THE PRENUCLEAR FIELD MATTERS: QUESTIONS AND STATEMENTS IN STANDARD MODERN GREEK

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ABSTRACT

Within the AM model of intonational phonology, nuclear rather than prenuclear pitch accents typically monopolize our interest as the purported pivots for meaning distinctions among utterances. This paper compares, through one production and two perception experiments, the prenuclear field in statements versus polar questions in Greek, which can be string identical, differing only in intonation. Systematic differences in the prenuclear pitch accents of these two utterance types were found in both their peak alignment and scaling. Moreover, identification and discrimination experiments showed that listeners were attuned to these differences. These results underline the importance of research on the phonetics and phonology of prenuclear pitch accents and their contribution to the meaning of utterances.

Keywords: Intonation, prenuclear pitch accents, questions, statements.

1. INTRODUCTION

In the 35 years since the inception of the Autosegmental Metrical framework, e.g., [12], [13], more attention has been paid to nuclear than prenuclear pitch accents, mostly due to the assumption that the former but not the latter contribute to the distinctions in meaning among different types of sentences, for example statements vs. questions ([11] for discussion and references).

However, there is accumulating evidence for the important role that fine phonetic differences in the prenuclear stretch of string identical statements and questions play in both production and perception studies (e.g. [7], [9], [10], [11], [14]).

Among the prenuclear F0 cues reported to aid listeners differentiate statements from questions, are the presence of different Accentual Phrase boundaries at the end of prenuclear words [8], differences in the prenuclear peak scaling values [14], down-stepping [15], and differences in the slope and shape of the fall after the peak [11].

This paper adds to our understanding of the importance of the prenuclear field; it is shown that string identical polar questions and statements are perceptually and acoustically distinct even before the nuclear melody. In line with past research, we show that one cue for the distinction stems from down-stepping in questions, a strategy not employed in statements. Importantly, it is also shown that the high targets of prenuclear pitch accents are aligned earlier in questions than statements.

1.1. Melody of Greek statements and yes-no questions

The same segmental string (1) can be uttered as a statement (1a), Fig. 1, or a question (1b), Fig. 2, in Greek, depending only on its melody.

(1) [i eléni ðilóni ta onómata me molívi]
    (a) *Eleni registers the names with a pencil.*
    (b) *Does Eleni register the names with a pencil?*

Figure 1: A typical statement melody in Greek. The last word, [mo'livi] carries the L+H* nucleus, followed by L-L% edge tones.

| i | e'leni | ði'loni | ta | o'nomata | me | mo'livi |

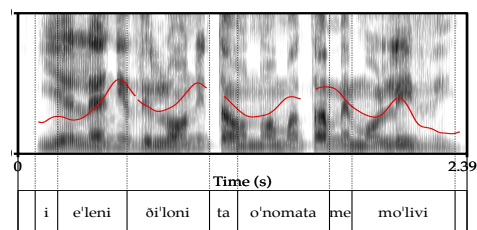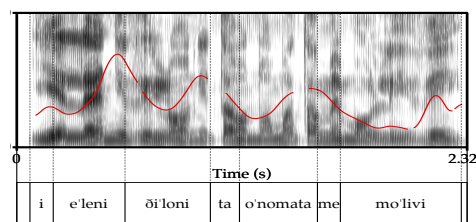**Figure 2**: A typical yes-no melody in Greek. Compare the last word, [mo'livi] with Fig 1. Here it carries a L* nucleus, followed by L+H-L% edge tones.

| i | e'leni | ði'loni | ta | o'nomata | me | mo'livi |

The melodic difference in nuclear pitch accents and edge tones between statements (L+H* L-L%; Fig. 1) and yes-no questions (L* L+H- L%; Fig. 2) is uncontroversial, described in detail in [2], [3], [4],

[5]. However, the acoustic realization and status of the prenuclear pitch accents in past reports is unclear: on one hand, it is suggested that the most frequently used pre-nuclear pitch accent is L*+H in statements, questions, and negatives, deemed the prenuclear accent par excellence in Greek [2], [3], [5]. On the other hand, there are reports of later L and earlier H alignment in polars than in statements for the prenuclear L*+H pitch accents [1], [6].

