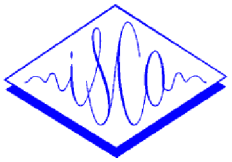

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Effects of stress on intonational structure in Greek

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Abstract

This paper presents the results of a production experiment that examines the effects of stress on the realization of tonal events in the intonation of Greek. Words in three different stress categories—final, penultimate and antepenultimate stress—were examined in two different prosodic positions: at the edge of an intermediate phrase and in phrase medial position. The results show that stress position affect the alignment and scaling of tones at the edge of an intermediate phrase but not in phrase medial position. Moreover, a phrase final word showed considerably longer duration than the same word in phrase medial position.

1. Introduction

This paper deals with the effect of stress position on the phonetic realization of tonal events in Greek. It is based on the analysis of the prosodic and intonational structure of Greek in GRToBI [1], [2] within the framework of autosegmental metrical phonology [3], [4], [5]. Three levels of phrasing are recognized for Greek: the prosodic word (PrW), the intermediate phrase (ip) and the Intonational Phrase (IP). In the analyses of the intonational structure of Greek in [1] and [2], support for these three prosodic levels is provided through tonal and segmental evidence, on the basis of a corpus of spoken Greek, containing data from read text, news broadcasting, interviews, and spontaneous speech. However, as it is also remarked in [1] and [2], several questions remain open in the analysis of Greek intonation which can only be addressed through controlled experiments.

The present paper uses a controlled production experiment to investigate the interaction of phrasing and stress. Three categories of words were chosen according to the position of stress in them: *oxytones* (final stress), *paroxytones* (penultimate stress), and *proparoxytones* (antepenultimate stress). Within each stress category, the same word (*target* word) was examined (i) at the edge of an ip (*ip* condition) and (ii) in phrase medial position (*medial* condition). Note that the particular two phrasing conditions were chosen because words in them carry the same sequence of tones, a L tone followed by a H tone (showing different alignment in each condition), and are thus easier to compare.

The rest of this paper presents the experimental method and results in section 2 and concludes in section 3.

2. Experiment

2.1. Method

10 native Greek speakers read 30 sentences, repeating each one three times. In this paper I report results from two speakers, a 21-year old male and a 25-year-old female. Both are undergraduate students, and participated in the experiment for class credit. The sentences were recorded in a quiet room.

15 Greek proverbs were chosen for the *ip* condition, with the target word at the edge of an intermediate phrase. 15 corresponding sentences were constructed with the target word in phrase medial position. Proverbs were used for the *ip* condition to ensure the appropriate intonational structure for the utterances: proverbs have a semi-stylized melody, containing two intermediate phrases separated by a continuation rise. The target word was at the edge of the first intermediate phrase, which ends in a continuation rise. Greek continuation rises typically have a L* nuclear pitch accent, followed by a H^- phrase accent [1], [2], [6]. For the *medial* condition, a list of sentences was constructed so that each proverb is paired with a sentence containing the same *target* word in phrase medial position. The L*+H is the typical accent in prenuclear positions in Greek [6], [7], [8].

Stress was another parameter manipulated: Greek stress occurs in one of the three final syllables of a word [9], [10]. Accordingly, the target words belong in one of three categories: *oxytone*, *paroxytone*, and *proparoxytone*. There are five sentences for each of the three stress conditions to determine the effect of stress location on tonal alignment. Examples for the stress groups are given in Table 1.

Table 1: Examples of material in the *ip* condition: oxytone (1), paroxytone (2), proparoxytone (3). Since the sentences are proverbs, loose translations of equivalent proverbs in English are given. Target words are in bold.

1. [ton fronìmon ta **peDjà**, prin pinàsun majirèvun]
“the early bird gets the worm”
2. [òpu lalùn polì **kokòri**, arjì na ximeròsi]
“Too many cooks spoil the broth”
3.[màtja pu Den **vlèpode**, grìgora lizmoNùde]
”Out of sight out of mind”

F0 measurements were obtained from the F0 traces for several points: the syllable before the stressed one, the stressed and all post-stress syllables in the target words, as well as one or two syllables after the target word. The durations reported here have been normalized for speech rate. Since the proverbs were in general longer sentences than their non-proverb pairs, the absolute durations were not directly comparable, and therefore the normalized durations were compared. (Normalized duration = [absolute durationX speaking rate]/100. Speaking

rate = sentence duration/number of syllables in sentence.) All measurements were made using *Pitchworks* (Scicon).

