TEMPORAL DETERMINANTS OF PHRASING IN COORDINATED STRUCTURES IN GREEK

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ABSTRACT

This study examines the temporal characteristics of utterances, phrases, words and segments in coordinated structures with different phrasings in Greek. Eight speakers (4F, 4M) produced utterances with proper names (henceforth N) coordinated by [ce] 'and' in three phrasing conditions [N+N+N], N+[N+N], and [N+N]+N, in normal and fast speech rates. Ns were disyllabic or trisyllabic with penultimate or antepenultimate stress. Results show that phrasing and speech rate influenced different measures. Preboundary lengthening affected the phrase-final word, with largest lengthening on the phrase-final syllable, but extending up to the stressed syllable and affecting segments to different degrees. Utterance, phrase, word, and segment durations were shorter in fast than in normal rate. Overall, results on the effect of phrasing on duration support previous literature on Greek and other languages showing lengthening that extends beyond the final syllable. Novel findings on temporal patterns are reported by the combined effect of phrasing and speech rate.
Keywords: prosodic phrasing, duration, pre-boundary lengthening, speech rate

1. INTRODUCTION

The syntax-prosody relationship has been established in several languages [1, 2]. Syntactic phrase boundaries can be indicated prosodically through language-specific acoustic correlates: pauses, pre-boundary lengthening, sandhi and f_0 changes are reported as cues in adult speech processing, infant acquisition and speech impairments [1-4].

However, it is still debated whether such acoustic correlates of prosodic boundaries are consistently found in speech [5] and if so, whether they are reliable cues to syntactic units [6]. It is therefore necessary to establish the existence of these prosodic correlates in a specific language before investigating their use as prosodic cues in perception.

Little work has been done on this topic in Greek. So far, there have been reports on the importance of pitch cues, pre-boundary lengthening and segmental sandhi in the parsing of relative clause attachment and other types of structural ambiguities [7, 8, 9], but their presence in speech production is less well understood.

The presence of phrase-final lengthening in speech production has been established in Greek ([10-14]) and it is reported to occur mainly in the final pre-boundary syllable but also, to a smaller degree, in non-final stressed syllables. Cross-linguistically, and in Greek, little is known about the possible extent of pre-boundary lengthening in syllables preceding the stressed one. In [15] (and references therein) it is reported that lengthening decreases the further away a syllable is from a phrasal boundary and that it is mostly rimes rather than onsets that lengthen. One question addressed here is the extent of phrase-final lengthening in Greek, by including syllables preceding the stressed one in tri-syllabic words. The π-gestures theory [16] predicts stronger effects near boundaries without room for discontinuity, i.e., skipping syllables. It is interesting to test these predictions by examining possible variation in the scope of lengthening under different conditions of stress, number of syllables and segmental content.

We also investigate how speakers manipulate the presence and duration of pauses to disambiguate structurally ambiguous phrases, another under-researched question (cf. [14]).

Finally, we look into the effect of speech rate on phrase-final lengthening and pausing. Cross-linguistically there have been reports of modifications in the prosodic organization of phrases at fast rate ([17, 18]). Although segmental duration is in general reduced at fast rate, pre-boundary lengthening still marks strong prosodic boundaries ([17]). These effects have received little attention in the Greek literature (but see [14] for a recent study).

2. METHODOLOGY

Eight native speakers of Standard Modern Greek (4F, 4M), age range 28-57, with no history of hearing or speech problems, produced structures with three proper names coordinated by the conjunction [ce] 'and' in three phrasing conditions: A: [N+N+N], B: N+[N+N], and C: [N+N]+N. Three triads of proper names were used: 1. [ˈmina ce ˈnina ce ˈlina], with disyllabic penultimate stressed Ns; 2. [maˈrina ce meˈlina ce maˈnina], with trisyllabic penultimate stressed Ns; 3. [ˈelena ce ˈartemi ce ˈlaura], with trisyllabic antepenultimate stressed Ns. Each triad was produced in the three phrasings (A, B, C), two speech rates (comfortable/normal vs. fast), and three repetitions, by eight speakers, resulting in a total of 432 tokens.

Sentences of type A phrasing form a single phrase, while sentences B and C form two phrases. The written sentences were presented to the speakers with brackets indicating the three different phrasings (A, B, C) in random order.