The following experiments examine the prenuclear field of statements and questions in more detail.

1.2. Experimental hypotheses

Two hypotheses are examined. *Hypothesis 1:* listeners will discriminate between string identical statements and questions if the nucleus is removed. *Hypothesis 2:* differences will arise in the phonetic details of the prenuclear pitch accents between string-identical statements and questions.

The hypotheses were tested through one production and two perception experiments. The procedure followed was: (i) speakers produced a set of string identical statements and questions (Section 2); (ii) these productions were used, after their nucleus was removed, as stimuli for an identification and a discrimination perception experiment (Section 3); (iii) successfully identified utterances were acoustically analyzed to determine the differences that enabled listeners to tell them apart (Section 4).

2. DESIGN OF STIMULI

2.1. Participants, materials and method

Twelve monolingual speakers of Greek, 27-44 years, participated in the recording of the materials (6M, 6F). No-one reported speech or hearing problems.

Ten pairs of string identical statements and polar questions, like (1) above, were designed (10 statements and 10 questions X 3 repetitions X 12 speakers). They all had four pitch-bearing constituents—three prenuclear and a nuclear one.

The realization of the Greek L*+H has been described as a gradual rise from a trough (the L tone) to a peak (the H tone). In general, the L is aligned at the very beginning or slightly before the onset of the stressed syllable, and the H early in the first post-stress vowel [2], [3], [5]. Proximity of pitch accents creates tonal crowding in SMG which results in compression, an altering of the alignment of tones; for the L*+H, two unaccented syllables need to intervene between pitch accents to avoid tonal crowding [3]. Sentences were thus constructed with at least 2 unstressed syllables between stresses.

Recordings were made together with a larger body containing other statements, polar questions and wh-questions as distractors, without any instructions given for their production.

All materials were recorded with a Beyerdynamic MC 836 short shotgun cardioid lobe microphone writing directly on a desktop computer using a Nanoface sound card set at 44100Hz sampling rate. ProRec [8] was employed for prompting and segmenting the recording.

3. PERCEPTION EXPERIMENTS

Two perception experiments tested *hypothesis 1*.

3.1. Perception materials and method

The utterances described in Section 2 were used to create the discrimination and identification experiment stimuli. 240 stimuli (10 sentences X 2 sentence modes X 12 speakers) were created by removing the nucleus (the final constituent) of the utterances. Thus, the resulting stimuli had three constituents, all carrying prenuclear pitch accents.

In an AX Discrimination task 10 listeners (5M, 5F − different to those used for the production experiment) were presented with pairs of stimuli, either identical statement-statement (ss) or question-question (qq; 120 pairs) or non-identical sq/qs (120 pairs). They were told the utterances were incomplete and their task was to decide whether the first member of the pair was the same as the second.

For the Identification task, the same listeners were presented with the initial 240 stimuli and identified each as a statement or a question.

3.2. Perception results

The perception results show high discrimination scores (d' = 2.05, range = 1.3 - 2.8), moderate identification scores (mean correct identification = 66.6%, range = 56% - 75%), and better identification in statements (75.8%) than questions (57.3%).

We interpret these results as a confirmation of hypothesis 1: The prenuclear melody was enough for listeners to discriminate between the two utterance modes despite the excision of the nucleus, suggesting that the prenuclear details contribute to the meaning of questions and statements.

The following sections of this paper present acoustic analyses of the sentences that were correctly identified by listeners in the perception experiment. We show that there are systematic differences in the prenuclear field between statements and questions.

4. PRODUCTION ANALYSIS

A subset of the utterances (60/240) described in Section 2 were chosen for the phonetic analysis, based on successful discrimination: utterances were deemed successfully discriminated if at least 8/10 listeners were able to identify/discriminate them in the perception tests. The utterances were manually segmented and labelled in Praat.