2.2. Results and discussion

The differences in duration between the target words in the two phrasing conditions (*ip* and *medial*) will be presented first, followed by their tonal characteristics.

2.2.1. Duration

Across stress conditions, the final syllable of the target word lasts longer in the *ip* condition than in the *medial* condition (Figures 1A-C). The difference between the medial and the ip conditions is approximately the same across the three stress conditions: the average ratio [medial-duration/edge-duration] is 0.59 for oxytones, 0.49 for paroxytones, and 0.60 for proparoxytones. In other words, the same syllable lasts on average half as long in phrase medial position as it does at the edge of an intermediate phrase. These duration differences can be seen as the effect of phrase final lengthening, a common cross-linguistic phenomenon.

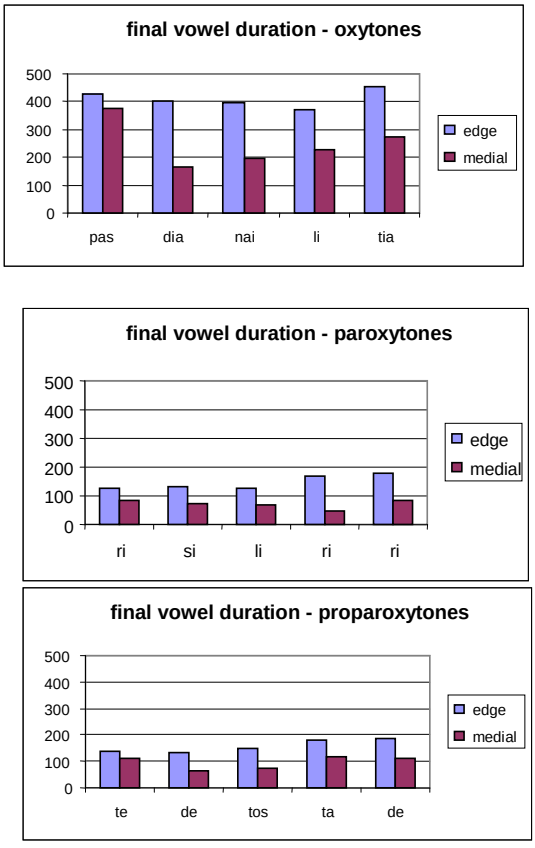


Figure 1: Final syllable duration in the phrase medial and phrase final positions. Top panel (A), oxytone words; Middle (B), paroxytones; bottom (C), proparoxytones

A further result worth noting is that final syllables in the oxytone condition are two to three times longer than syllables in paroxytones or proparoxytones. This is partially due to stress: Stressed vowels in Greek are on average 40% longer than unstressed vowels [11]. This duration difference is even bigger in the experimental material because the segmental makeup of the syllables is different in each condition. In particular, many of the final syllables in the oxytones contain the vowel [a], the longest of Greek vowels (~90ms for stressed [a]), whereas all of the final syllables in the paroxytones contain the vowel [i], the shortest of Greek vowels (~45ms for unstressed [i]) [for a discussion of Greek vowel characteristics see [11], [12], [13].

2.2.2. Tones and stress

Recall that the sequence of tones is the same in the *ip* and *medial* conditions, a L followed by a H, and that their alignment pattern is different. A target word in the *medial* condition carries a bitonal L*+H pitch accent aligned with the stressed syllable of the target word—the typical accent in prenuclear positions in Greek [2], [7], [8]. The phonetic realization of this bitonal in canonical conditions—that is, if there are at least two unstressed syllables between consecutive L*+H accents—is that the L aligns at the very beginning or slightly before the onset of the accented syllable, and the H early in the first post-accentual vowel. On the other hand, a target word in the *ip* condition carries two different tones: a L* nuclear pitch accent, commonly used in continuation rises, which is phonetically realized as a low plateau aligned with the stressed syllable, [2], [6], and the H^- phrase accent, marking the boundary of the intermediate phrase [1], [2], [6].

In the figures below, I show F0 for the syllable before stress and all the syllables after it until the first or second syllable of the word following the target word. The results presented in the figures and tables are from the female speaker. The results from the male speaker are similar but are not shown because of space limitations.

Figures 2A-C show oxytone, paroxytone, and proparoxytone words respectively in the *medial* condition. In all three, the L* part of the L*+H accent is at or near the onset of the accented/stressed syllable. For 15% of the tokens, the lowest point of the bitonal occurs before the onset of the stressed syllable. The average distance in those cases is 8 ms before the onset of the stressed syllable.

