

# 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 Greek language-specific characteristics.

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. On the other hand, stress, focus and tempo may have variable effects on both consonant and vowel segmental durations (e.g. Botinis 1989; Fourakis, Botinis & Katsaiti 1999; Fant, Kruckenberg & Liljencrants 2000). 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.

## 2 Experimental procedures

The speech material of this investigation consists of a set of nonsense key words in the carrier sentence /to 'klab \_\_\_\_ 'pezi ka'li musi'ki/ 'the club \_\_\_\_ plays good music'. 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 key words with alternative stress patterns (i.e. first or second syllable stress), at two tempi (i.e. normal and fast), and six times each production. The key words

were also pronounced at two foci (i.e. focus and non-focus). Non-focus productions were pronounced more or less “neutrally”, i.e. the speakers had no contextual information, whereas focus productions were pronounced in “question ~ answer” pairs (Q: “which club plays good music” ~ A: “the club {word in focus} plays good music”).

The speech material was recorded in a sound-treated room and 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/) under stress, focus and tempo conditions 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 StatView and presented in figures. The following conventions are used: C=consonant, V=vowel, S1=first syllable; S2=second syllable; W=word, +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 segment for each vowel in first syllable. There were significant vowel category differences as well as significant effects on adjacent consonants. 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 (co-syllabic) consonant, in a complementary distribution pattern, with significant differences between /i/ and /e,o,a/ but also on the postvocalic 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.

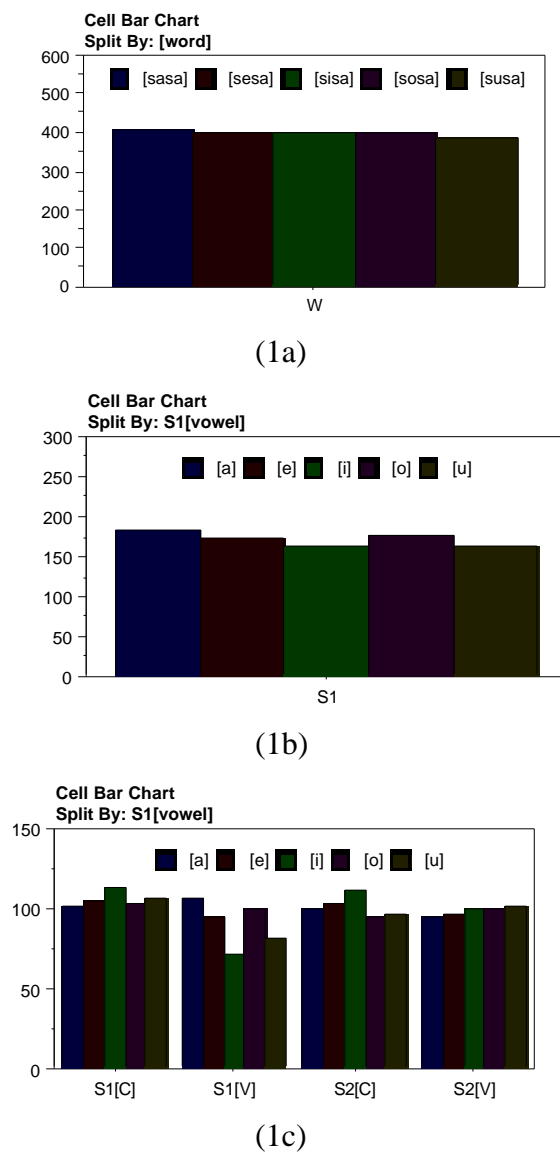


Figure 1. Word durations (a), syllable durations (b) and segment durations (c).

3.2 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.

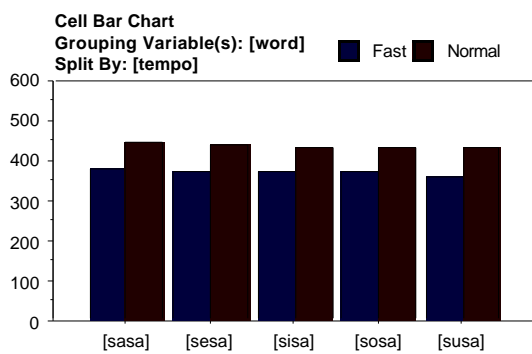


Figure 2. Word durations at fast and normal tempo.