4.1. Measurements

The following measurements were performed and either repeated measures or paired-samples t-tests were used for comparisons.

The duration of all segments was measured (C0, V0 = consonant and vowel of stressed syllable; C1, V1 = consonant and vowel of post-accentual syllable), as well as the alignment of tones with respect to the segmental material (LtoC0 = Distance (ms) between L and C0 onset; V1toH = Distance (ms) between V1 onset and H).

In addition, the scaling (in Hz) of L and H points for each prenuclear pitch accent was measured as well as the F0 slope (the rise in Hz from the L to the H tone divided by their distance in time). To quantify down-stepping differences, the F0 difference between every two consecutive peaks in statements ($F0_{H1}$—$F0_{H2}$, $F0_{H2}$—$F0_{H3}$, etc) was compared to the corresponding difference in polars; similar comparisons were carried out for the L tones, resulting in comparisons among eight variables, four regarding the peaks and four regarding the troughs.

4.2. Production analysis results

Several F0 differences emerged in the prenuclear field of statements and questions, such as phrasing and the type of pitch accent present (e.g. L*+H vs. L* or L+H*). In this paper only utterances with the same prenuclear pitch accent, L*+H, in statements and polars are examined. This rising pitch accent was realized with alignment and scaling differences in the two modes, as shown below, thus confirming *hypothesis 2*.

4.2.1. Alignment

The H tone in the L*+H pitch accent aligned after the onset of V1. In questions it aligned significantly earlier than in statements (mean V1toH for statements 24ms, SD = 39ms, mean V1toH for polars 10ms, SD = 37ms, paired samples t-test: *t* (36)=2.597, *p*=.014, Figure 3). No significant difference was revealed for the L tone (mean LtoC0 for statements 21ms, SD = 22ms, mean LtoC0 for polars 21ms, SD = 26ms).

Figure 3: Mean distance (and SD) of the peak after the onset of the first post-accentual vowel across statements and polar questions.
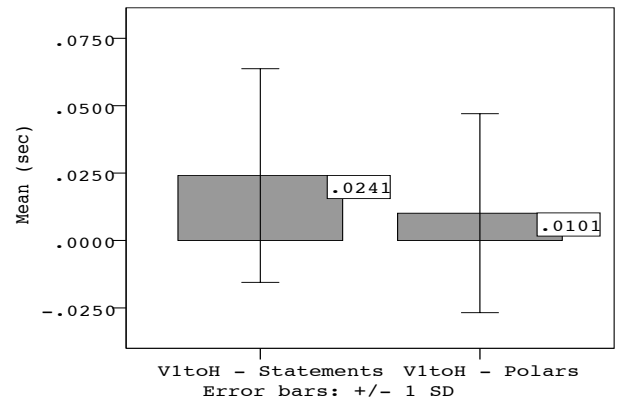
4.2.2. Slope

The slope of each pitch accent in statements was compared in a repeated measures design with the corresponding one in questions. The design tested the effect of sentence mode on the slope, treating the pitch accent (first, second or third in the utterance) as a between-subjects factor. The slope was significantly steeper in questions than in statements (repeated measures: $F(42)=30.222$, $p<.001$). Post-hoc tests (Bonferroni adjusted) revealed this difference was mainly due to the first pitch accent, which had a higher F0 peak in questions than statements, and to a lesser degree to the third pitch accent which had a lower peak in polars (Fig. 4).

Figure 4: Mean slope differences across words in statements and questions.
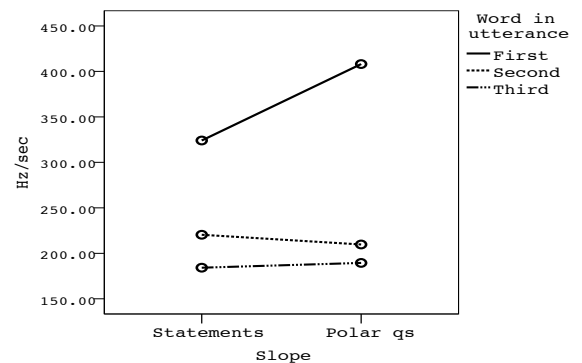
4.2.3. Down-stepping

An additional difference between sentence modes was down-stepping, which was present in polar questions but not in the string-identical statements (Fig. 5 shows an example of a pair of statement-polar question indicative of down-step).