The H tone aligns with the first post-accentual vowel, approximately 34 ms after the onset of the post-accentual vowel (Table 2). There is no difference in the alignment across the stress conditions. This is so even for oxytones where the post-accentual vowel belongs to the following word (Figure 4A). This suggests that Greek intonation does not mark word boundaries because then bitonals would not span two words and there would be tonal crowding at the edge of oxytones. One more characteristic of the H tone is that it aligns with the post accentual vowel regardless the duration of the stressed syllable. This supports the claim in [7] and [8] that the H is anchored on a segmental target and does not occur at some fixed distance from the L*.

Table 2. Average distance of the H tone of the L*+H bitonal from the onset of the post-accentual vowel.

	average	**STDV**
Oxytone	36.75 ms	4
Paroxytone	31.50 ms	6
proparoxyt	36.25 ms	3

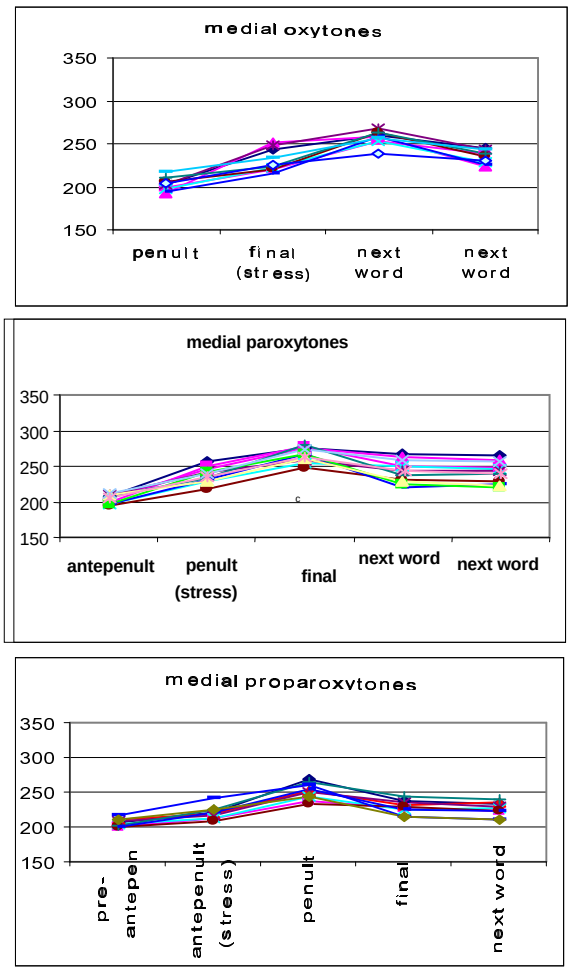


Figure 2. Top panel (A), oxytone words in phrase medial position; middle panel (B) paroxytone words; bottom panel (C) proparoxytone words.

The scaling of the two parts of the bitonal is shown in Table 3. Both tones are realized at a fairly constant pitch, across stress conditons. The L* shows the least variability.

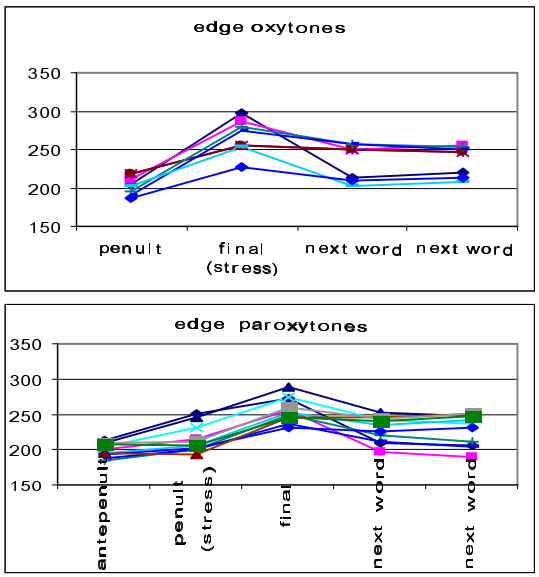
L*	**average**	**STDV**	**range**
Oxytone	203	7	193-217
Paroxytone	207	10	195-227
Proparoxyt	206	6	200-217
H	**average**	**STDV**	**range**
Oxytone	258	8	239-268
Paroxytone	262	14	242-280
Proparoxyt	251	11	234-268

Table 3: Scaling of the L* and H parts of the bitonal accent in the three stress conditions.

