

# METRICAL REPRESENTATIONS OF DEMARCATION AND CONSTITUENCY IN NOUN PHRASES

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## ABSTRACT

This paper reports on the results of two groups of experiments conducted in order to examine the melodic correlates of demarcation and constituency in subordination and coordination structures.

Experimental material were noun phrases of the form "A of B of C of D" and "A, B, C and D" followed by a short VP. A, B, C and D were noun groups like "article + noun" or "pronoun + noun" or "pronoun + adjective + noun". The relation between grammatical structure and pitch is examined in terms of both phonological interpretation and phonetic data. Also a phonological model of intonation is proposed bearing on the results of the experimental material.

## 1.INTRODUCTION

Since the introduction of Generative grammar which put an emphasis on the hierarchical structure of sentences of a language, many studies have been made on the relation between prosody and syntax. And after Pierrehumbert's [11] innovative work on intonation a new dispute started over the extent to which pitch range organization constitutes phonological parameter or not and if accent level bears any linguistic information other than the traditional HL distinction. That is, if range and target manifestations of the pitch contour are constrained by phonological factors or free to vary according to the semantics and pragmatics of the text. The latter supposition, known as "Gradient Variability" of pitch contour parameters leaves the control of accent target, range, baseline and overall  $F_0$  level positioning to non linguistic factors. Moreover it assumes that all the above parameters can vary gradiently in order to convey semantic and pragmatic information. Gradiently means that the greater the value of a semantic attribute (emphasis, finality, etc.) the greater the variation. In this paper we provide evidence from Modern Greek that  $F_0$  range variations and positioning of  $F_0$  targets over high accents are constrained by syntax. This is in accordance with the work of others ([3], [8], [11]) in the field.

Specifically, our aim in the experiments was (1) to see if certain syntactic structures have correlates in the tonal string construction of an utterance and (2) to testify our

general observation that variability in pitch is constrained in both H\* accent positioning and pitch range over an intonation word as well as over wider phonological domains like intonation phrases.

## 2.EXPERIMENTS

### 2.1 Material and measurements

In the experiments we conducted we examined two cases, with opposing syntactic structures as well as semantic content, namely *coordination* and *subordination*. Special attention was taken to match testing sentences for total number of syllables and timing in stress. With the latter, we mean the matching in the number of unstressed syllables between successive stresses across sentences.

Noun phrases had the form "A of B of C of D" for subordination and "A, B, C and D" for coordination.

Constituents were comprised of one, two or three intonation words (IW) each, that is *article+noun* (one IW) or *pronoun+noun* (2 IW) or *pronoun+adj+noun* (3 IW). In 1-IW case all four A to D constituents were present while in 3-IW cases only A and B participated in the sentence in order to keep constant the total number of syllables.

Subjects were two male (GS, CS) and one female (KS) speakers, and four utterances with the same tonal string were kept from each subject for averaging.

The measured pitch contour parameters were:

- 1.The pitch level on H\* accents.
- 2.The difference between the lowest pre-nuclear and nuclear H value over an IW, considering it to be the pitch register width for that particular IW, in absence of a low accent.
- 3.The difference between H\* and L\*, wherever L\* accents were available.

The reason for the third measurement was to obtain an estimation of pitch register range over an intonation phrase.

### 2.2 Observations

Experiments exhibited a systematic behavior in the way subjects arranged clauses and clause internal constituents within pitch range.

In terms of tonal string representation two types of contours were observed according to the clause boundary tone:

1. Clause termination with a LL% tone following a H\* accent.
2. Clause termination with a HH% tone following a L\* accent.

The rest of the accents were H\* so that a tonal description of clauses is (we assume Pierrehumbert's notation):

$$(H^*) \left\{ \begin{array}{l} H^* L^- L\% \\ L^* H^- H\% \end{array} \right\}$$

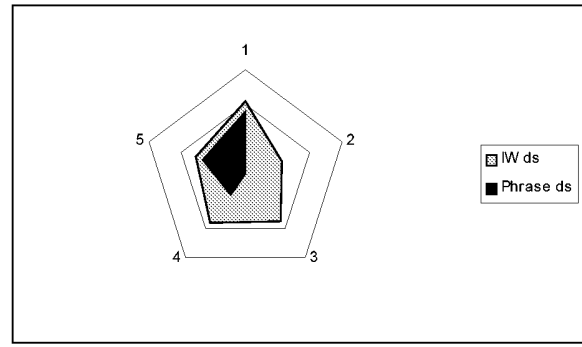
The parenthesis means zero or more accents.

From the analysis of the experiments it was evident that H\* accent declination over noun phrases must be treated in hierarchical terms. This hierarchy has been mentioned in the work of many phonologists either as a factor that should enter the phonetic implementation of pitch [8] or as separate phonological layer [5], with domain as large as a clause or phrase. Our data showed that phrase initial accents interrupted the downward trend of H\* accents of the preceding phrase. This result can of course be interpreted as a local perturbation on pitch that signals a semantic characteristic like demarcation. However from the experiments it was also clear that this interruption spreads over the rest constituents of the group. In such case we conclude that it must be treated as a clause-wide characteristic than local.

