

PROSODIC EFFECTS ON SEGMENTAL DURATIONS IN GREEK

Antonis Botinis* Marios Fourakis[†] and Irini Prinou[‡]

*Department of Languages, University of Skovde, Sweden [antonis.botinis@isp.his.se]

[†]Department of Speech and Hearing Sciences, The Ohio State University, USA

[‡]Institute for Language and Speech Processing, Athens, Greece

ABSTRACT

This is an acoustic study of prosodic effects on segmental durations with reference to syllable structure, stress, focus and tempo in Greek. Disyllabic nonsense words with one, or two, or three consonants in the initial syllable were examined in stressed/unstressed, focused/unfocused and normal/fast tempo productions in a carrier sentence contexts. The results indicate that: (1) syllabic onset branching has a bigger effect on the consonant than the vowel; (2) stress has a bigger effect on the vowel than the consonant; (3) focus effects are not substantially different from stress effects; and (4) tempo has a rather even effect on consonant and vowel durations.

Keywords: syllable structure, stress, focus, tempo

1. INTRODUCTION

The present contribution is based on an acoustic experiment in Greek aiming to provide answers to the following questions:

1. What are the effects of syllable structure on segmental duration? Does syllabic onset branching trigger segmental compression or is segmental duration independent of syllable structure?
2. What are the effects of prominence, with reference to stress and focus, on segmental duration in relation to syllable structure? Is the vowel or the consonant affected most?
3. What are the effects of tempo on segmental duration in relation to syllable structure?
4. What is the interaction of prosodic effects on segmental duration?

The canonical syllable structure in Greek is the open one, with intervocalic consonants syllabified on the right as a rule. There are no syllable quantity or length distinctions and lexical stress distribution is not syllable structure sensitive, apart from Classical Greek accentuation rule effects, some of which are still preserved. Stress is however confined to the last three syllables at word level with distinctions in all major word classes.

2. EXPERIMENTAL METHODOLOGY

Nonsense test words with different syllabic structures were produced by four Greek speakers in six repetitions. The test words /'sasa/ vs. /sa'sa/ /'spasa/ vs. /spa'sa/ and /'splasa/ vs. /spla'sa/ were placed in the carrier sentence /to 'sinθima ... a'kuyete a'stio/ (the password ... sounds funny). The prosodic variability under investigation consists of three factors:

1. 3-level syllable structure, i.e. C(C(C))V
2. 4-level prominence, i.e. ±[stress] and ±[focus]
3. 2-level tempo, i.e. normal vs. fast

The syllable structure is in accordance with the Greek phonotactics. Stress was produced at either initial or final position and focus was elicited in question-answer sets whereas unfocused material consisted of declarative sentences with no preceding question. Normal tempo was produced with a comfortable speech rate and fast tempo was produced at a maximal speech rate. Greek refers to standard Athenian Greek. The acoustic analysis and related graphical displays concern the consonant [s] and the vowel [a] of the test words' first syllable with the following labeling: [1-onset], [2-onset], [3-onset] refer to single, double and triple consonantal onset of the syllable respectively; [+S], [-S] and [+F], [-F] refer to ±[stress] and ±[focus] respectively (these 2-way stress and 2-way focus sets are defined at syllable and word level respectively and thus -[S]+[F] stands for a constituent whose syllabic head is unstressed in a focused word). ANOVA and Scheffe's post-hoc statistical analysis and processing were carried out with the StatView statistical package.

3. RESULTS

Figure 1 shows the main effects of syllable structure, prominence and tempo on [s] and [a] segmental durations and Figure 2 shows prominence and tempo interactions with syllable structure.