Figures 3A-C show oxytone, paroxytone, and proparoxytone words respectively in the *edge* condition. The L* nuclear pitch accent displays variable alignment. Its alignment is atypical in oxytones because of tonal crowding: the whole movement of the L* nucleus and the H- phrase accent must be realized within the same syllable. In 60% of the tokens, the L is pushed leftwards towards the left edge of the stressed syllable and in 40% of the tokens it is pushed even further left—on average 15ms before the onset of the stressed syllable. A similar but less pronounced effect can be observed for paroxytone words. That is, the L* is pushed towards the left edge of the stressed syllable but does not escape the stressed syllable except for a couple of tokens. In proparoxytone words, the word edge is two syllables away from the stress and the L* nucleus is fully realized in the middle of the stressed syllable (Figure 3C).

On the other hand, the alignment of the H^- phrase accent is invariable. It always occurs at the right edge of the final word of the intermediate phrase. The alignment of the phrase accent here is different from the alignment of phrase accents in polar questions in Greek, [14], [15], [16], where there is more variability in the anchoring point. This may be due to the different position of the phrase accent in the Intonational Phrase: the phrase accent of polar questions is in final position in the Intonational Phrase and it is followed by a boundary tone, whereas in this experiment the ip—and its phrase accent—is not final and not followed by a boundary tone. Perhaps in such a position where the phrase accent alone demarcates the edge of the phrase, without the presence of a boundary tone, it has less freedom to move.

Finally, returning to the effects of stress on the structure of the ip, in the oxytones, there is a sharp rise from the L* to the H^-, whereas in the proparoxytones, there is sagging observed between the two tones since there intervenes one syllable between the two tones.



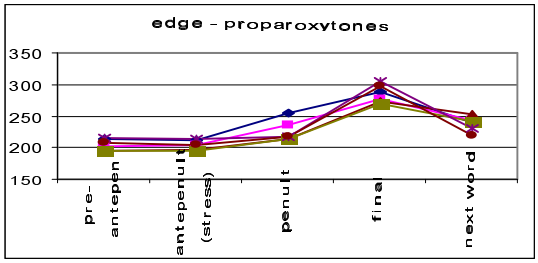


Figure 3. Top panel (A), oxytone words in phrase edge position; middle panel (B) paroxytone words; bottom panel (C) proparoxytone words.

The scaling of the L* nuclear pitch accent and the H- phrase accent are more variable than the tones in the bitonal L*+H (Table 3). The H- phrase accent is on average 14 Hz higher than the H part of the L*+H bitonal.

L*	**average**	**STDV**	**range**
Oxytone	199	11	186-219
Paroxytone	213	17	194-251
proparoxyt	206	7	195-212
H-	**average**	**STDV**	**range**
Oxytone	263	23	227-297
Paroxytone	254	15	231-289
proparoxyt	282	14	265-305

Table 3: Scaling of the L* and H parts of the bitonal accent in the three stress conditions.

The highest values for the H- phrase accent are found in proparoxytone words, which are on average realized 30Hz higher than paroxytones and 20 Hz higher than oxytones. This may be because in proparoxytones all the tones have the time to be fully realized whereas the tonal crowding in the other two stress conditions results in tonal undershoot. Furthermore, the high variability in the realization of the H- phrase accent in oxytones may be the result of undershoot in the sense that in this case we observe the least rule-governed behavior.

Finally, there is more variability for the H- phrase accent than for the L* nuclear pitch accent, a phenomenon observed cross-linguistically.

3. Conclusion

Across stress conditions, there were consistent differences between the words at the edge of an ip and words in phrase medial position.

At the edge of the ip, stress affects the alignment of the L* nuclear accent: there is canonical alignment when there is one syllable between the stressed one and the edge, but as the stressed syllable is found nearer the edge, tonal crowding pushes the L* further to the left, as far as a few milliseconds before the onset of the stressed syllable. On the other hand stress position does not affect the alignment of the H- phrase accent, but it does affect its scaling: in cases of tonal crowding there is more variability on the F0 values this phrase accent. In phrase medial position, stress does not affect the alignment of the prenuclear L*+H pitch accent. The local minimum F0 is consistently located at the onset of the stressed syllable and the local maximum in the post-accentual vowel.

4. References

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