Recordings were carried out in a sound-treated studio with a Røde NT1-A cardioid condenser microphone. Annotations and segmentations were carried out in Praat [19]. Segmentation at utterance, phrase, word and segmental level was carried out.

We hypothesize phrasing will affect all unit durations (i.e., utterance, phrase, word, segment), with longer durations next to stronger (phrase) than weaker (word) boundaries due to pre-boundary lengthening, e.g., longer durations for the first proper name in phrasing B than in A. Furthermore, because of previous reports in the literature [11, 15], we measured all segments in each N to determine if the scope of pre-boundary lengthening extends to syllables preceding the final one. With reference to speech rate, we hypothesize that the magnitude of the durational effects will be reduced at the faster speech rate. Regarding pauses, as the conjunction ‘ce’ has a voiceless stop in onset position, the closure duration of [c] could not be distinguished from a possible preceding pause. Results are reported for this (possibly combined) interval and compared across phrasings.

Mixed model ANOVAs tested each temporal measure as dependent variable. Note the difference in stress position between triad 3 (antepenult) and triads 1 and 2 (both penult), due to which triad 3 underwent a separate statistical analysis from triads 1 and 2. Independent variables included phrasing (A, B, C), speech rate (normal, fast) as fixed factors, and speaker (1-8) as random factor. For the statistical analysis of triads 1 and 2, the additional fixed factor of interstress interval was included (i.e., the number of unstressed syllables between consecutive stresses: 2 or 3 syllables).

3. RESULTS

3.1. Utterance and word duration

Utterance duration was affected by phrasing ($F(2, 417)=63.49$, $p < 0.001$), with [NNN] utterances significantly shorter than N[NN] or [NN]N ones (Table 1), but no significant differences between the last two. The speech rate main effect was also significant ($F(1, 417)=468.64$, $p < 0.001$); utterances produced at fast speech rate were significantly shorter than those produced at normal rate (mean: 1353 ms vs. 1673 ms). There was a significant speech rate by phrasing interaction ($F(2, 417)=4.46$, $p=0.012$); N[NN] and [NN]N utterances were reduced by 20% in fast speech and NNN ones by 17%.

	Utter	N1	N2	N3	ce1	ce2
NNN	1396	356	342	421	140	139
N[NN]	1585	453	333	424	240	136
[NN]N	1558	332	441	429	140	216

Table 1: Utterance, N1, N2, N3, and conjunction ce1 and ce2 durations (ms) by phrasing; ce durations may include pause durations (see text for details).

Phrasing also affected word duration, with the first N significantly longer ($F(2, 415)=214.05$, $p < 0.001$) in the N[NN] phrasing and the second N ($F(2, 416)=135.66$, $p < 0.001$) in the [NN]N phrasing (N1 & N2 in Table 1) due to pre-boundary lengthening. There was also an effect of speech rate, with both nouns significantly longer in normal (N1: 424 ms; N2: 413 ms) than in fast (N1: 337 ms; N2: 330 ms) speech rate (N1: $F(1, 415)=291.23$, $p < 0.001$; N2: $F(1, 416)=197.38$, $p < 0.001$), but no interactions between phrasing and speech rate. As expected, utterance final Ns were not affected by phrasing (N3 in Table 1) but only by speech rate (normal: 451 ms vs. fast: 398 ms), ($F(1, 414)=84.15$, $p < 0.001$).

Finally, results for the conjunction [ce] durations, which can include pause durations, showed that the first [ce] was significantly longer in the N[NN] phrasing ($F(2, 416)=155.36$, $p < 0.001$) and the second [ce] in the [NN]N phrasing ($F(2, 416)=179.99$, $p < 0.001$) (Table 1). Speech rate affected the duration of the conjunctions (ce1: $F(1,416)=82.75$, $p<0.001$; ce2: $F(1,416)=146.72$, $p<0.001$) with significantly longer durations in normal than fast rate (ce1: normal: 198 ms, fast: 149 ms; ce2: normal: 187 ms, fast: 140 ms).