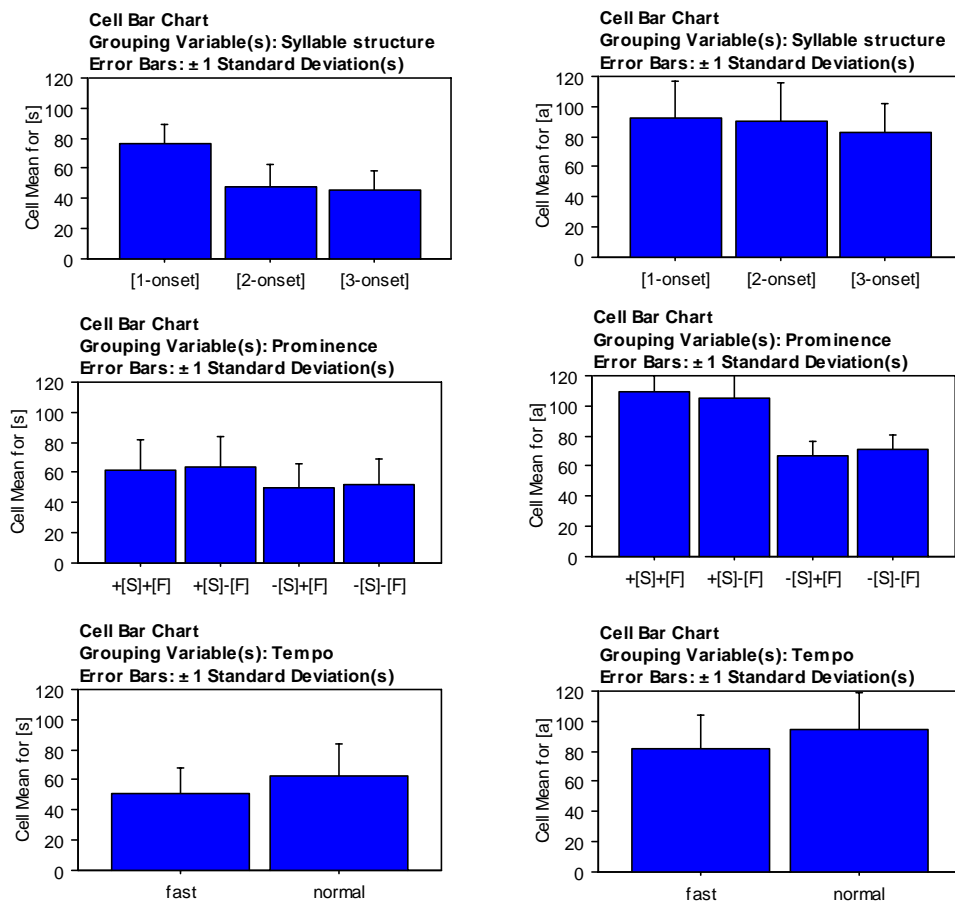


Figure 1. Prosodic main effects on Greek consonant [s] (left) and vowel [a] (right) durations: syllable structure (top panel), prominence (middle panel) and tempo (bottom panel).

3.1 Main effects

First, syllable structure has a significant effect on consonant ($F=525, p<0.0001$) as well as on vowel ($F=40, p<0.0001$) durations.

	[1-onset]	[2-onset]	[3-onset]
C	76 ms	47 ms	45 ms
V	92 ms	90 ms	83 ms

The consonant differences between [1-onset] and [2-onset], are significant ($p<0.0001$) but not between [2-onset] and [3-onset]. The vowel differences between [2-onset] and [3-onset], are also significant ($p<0.0001$) but not between [1-onset] and [2-onset].

Second, prominence has a significant effect on consonant ($F=68, p<0.0001$) as well as on vowel ($F=593, p<0.0001$) durations. Both consonant and vowel differences are significant (at the 0.0001

level) between stressed and unstressed syllables whereas focus has only vowel significant tendencies.

	+focus ≈		-focus	
	+stress >	-stress	+stress >	-stress
C	61 ms	50 ms	64 ms	52 ms
V	110 ms	67 ms	105 ms	71 ms

Third, tempo has a significant effect on consonant ($F=194, p<0.0001$) as well as on vowel ($F=231, p<0.0001$) durations.

	Normal >	Fast
C	63 ms	51 ms
V	95 ms	82 ms

Both consonant and vowel differences are significant (at the 0.0001 level) between normal and fast tempi.

