effects on the final vowel which had no noticeable duration differences.

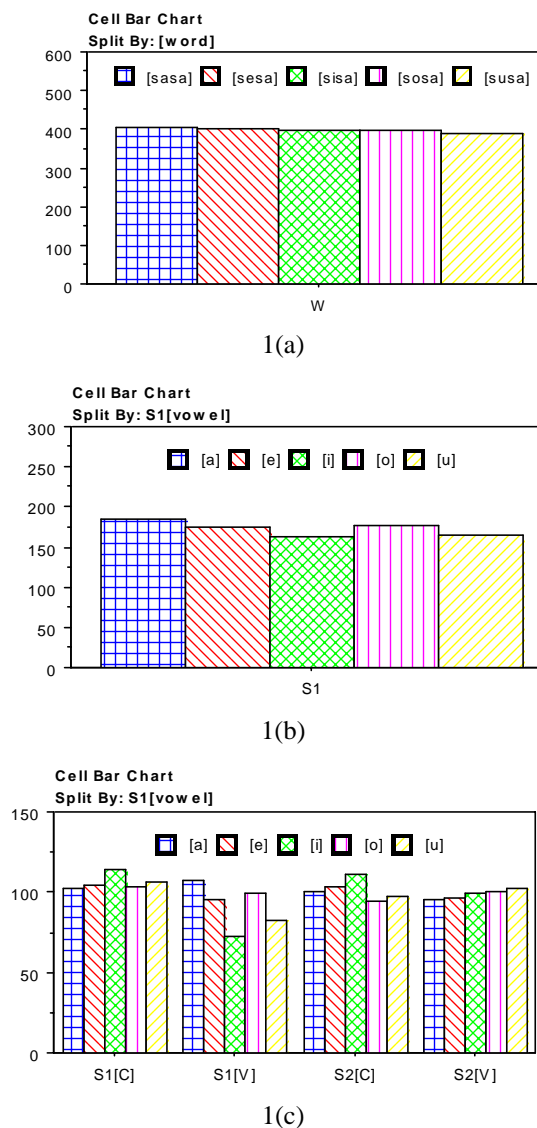


Figure 1. Word, syllable, segment durations (a,b,c).

3.1.1. Vowel category and prosodic interactions

Figure 2 shows the durations of the five different words in the two tempo conditions. Words at fast tempo were shorter than at normal tempo regardless of the vowel in the first syllable. Figure 3 shows vowel durations in stressed and unstressed syllables. There was a consistent effect of stress, with all unstressed vowels being shorter than stressed vowels ($p<.001$). Figure 4 shows vowel durations at normal and fast tempo. Vowels produced at fast tempo were shorter than vowels produced at normal tempo ($p<.01$) but there was a significant interaction between vowel category and tempo, because the difference for the vowel [u] was not significant. Figure 5 shows vowel durations when the word was

produced in focus versus non-focus. There were no significant effects or interactions.

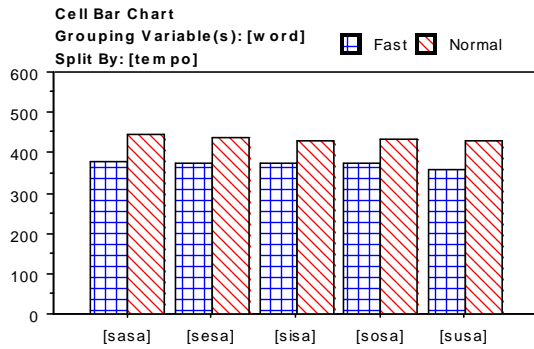


Figure 2. Word durations at fast and normal tempo.

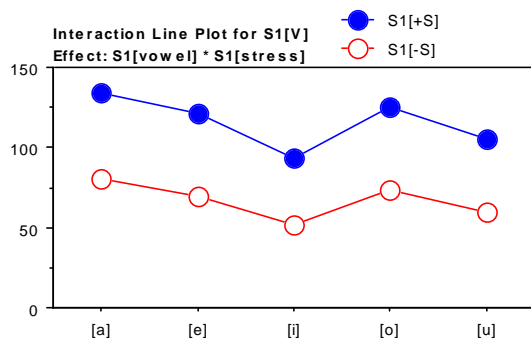


Figure 3. Stressed and unstressed vowel durations.

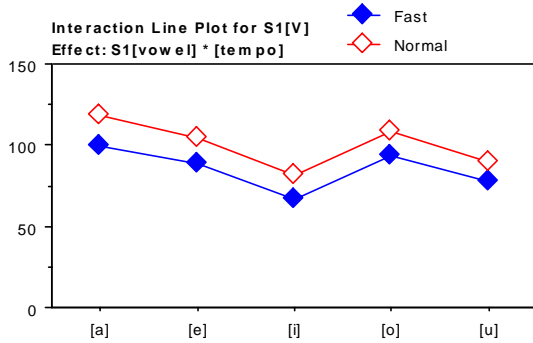


Figure 4. Vowel durations at normal and fast tempo.

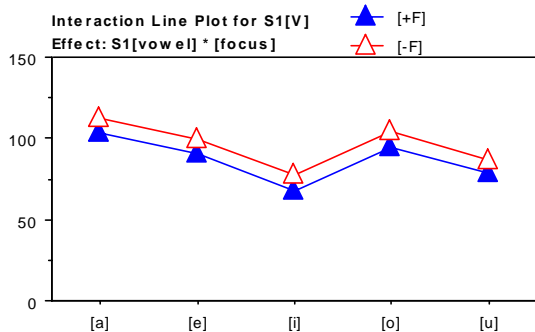


Figure 5. Vowel durations in focus and non-focus.