3.2. Segmental duration

Segmental duration was first examined in triads 1 & 2. Initially, we report segmental duration in the stressed and the post-stressed syllable of the first two Ns, which can occur next to stronger or weaker phrase boundaries. Due to the large number of analyses, most F and p values are included in endnotes. Phrasing had a significant effect on all segments except for the consonant in the stressed syllable of N1[i]. Since the latter was the bilabial nasal in triad 1 and the alveolar tap in triad 2, we ran separate analyses on these consonants and found a significant phrasing effect on /m/ ($F(2,130)=3.43$, $p=0.035$) but not on the tap, suggesting that preboundary lengthening is conditioned by the segmental make-up of the segmental string.

Figure 1 shows longer durations for all segments of the first N in the phrasing N[NN] (top panel, left), and of the second N in the phrasing [NN]N (top panel, right), i.e., next to a phrasal boundary in both cases, compared to the other phrasings. Segmental durations for both N1 and N2 in the other two phrasings were shorter; post-hoc tests showed no significant differences between them. For both N1 and N2, we observe the greatest lengthening on the final vowel before a phrase boundary (Figure 1 and Table 2).

	strC	strV	final_C	final_V
N1/n	4	32	16	93
N1/f	15	32	41	75
N2/n	9	26	34	99
N2/f	20	23	28	72

Table 2: Increase (%) in segmental duration of N1 in N[NN] phrasing and N2 in [NN]N phrasing in normal (n) and fast (f) speech rates for triads 1&2. % calculated in relation to the means of corresponding Ns in the other phrasings.

We also examined possible durational variation due to differences in the interstress interval, i.e., two unstressed syllables between the stressed ones in triad 1 vs. three unstressed syllables in triad 2. We report results on identical syllables in the triads, i.e., the segments of the final syllable of N1 [na] in [mina] and [marina] and the final syllable of N2 [na] in [nina] and [melina] so as to avoid the influence of inherent durational differences and related contextual effects among different segments. The duration of all segments differed significantly[ii]. Post-hoc tests showed significantly shorter segmental durations in triad 2, which has a longer interstress interval of three syllables. This was also the case for the vowel of the [ce] conjunctions which was significantly shorter in triad 2.

All segment durations were significantly shorter in fast speech[iii]. Differences in the percentage increase of segmental duration in pre-boundary position in the two rates can be seen in Table 2. A larger percentage increase for the final vowel is noted in normal than fast rate of production while greater percentage increase may be seen for some consonants in fast speech. Table 2 also shows greater lengthening effects on the vowel compared to the consonant in each syllable and a reduction in the magnitude of effects as we move away from the phrasal boundary.

Presence of a pause at phrase boundaries was examined by comparing the duration of the prevocalic interval of the conjunction [ce] in the three phrasing conditions. An effect of phrasing and rate was found (endnotes i, iii). For the first [ce], longer duration was found in the N[NN] utterances (193 ms vs. 84 for NNN and 80 for [NN]N) and for the second [ce] in the [NN]N utterances (162 ms vs. 81 for NNN and 78 for N[NN]), as expected. These large differences are interpreted to suggest the presence of a pause. Longer durations in normal than fast rate were also found (ce1: 141 vs 98; ce2: 124 vs. 87).

In order to examine the potential presence of effects beyond the stressed syllable, we ran an analysis on the segmental durations in the first unstressed syllables of N1 and N2 in the trisyllabic words (first syllables in [marina] and [melina]). No phrasing effects were found on the initial consonant. Significant effects were found on the vowel (N1: $F(1,130)=12.40$, $p<0.001$; N2: $F(1,129)=3.35$, $p=0.038$); post-hoc tests showed that duration decreased in the order N[NN]=NNN>[NN]N for N1 and [NN]N=NNN>N[NN] for N2. These results suggest that there was not a preboundary lengthening effect beyond the stressed syllable.

	strV	midC	midV	fin_C	fin_V
N1/n	17	2	13	25	82
N1/f	16	8	11	31	81
N2/n	10	12	18	26	174
N2/f	21	16	20	17	173

Table 3: Increase (%) in segmental duration of N1 in N[NN] phrasing and N2 in [NN]N phrasing in normal (n) and fast (f) speech rates for triad 3. % calculated in relation to the means of corresponding Ns in the other phrasings.