Figure 5: Two superimposed pitch contours, one from a statement (dotted line) and one from a polar question (straight line). Contours are taken from the utterances in (1).
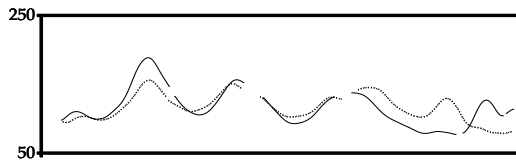
As explained in 4.1, eight measurements were computed to identify possible down-stepping. The comparison across statements and questions showed that the difference in Hz between the first peak and the second was bigger in polar questions than statements (paired-samples t-tests: $t(14)=3.506$, $p=.003$), and a similar difference was revealed between the second and third peaks ($t(14)=4.094$, $p<.001$, Table 1). Similarly, the difference between the second and third L tone was bigger in questions than in statements ($t(14)=3.470$, p .004) but not between the first and second (Table 1).

Table 1: Mean (and SD in brackets) difference (Hz) of tonal targets in consecutive pitch targets.

		Difference between 1st & 2nd pitch accent	Difference between 2nd & 3rd pitch accent
Statements	L	8.82 (4.9)	-0.9 (8.1)
	H	-21 (15.3)	-2.2 (12.5)
Polar questions	L	4.27 (10.4)	-10 (8.7)
	H	-40 (22.1)	-14.5 (12.7)

5. DISCUSSION AND CONCLUSION

The goal of the paper was to investigate whether the prenuclear field of string identical questions and statements is perceptually and acoustically distinct. As a test-bed, Greek polar questions vs. statements were used.

Systematic acoustic F0 differences emerged in the prenuclear field, which enabled listeners to perceptually distinguish between questions and statements despite the absence of the nucleus.

Specifically, the acoustic realisation of the prenuclear rising L*+H pitch accent, which is often used both in statements and polar questions was tested. Phonetically, polar L*+H pitch accents are distinct from their statement counterparts both in their alignment and their scaling. First, the H tone in the L*+H pitch accent as produced in polar questions aligned significantly earlier than in statements (10ms after the V1 onset for polars and 24ms for statements). Second, the rise in polars was steeper than in statements because the H peaks in polars reach higher F0 values than in statements and

do so earlier in time thus creating a steeper rise. Third, there was down-step in polars between consecutive pitch accents while no such strategy was employed for statements.

These differences were salient enough for listeners to discriminate between the two melodies even when the nuclear melody was excised from the utterances they heard. Recall that these utterances were string identical, so the fine alignment differences that were uncovered cannot have arisen due to any segmental influences.

More research is needed to identify the exact details that listeners attend to which help them discriminate between the two sentence modes. Do the alignment differences play as important a role as down-stepping and the steepness of the pitch accent rise? Moreover, in addition to the alignment and scaling differences detected between Greek statements and questions, we also observed differences in the slope and shape of the F0 curve, which will be examined, especially given that they have been reported to play a role in languages such as Italian [9] and German [11].

Still, it is clear that the prenuclear field allows enough information for the perceptual distinction of the two sentence modes. Further planned experiments will be instrumental in the phonological modelling of the differences that have been uncovered here. A decision must be made on whether the earlier alignment of the H tone found for the L*+H pitch accent in questions will lead to the postulation of a new phonological category, or whether this alignment difference is to be viewed as a mere phonetic detail in realization of the same phonological entity.

Overall, the results presented suggest that prenuclear pitch accents can contribute to the meaning of utterances and more attention should be paid to the detailed structure of the prenuclear field.

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