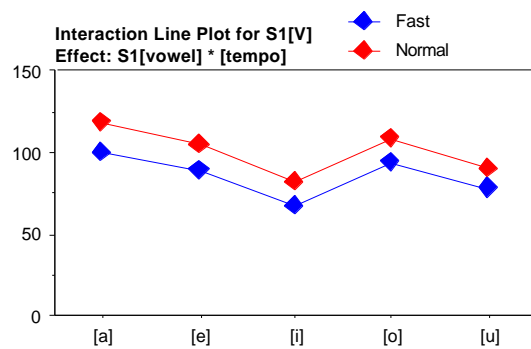


Figure 4. Vowel durations at normal and fast tempo.

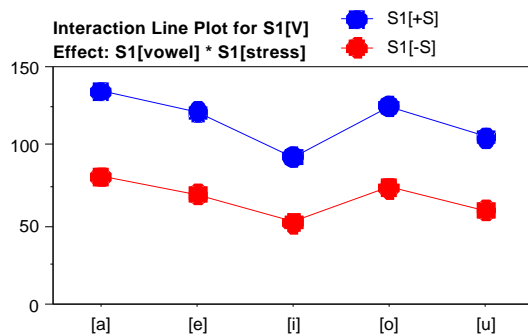


Figure 3. Stressed and unstressed vowel durations.

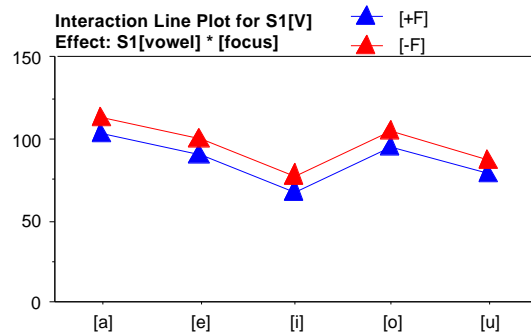
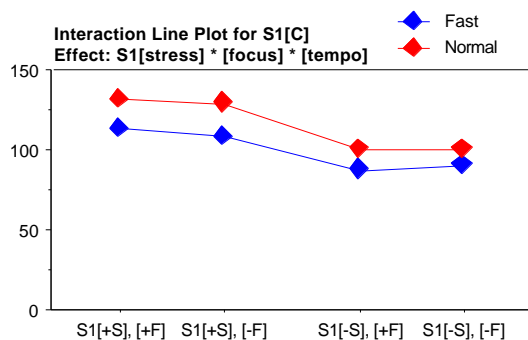


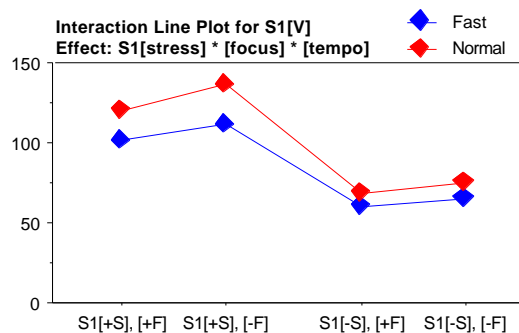
Figure 5. Vowel durations in focus and non-focus.

3.3 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.** Vowel 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 first 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 (but not unstressed) shortened significantly going from normal to fast tempo. There was no significant effect of focus.

#### 4 Discussion

The main results indicated that, in combination with different intrinsic durations of Greek vowel categories, the co-syllabic consonant has a negative co-variation 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 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 Botinis 1989; Botinis, Bannert & Tatham 2000). With reference to other languages, focus may have no effect on segment durations in German (Bannert 1982) whereas, in Swedish, focus may have a substantial increase (Botinis, Erkenborn, Isacsson & Westin 1999). On the other hand, tempo and stress may have significant interactions in Greek, which is an indication that a shift from normal to fast tempo results in a significant shortening of “longer” rather than “shorter” segments.

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