Finally, similar results were found in triad 3. Phrasing had a significant effect on all segments[iv]. Figure 1 shows longer durations of all segments of the first N in the phrasing N[NN] (bottom panel, left) and of the second N in the phrasing [NN]N (bottom panel, right). A significant effect of speech rate was also found on all segments[v] with shorter segmental durations in fast speech. Post-hoc analyses showed that significant lengthening reached the first stressed vowel of N1 only in normal rate. No significant lengthening effects were evident on the consonant of the first post-stressed syllable in either rate while for the vowel of this syllable significant effects were present only for N2. Significant lengthening effects were found systematically on both segments of the last syllable of N1 and N2 in both rates. Table 3 shows similar percentage increase in final vowel duration across speech rates, greater final vowel lengthening for N2, greater effects for vowels than consonants in each syllable and a reduction in the magnitude of effects as we move away from the phrasal boundary. Finally, regarding the prevocalic interval of [ce], longer duration was found in the N[NN] utterances for the first [ce] (173 ms vs. 100 for NNN and 96 [NN]N) and in the [NN]N utterances for the second [ce] (158 ms vs. 83 for both NNN and N[NN]), suggesting the presence of a pause. Longer durations were present in normal than fast rates (ce1: 137 vs 109; ce2: 124 vs 92).

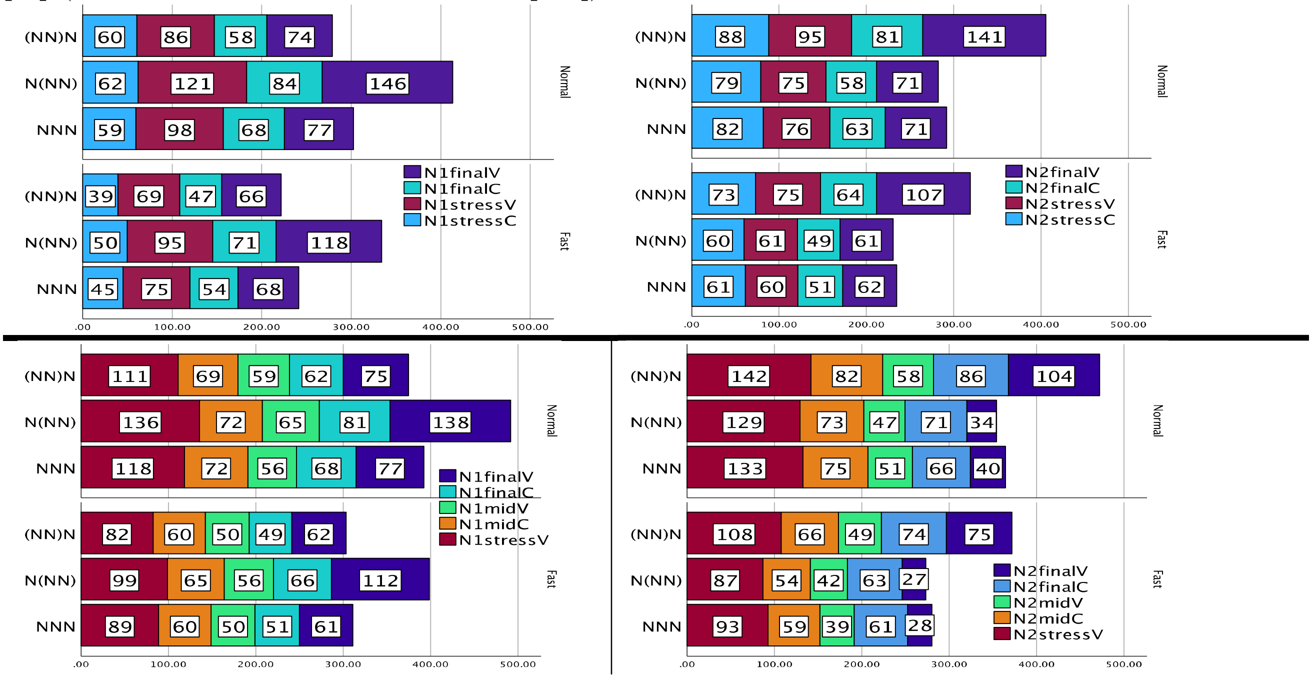

Figure 1: Triads 1, 2 (top) and 3 (bottom): N1 and N2 segmental durations by phrasing and speech rate.

4. DISCUSSION

In agreement with previous literature [10-14], this study shows that although pre-boundary lengthening affects mostly the final syllable and especially the final vowel, it extends to earlier syllables but with gradually reduced degree the further away from the boundary. Lengthening affects vowels to a greater degree than onset consonants in each syllable.