Clearly, phrase initial H\* accents exhibited a declination pattern (herein referred to as "*phrase downstep*") in their relative heights, in parallel with the declination of immediate constituents. However, phrases did not decline the same fast as their constituents as shown in fig. 1.

Moreover accent level organization was reflected in pitch range either locally (decrement of the difference between pre-nuclear low and nuclear high tones) or over larger intonation constructs (pitch register width decrement of clauses).

Finally, syntactic differences between coordination and subordination were reflected in both the structure of the tonal string and H\* accent arrangement within the pitch range.



**Figure 1:** Comparative radar plot of Phrase vs. IW downstep. Phrase downstep is always bounded by IW downstep (Values from 5 measurements).

### 3.MODELING

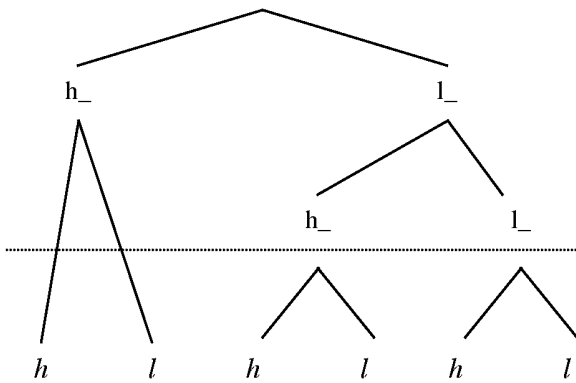
#### 3.1.Phrase downstep

References in works of others on the hierarchical organization of utterances are dated since 1988 [11] or earlier [14] referred to as "nested declinations".

Our position is that boundary tones should not be treated as producing a local interruption of a globally defined downstep but rather as signaling the beginning of a new intonation phrase which follows a declination pattern other than that of immediate constituents. As figure 1 shows there is ample evidence in our experiments for at least two downstep factors, one for immediate constituents and another for phrase groups. This distinction between downstep factors however, should not be considered only as a matter of a more elaborate phonetic implementation because what it reveals is in our sense a phonological distinction. In a tree representation of H\* accents this means that tree internal nodes should be treated differently by a Relative Prominence or Height Projection Rule (like those of Pierrehumbert [12] or Ladd [8]) as figure 2 shows for the NP of the sentence /e`kini ti `mera e`nos xi`mona e`kinu tu `etus `piya `volta/. In demonstrations following we will mark tree-internal nodes with h<sub>-</sub> and l<sub>-</sub> (as opposed to terminal h l) to show that they are parts of a different level of metrical representation.

Clearly, the introduction of two different downstep factors for internal and terminal nodes in a metrical representation not only explains our experimental results but also seems to have a further dynamic when used for the interpretation of the results of other experiments such as Ladd's *and-but* clauses<sup>1</sup>.

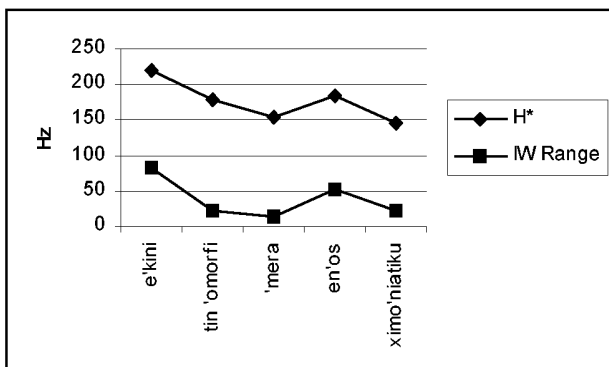
<sup>2</sup> We refer to Clement's comments on the relative prominence of B clause in contrasts of the form "(A and B) but C" vs. "A but (B and C)" [1].



**Figure 2:** Metrical tree representation of the NP of the sentence /e'kini ti `mera e`nos xi`mona e`kinu tu `etus `piya `volta/. The horizontal line distinguishes two separate downstep levels.

