

# **The prosodic structure of Greek**

## **A phonological, acoustic, physiological and perceptual study**

**Antonis Botinis**

### **Summary and results**

#### **0 Outline**

This study deals with Greek prosody and is composed of four parts. In the first part (1) the phonological system of Greek prosody at the lexical level, word level, phrase level and sentence level is described and the rules to assign lexical stress, word stress, phrase stress and sentence stress to the corresponding level are presented.

The second part (2) is a report of three acoustic experiments. The purpose of experiment I was to investigate the contribution of the three acoustic parameters of fundamental frequency ( $F_0$ ), duration and intensity to the construction of word and sentence stress. Experiment II was to investigate the three parameters' contribution to phrase stress and compare the acoustic manifestation of an enclitic structure to one of a proclitic structure. Experiment III was to investigate two different syntactic structures' acoustic manifestations and examine their relation to prosody.

The third part (3) is a report of a physiological investigation of the variations of subglottal air pressure ( $P_s$ ) associated with word stress in post-focal position. The purpose of this experiment was to find out how the acoustic parameters co-vary with subglottal pressure and if

subglottal pressure affects one or more acoustic parameters, to what degree.

The fourth part (4) is a report of six perceptual experiments. The purpose of experiment I was to find out which of the acoustic parameters contributes most to the perception of word stress after focus. Experiment II was to find out which of the acoustic parameters contributes most to word stress perception before focus. Experiment III was designed to test if  $F_0$ , which contributes most to pre-focal word stress, is perceived categorically or continuously in the vertical dimension; experiment IIII was to test if  $F_0$  is perceived categorically or continuously in the horizontal dimension. Experiment V was to find out which of the acoustic parameters contributes most to the perception of phrase stress, and experiment VI was designed to test if  $F_0$  is perceived categorically or continuously.

## **1 Greek Prosodic Phonology**

In this study, language is thought of as a complex entity of different levels of representation. Each level is associated with its corresponding prosodic category, i.e., the lexical level with lexical stress, the morphological level with word stress, the syntactic level with phrase stress, and the semantic and textual level with sentence stress. The lexical stress is given by the lexicon and may appear on any one of the last three syllables. The word stress may coincide with the lexical stress although it usually moves to the right whenever the word boundary moves to the right by the addition of extra syllables through inflection and derivation or when some morphemes attracting word stress are added to the lexical word. The phrase stress appears two syllables to the right of word stress when the phrase boundary is more

than two syllables to the right of word stress. The sentence stress appears on the last lexical element bearing focus. However, phrase stress attracts sentence stress within the domain of the phrase no matter which element is in focus.

The prosodic categories are organized into a hierarchical structure and have a classificatory function, either they exist or not, and every category has its own distribution rules which apply to the corresponding level. The freedom of the prosodic categories varies according to the level on which their rules are applied. The lower the level the less dependent the prosodic rules are upon the higher levels of representation. In other words, word stress needs information only about the position of lexical stress and the word boundary whereas phrase stress, apart from word stress information, needs information about phrase boundaries as well, i.e., a higher level is involved. Thus, prosody cannot be independent from the morpholexical, syntactic and semantic structure of the language; it is rather an abstract linguistic entity which the different prosodic categories create with concrete contributions from the corresponding levels of representation.

## **2 Acoustic Analysis**

In acoustic experiment I the parameters of  $F_0$ , duration and intensity were found to contribute to pre-focal word stress, only duration and intensity to post-focal word stress and  $F_0$ , duration and intensity to sentence stress. Of the three acoustic parameters examined, duration and intensity run parallel to each other and are usually present for both word and sentence stress. The word stress acoustic parameters are not constant across the syntagm but their manifestation is organized in relation to the sentence stress position.

In experiment II phrase stress is manifested by the rising of  $F_0$  at the pre- and focal position and the falling and flattening of  $F_0$  at the post-focal position combined with longer duration and higher peak intensity. At non-focal position the acoustic structure of phrase stress is the same as the word stress, the difference between the two categories being of perceptual as well as of functional nature.  $F_0$  is not a strong enough perceptual cue for the phrase stress distinction the way it is for the word stress, on the other hand, word stress operates at the morphological level to distinguish contrastive words whereas phrase stress operates at the syntactic level to distinguish contrastive structures. Apart from phrase stress, the enclitic structure appears with the same acoustic manifestation as the proclitic one.

In experiment III the influence that syntax may have on prosody has been corroborated. Two noun phrases with the same number of syllables, in the same context, one with a word and a phrase stress and the other with two word stresses may apparently have the same acoustic manifestation outside focus; but when focus is involved the noun phrases take completely different acoustic manifestations. The application of sentence stress on the lexical entity with a word stress is blocked when the lexical entity is in a phrase where there exists a phrase stress, whereas sentence stress may be applied to any one of the lexical entities composing the phrase and have a word stress.

### **3 Physiological Analysis**

In the physiological experiment the  $P_s$  was found to co-vary with intensity. It seems, then, that the larynx is mainly responsible for  $F_0$  variations and the subglottal system for intensity. Intensity was found

to correlate with  $F_0$  for sentence stress but with duration for post-focal word stress, an implication that the acoustic parameters are independent of each other and not produced by the same mechanism.

#### **4 Perceptual Analysis**

In the perceptual experiment I duration was found to be the most important acoustic cue although a combination with intensity was necessary for the perception of word stress at post-focal position. Listeners could perceive word stress distinctions after focus where the acoustic parameters are weakly manifested even with synthetic speech. The context,  $F_0$ , and formant structure did not have any perceptual contribution at this position.

In experiment II  $F_0$  was found to be the all important perceptual cue for the pre-focal word stress distinction. A hierarchy of the acoustic parameters is still questionable since  $F_0$  is the primary cue and overrides duration and intensity as conflicting cues.

In experiment III the question of whether  $F_0$  is perceived categorically or continuously in the vertical dimension for the pre-focal word stress distinction is still unanswered. However, the main finding of this experiment was that the prosodically contrastive words kept their original meaning even with a neutralized  $F_0$ -contour. It seems as if  $F_0$  functions as a distinctive feature with intensity and duration as redundant features and when the distinctive features are neutralized, the redundant ones take over. Thus,  $F_0$  is not an absolute necessity for word stress perception; duration and intensity may equally effectively convey the word stress concept at pre-focal position the same way they do at post-focal position.

In experiment IIII in which  $F_0$  had been moved horizontally across the prosodic minimal pair under investigation at pre-focal position, word stress was perceived categorically.  $F_0$  had to be far away from the midpoint of the syllable to neutralize the influence of duration and intensity from the original word. This finding reflects the influence that duration and intensity may have on pre-focal word stress perception.

In experiment V listeners could perceive phrase stress and associate it with the proper syntactic and semantic structure. The phrase stress  $F_0$ -rise contributes most to phrase stress perception, but it has to be combined with duration and intensity to denote the concept of phrase stress in contrast to word stress in pre-focal position where  $F_0$  itself is the decisive factor. In the light of these findings it seems that the idea that a certain parameter does not contribute to stress perception should be reconsidered. A particular parameter may not contribute by itself at all; however it may be decisive when combined with the other acoustic parameters.

In experiment VI the question of whether  $F_0$  is perceived categorically or continuously for the phrase stress distinction is still unanswered. However, the present experiment corroborates the results of experiment V where  $F_0$  was not enough to convey phrase stress by itself, and experiment III where intensity and duration became distinctive features when  $F_0$  was neutralized.