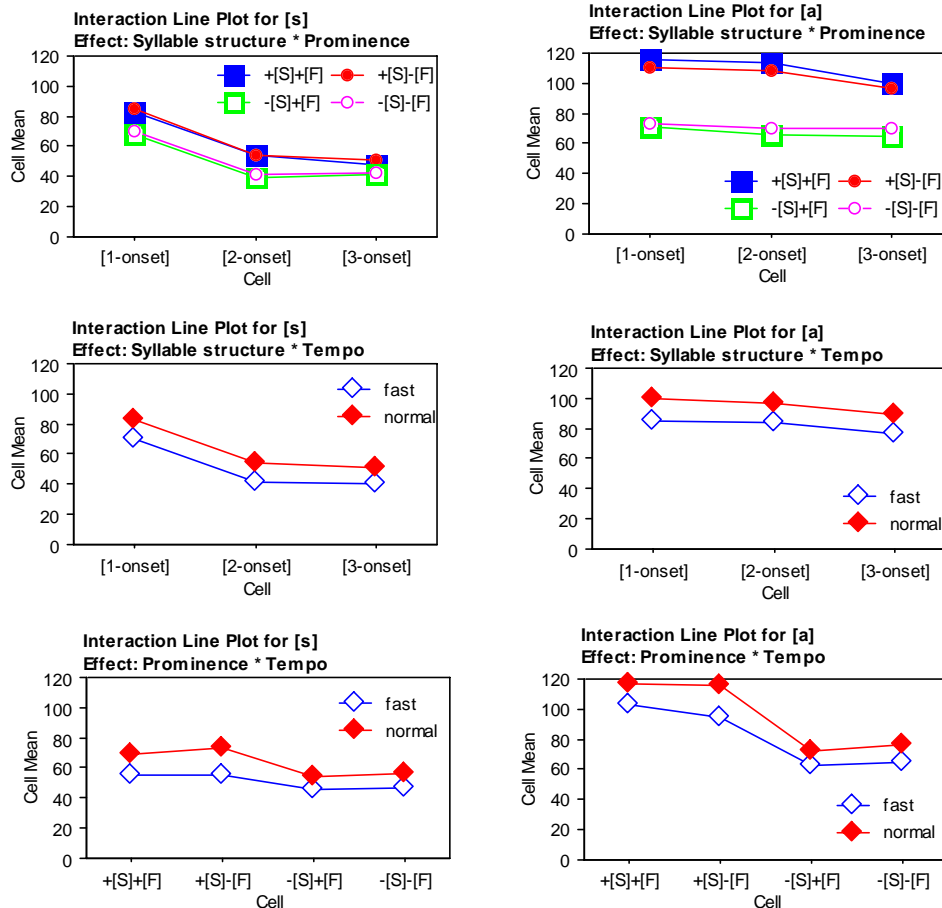


Figure 2. Prosodic interactions on Greek consonant [s] (left) and vowel [a] (right) durations: syllable structure crossed with prominence (top panel), syllable structure crossed with tempo (middle panel) and prominence crossed with tempo (bottom panel).

3.2 Interactions

There are significant interactions between syllable structure and prominence as well as between prominence and tempo for both consonant and vowel. The syllable structure * prominence interaction ($F=2.7$, $p<0.01$) on the consonant duration is due to the fact that there are no differences between the stressed and unstressed conditions in the [3-onset] condition. The prominence * tempo interaction ($F=6$, $p<0.0005$) on the consonant duration is due to the fact that there are no differences between the fast and normal tempo in the unstressed conditions. The syllable structure * prominence interaction ($F=6$, $p<0.0001$) on the vowel duration is due to the fact that the differences between stressed and unstressed syllables are much smaller in the [3-onset] condition than in the other onset conditions. The prominence * tempo interaction ($F=6.9$,

$p<0.0001$) on vowel duration is due to the fact that, similar to the consonant durations, there are not differences between fast and normal tempo in the unstressed conditions. There were no significant interactions between syllable structure and tempo for either the consonant or the vowel durations.

4. DISCUSSION

All analysed prosodic variables of syllable structure, prominence and tempo produced significant main effects on both consonant and vowel durations in Greek.