### 3.2 Register width variation

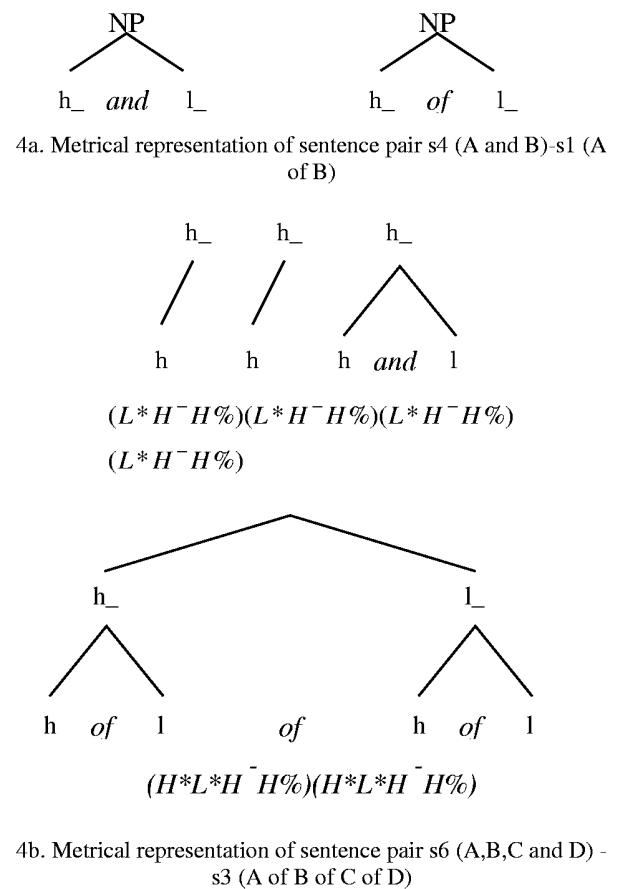
Although the need for modeling pitch register level contrasts is well established ([3], [8], [9], [10], [11]) there has been little or no mention of register width variations. In many cases register bottom coincides with speaker's pitch baseline which has been proven to follow an invariable declination [12]. In these cases we can directly deduce with no further assumptions that *F0* range variations follow the same declining scheme as *F0* peaks. However, experiments show that, *F0* baseline and register bottom do not always coincide. Constituency within a intonation group is manifested by a radical decrease in register width when moving from phrase initial to subsequent accents of the same group. We consider this behavior as a local *F0* range downstep that evolves in parallel with *F0* declination. In figure 3 it is shown the *F0* peak and range variation for the NP part of the sentence *INP*((e'kini tin `omorfi `mera) (e`nos xi`mo`niatiku `mina)) *VP*(piya volta).



**Figure 3:** Variation of H\* target values and IW pitch range for the NP /e'kini tin `omorfi `mera e`nos ximo`niatiku `mina/ with tonal string: H\*H\*H\*LL%H\*H\*L\*HH%

### 3.3 Coordination and Subordination Contrasts

Comparative examination of NPs with the same number of phrase constituents showed that generally there is no evidence for a phonetic distinction of sentences with the same bracketing structure, despite the fact that in other experiments [2] the kind of the conjunction played a role in the phonetic implementation. Metrically equivalent phrases like those in figure 4a, have the same contour either in terms of their tonal strings or in terms of accent level configuration. However in cases where the bracketing structure was not the same, subordination had the tendency to arranging constituents in groups of two accents each. For example, comparison of sentences "s3" (subordination) and "s6" (coordination) in figure 4b., shows differences in both grouping and tonal string content:



**Figure 4**

## 4. PHONETIC IMPLEMENTATION

In what follows we give a description of a phonetic realization scheme based on our observations. The scheme bears much resemblance to others proposed by Ladd [8] but it is not the same in detail because it makes provision for two separate downstep factors. The general formula that computes *F0* values is:

$$\log(F_{i,j}) = \log(F_{\min} \cdot f(d) \cdot g(a) \cdot p)$$

$F_{i,j}$  is the computed target level of the accent tone and  $F_{\min}$  speaker's baseline.  $p$  is a factor inserted in the representation to provide for pure gradient variability and can take a continuous range of values. In neutral utterances it is 1.

Any given register setting is defined as:

$$f(d) = N \cdot r^i$$

where  $i$  is a positive integer and  $r$  the register downstep factor.

An accent tone level within a specific register setting is defined as:

$$g(a) = w^{(i+1)T} \cdot a^j$$

$w$  is a predefined initial register width and  $i$  the register specification mentioned above. This counts for register width downstep.  $T$  is +1 for high accents and -1 for low accents.  $a$  defines the accent level downstep factor within a register.

## CONCLUSIONS

In the former, we tried to give a phonological interpretation and provide a phonetic realisation from instrumental data for noun phrases of modern Greek. Central point in our observations was that differences in downstep factors provide evidence for considering them as a new phonological contrast, just like the H/L distinction, that should be introduced in a phonological description of pitch

It is interesting to see that modeling noun phrase intonation as two separate declining trends (separate in the sense that they require different downstep factors) enables us to describe metrical relations with a class of hl binary trees that do not require the over-explanatory power of inverse lh pairs. Moreover, as can be seen from the following grammatical productions left-branched terminations are absent from our tree realisations. The following Context Free Grammar describes the proposed class:

$NP \mapsto h\_l\_ \mid hl$	non-terminal tree nodes
$h\_ \mapsto h\_l\_$	
$l\_ \mapsto h\_l\_$	

$h\_ \mapsto hl\_ \mid hl$	terminal tree nodes
$l\_ \mapsto hl\_ \mid hl$	

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