Novel evidence on the scope of pre-boundary lengthening in Greek is also provided: it turns out that pre-boundary lengthening can extend up to the stressed syllable but not to the syllable preceding it. Lengthening effects were evident not only on the stressed penultimate (e.g., on the [mi] in [ˈmina]) but also on the stressed antepenultimate syllable to some degree, i.e., only for N1 in normal rate (i.e., on the [e] of [ˈelena]). Thus, variation in the scope of effects was evident in triad 3 words. Interestingly, for N1 in normal rate, effects were not significant for the middle post-tonic syllable (typically a reduced syllable in Greek [20, 21], which may thus constrain lengthening effects) suggesting that effects can skip syllables and be attracted by stress, cf. [11, 17]. For N2, effects were not significant beyond the vowel of the middle post-tonic syllable (i.e., the [e] of [ˈartemi]). These results suggest that stress and rate modulate lengthening effects. In addition, syllable structure and segmental parameters, as discussed below, may play a role.

Novel findings are reported concerning the relationship between lengthening effects and segmental production constraints. Notably, effects varied among onsets with, for instance, presence of lengthening on a bilabial /m/ in the onset of a stressed syllable but absence of effects on a tap in the same position. Such differences suggest that segmental production requirements constrain lengthening as, for instance, it is not articulatorily possible to prolong a tap without compromising its identity.

Lengthening effects were present in both normal and fast rates of production with the magnitude of effects differing among consonants and vowels in the two rates and between triads 1/2 and 3 (Tables 2 & 3). The results suggest that lengthening still marks prosodic boundaries in fast rates; however, temporal constraints due to rate and stress result in modifications in the prosodic organization of phrases.

Finally, in addition to lengthening, phrasing was found to be marked by pauses as suggested by the results of the prevocalic interval of the conjunction [ce]. Intervals, and thus partially pauses, were also shorter in fast rates of production.

Work is underway that examines other acoustic parameters, i.e., f_0, to explore its contribution to marking prosodic boundaries in both rates of production.

6. REFERENCES

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[i] Statistical information for the phrasing factor in triads 1&2.

	N1		N2	
	F (2,267)	p	F (2,267)	p
StrC	3	=0.051	22.6	<0.001
StrV	139.42	<0.001	82.43	<0.001
Final_C	159.04	<0.001	106.19	<0.001
Final_V	368.86	<0.001	282.58	<0.001
Ce_C	116.15	<0.001	155.13	<0.001

[ii] Statistical information for the interstress interval factor in triads 1&2.

	N1		N2	
	F (1,267)	p	F (1,267)	p
Final_C	61.16	<0.001	29.21	<0.001
Final_V	40.27	<0.001	5.27	=0.022
Ce_C	2.67	=0.103	3.61	=0.058
Ce_V	286.25	<0.001	406.59	<0.001

[iii] Statistical information for the speech rate factor in triads 1&2.

	N1		N2	
	F (1,267)	p	F (1,267)	p
StrC	75.81	<0.001	170.13	<0.001
StrV	204.75	<0.001	190.34	<0.001
Final_C	133.10	<0.001	130.07	<0.001
Final_V	50.77	<0.001	61.07	<0.001
Ce_C	38.45	<0.001	81.20	<0.001

[iv] Statistical information for the phrasing factor in triad 3.

.	N1		N2	
	F (2,130)	p	F (2,130)	p
StrV	18.57	<0.001	8.92	<0.001
Mid_C	3.08	=0.049	7.91	=0.001
Mid_V	12.40	<0.001	18.22	<0.001
Final_C	46.19	<0.001	32.60	<0.001
Final_V	143.63	<0.001	114.10	<0.001
Ce_C	77.39	<0.001	61.72	<0.001

[v] Statistical information for the speech rate factor in triad 3.

5.	N1		N2	
	F (1,130)	p	F (1,130)	p
StrV	125.79	<0.001	123.78	<0.001
Mid_C	44.25	<0.001	57.73	<0.001
Mid_V	33.99	<0.001	36.24	<0.001
Final_C	80.10	<0.001	18.29	<0.001
Final_V	32.67	<0.001	21.81	<0.001
Ce_C	25.19	<0.001	26.36	<0.001