4.1 Syllable Structure

Syllable structure, and syllable onset structure in particular, has a major effect on segmental duration which is most pronounced in the consonantal part of the syllable and thus, with reference to the CV (i.e. consonant-vowel) syllabic archetype, onset

branching triggers consonantal shortening. This is a strong evidence for a higher planning control at the syllabic level, which may have concrete phonetic realisations and a direct interplay with segmental durations. Thus, the present results indicate that the temporal organisation in Greek is syllable-timed rather than segment-timed. In this sense, the duration of the syllable is subjected to syllable-level temporal constraints and is not simply defined by the linear addition of segmental durations. Segmental shortening triggered by syllable structure is constant under all investigated prosodic conditions, although significant interactions with prominence are also evident. The present results also support the onset-rhyme structural division of the syllable as the effect of onset branching is mainly on onset consonant durations. On the other hand, onset branching effects all branching elements of the syllabic head, including the vowel nucleus, which is a direct evidence for the temporal organisation of the entire syllable as a structural unit.

4.2 Prominence

Prominence, and lexical stress in particular, has a major effect on segmental duration which is most pronounced in the vocalic part of the syllable. Focus, on the other hand, in relation to the stressed syllable, has a minor effect distributed mainly on the vowel nucleus. Thus, in the present study, the main distinction of prominence is related to stress production with reference to temporal organisation. These results are in general agreement with earlier studies in Greek prosody (e.g. [1], [2], [3], [4]) according to which duration is a constant correlate for stress distinctions whereas, for focus distinctions, duration does not show a constant distribution (see [1]). In other languages however, such as English and Swedish, duration may have a substantial contribution for focus distinctions. In English, duration may even function as a strong perceptual cue and, in combination with intensity (i.e. the energy integral), has been proposed as the main perceptual correlate (see [5]). In Swedish, the effects of focus in relation to stressed syllable are approximately the same as the effects of stress in relation to unstressed syllable with a three-way (i.e. +[focus], > +[stress] > -[stress] duration distribution (cf. [6]).

4.3 Tempo

Tempo has a major effect on segmental duration and, with reference to normal tempo as the

unmarked tempo production, fast tempo triggers substantial shortening of both consonant and vowel constituents of the syllable in a rather even way. The internal syllable structure duration pattern is not affected substantially under normal and fast tempo conditions. With reference to syllable structure and prominence interactions, vowels and prominent syllables are affected most by tempo conditions. Tempo effects on segmental durations and vowels in particular are in general agreement with earlier studies in Greek (e.g. [3], [4]).

5. CONCLUSION

In conclusion, duration distribution is basically related to the vowel vs. consonant distinction as well the prosodic condition. The magnitude of duration effects in this study is, for the consonant, [syllable structure > stress > tempo] and for vowel [stress > tempo > syllable structure]. Focus does not have any substantial effects in comparison to stress either on the consonant or the vowel. Syllable structure and prominence (i.e. stress and focus) as well as prominence and tempo have significant interactions on both consonant and vowel durations.

6. REFERENCES

- [1] Botinis, A. (1989), *Stress and Prosodic Structure in Greek*. Lund University Press, Lund.
- [2] Botinis, A. (1998), Intonation in Greek. In: D. Hirst and A. Di Cristo (eds), *Intonation Systems*. Cambridge University Press, Cambridge, pp. 288-310.
- [3] Fourakis, M. (1986), An acoustic study of tempo and stress on segmental intervals in Modern Greek. *Phonetica* 43, pp. 172-188.
- [4] Fourakis, M., A. Botinis and M. Katsaiti (1999), Acoustic characteristics of Greek vowels, (to appear in *Phonetica*).
- [5] Beckman, M. (1986), *Stress and Non-Stress Accent*. Foris, Dordrecht.
- [6] Botinis, A., S. Erkenborn, C. Isacsson and P. Westin (1999), Prosodic variability and segmental durations in Greek and Swedish. *Swedish Phonetics Conference FONETIK '99*, Department of Linguistics, University of Gothenburg, (in press).