3.2. Interactions: Effects of tempo, stress and focus on the segments of the first syllable.

Figure 6 shows the effects of stress, tempo, and focus on the durations of the word initial consonant. There was a significant main effect of stress ($p < .01$). Initial consonants were shorter when their syllable was unstressed than when it was stressed. There was a significant effect of tempo ($p < .01$). Initial consonants at fast tempo were shorter than at normal tempo. There was no significant effect of focus ($p > .05$). There was a significant interaction between tempo and stress ($p < .01$). Initial consonants were not affected by tempo when belonging to an unstressed syllable.

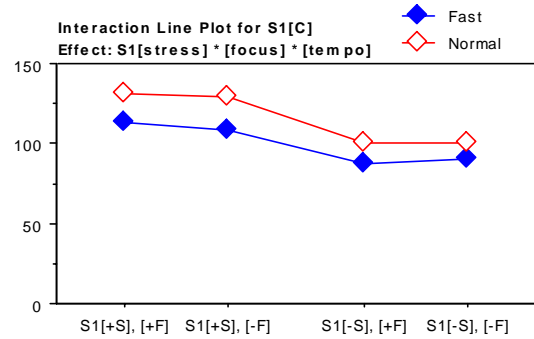


Figure 6. Consonant duration as a function of tempo, stress and focus.

Figure 7 shows the effects of stress, tempo, and focus on the durations of the vowel in the initial syllable. There was a significant main effect of tempo as discussed above for Figure 4, but this effect was mostly concentrated on stressed vowels, as there was a significant interaction between tempo and stress. Only stressed vowels shortened significantly going from normal to fast tempo. Unstressed vowels were not affected. This is indicative of the incompressibility effect as per Klatt [4]. There was no significant effect of focus.

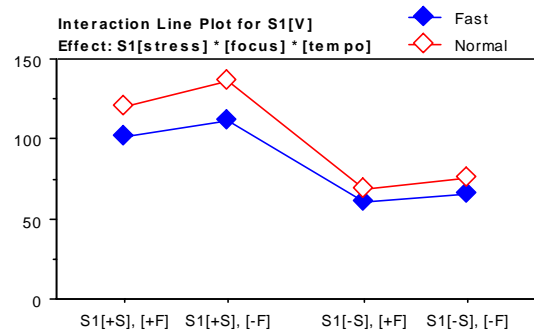


Figure 7. Vowel duration as a function of tempo, stress, and focus.

4. Discussion

The main results indicated that different vowel categories have different durations, i.e. "intrinsic" durations in Greek. This is regularly referred to in the international literature and has even been suggested as a universal. Furthermore, the consonant has a negative co-variation tendency with its co-syllabic vowel, i.e. the consonant-vowel durations seem to be in a complementary distribution. On the other hand, the prosodic categories of stress and tempo have a significant effect on both the first syllable consonant and vowel, but focus does not. Focus in Greek is mainly correlated with a local tonal expansion in combination with a global reorganization of tonal structure, especially a post-focal tonal flattening (see [2]).

With reference to other languages, both similarities and dissimilarities at segmental durations and prosodic effects have been reported. For Standard German, e.g., Bannert [5] studied temporal and tonal interactions on vowels and consonants in stressed syllables of disyllabic words. Focus had no significant effect on vowel or consonant durations; yet there was a large increase of the tonal maximum in the stressed syllable of the word in focus, which indicates that the main correlate of focus in German is a well-defined tonal structure which is rather autonomous in relation to duration structure. In this respect, focus has basic typological similarities in Greek and German.

Standard Swedish, on the other hand, shows a different typological pattern. Bannert [6,7] investigated the effect of focus on stressed VC-sequences in Swedish where quantity is expressed by length contrast in stressed sequences /V:C/ vs. /VC:/. There were significant interactions between focus and length distinctions as the long segments, but not short ones, were significantly lengthened by focus application. The other – and most concentrated upon – acoustic parameter of focus is a tonal manifestation in the form of a separate tonal gesture following the word accent. Thus, a lengthening effect of focus is evident in the syllable preceding the syllable where the tonal signaling of focus is realised. In other words, in Swedish the local domain of focus is the word and not only the stressed syllable like in Greek and German.

In a contrastive study of prosodic effects on segmental durations with variable consonant structure on syllable onset, stress had an increase effect, most in the vowel, in both Greek and Swedish whereas focus had an increase effect in Swedish but not in Greek. Furthermore, there were significant interactions between tempo and stress in Greek as well as between tempo and length distinctions in Swedish [8]. This is an indication that a shift from normal to fast tempo results in a significant shortening of "longer" rather than "shorter" segments.

Bannert and Czigler [9] investigated the durational variations of consonants in Swedish as singletons and in clusters and basic duration data are presented in variable prosodic conditions. Focus had a significant effect on consonants with different manner of articulation and voicing: /p, t, k, s, n, l/ had longer durations in word-initial, word-medial and word-final positions as singletons as well as in clusters of two or three consonants. Thus, focus has an increase effect on segment durations in Swedish but not in Greek or German, which is a major typological characteristic among these three languages.

5. Conclusions

With reference to the questions put in the introduction the following conclusions have been drawn: (1) The Greek vowels may have different intrinsic durations which mainly depend on the high~low articulations (2) The vowels may have complementary distribution duration effects on prevocalic consonant as well as on postvocalic consonant. (3) Stress and tempo may have significant main effects as well as significant interactions on consonants and/or vowels but not focus. (4) Focus in Greek may not have segmental duration correlates much like in German but not in Swedish.

6. References

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