

*Papers in
Laboratory
Phonology II*

*Gesture,
Segment,
Prosody*

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Secondary stress: evidence from Modern Greek

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16.1 Introduction

The need to express formally stress subordination in English has always been felt and many attempts to do so have been made, e.g. Trager and Smith (1951), Chomsky and Halle (1968). However, until the advent of metrical phonology (Lieberman and Prince 1977) all models tried to express stress subordination through linear analyses. The great advantage of metrical phonology is that by presenting stress subordination through a hierarchical structure it captures the difference in stress values between successive stresses in an economical and efficient way.

When Lieberman and Prince presented their model, one of their intentions was to put forward a "formalization of the traditional idea of 'stress timing'" (1977: 250) through the use of the metrical grid. This reference to stress-timing implies that their analysis mainly referred to the rhythm of English. However, the principles of metrical phonology have been adopted for the rhythmic description of other languages (Hayes 1981; Hayes and Puppel 1985; Roca 1986), including Polish and Spanish, which are rhythmically different from English. The assumption behind studies like Hayes (1981) is that, by showing that many languages follow the same rhythmic principles as English, it can be proved that the principles of metrical phonology, namely binarity of rhythmic patterns and by consequence hierarchical structure, are universal. However, such evidence cannot adequately prove the universality of metrical principles; what is needed is evidence that there are no languages which do not conform to these principles. Thus, it would be interesting to study a language that does not seem to exhibit a strictly hierarchical, binary rhythmic structure. If the study of such a language proves this to be the case, then the claim for the universality of binary rhythm may have to be revised. One language that seems to show a markedly different kind of rhythmic patterning from English is Modern Greek.

In fact, the past decade has seen the appearance of a number of studies of Modern Greek prosody both in phonology (Malikouti-Drachman and Drachman 1980; Nespor and Vogel 1986, 1989; Berendsen, 1986) and in phonetics (Dauer 1980; Fourakis 1986; Botinis 1989). These studies show substantial disagreement concerning the existence and role of secondary stress in Greek.

By way of introduction I present a few essential and undisputed facts about Greek stress. First, in Greek, lexical stress conforms to a Stress Well-formedness Condition (henceforth SWFC), which allows lexical stress on any one of the last three syllables of a word but no further to the left (Joseph and Warburton 1987; Malikouti-Drachman and Drachman 1980). Because of the SWFC, lexical stress moves one syllable to the right of its original position when affixation results in the stress being more than three syllables from the end of the word; e.g.

- (1) /'maθima/ "lesson" > /'maθima + ta/ "lesson + s" > /ma'θimata/ "lessons"

Second, as can be seen from example (1), lexical stress placement may depend on morphological factors, but it cannot be predicted by a word's metrical structure because there are no phonological weight distinctions either among the Greek vowels, /i, e, a, o, u/, or among syllables of different structure; i.e. in Greek, all syllables are of equal phonological weight. Therefore, it is quite common for Greek words with the same segmental structure to have stress on different syllables; e.g.

- (2) a. /'xo.ros/ "space"
b. /xo.'ros/ "dance" (noun)

It is equally possible to find words like those in (3),

- (3) a. /'pli.θos/ "crowd"
b. /'plin.θos/ "brick"

where both words are stressed on their first syllable, although this is open in (3a) and closed in (3b). Finally, when the SWFC is violated by the addition of an enclitic to a host stressed on the antepenultimate, a stress is added two syllables to the right of the lexical stress. For example,

- (4) /'maθima tu/ > /'maθi'ma tu/ "his lesson"
(5) /'ðose mu to/ > /'ðose 'mu to/ "give it to me"

All investigators (Setatos 1974; Malikouti-Drachman and Drachman 1980; Joseph and Warburton 1987; Botinis 1989) accept that the two stresses in the host-and-clitic group have different prominence values. However, not all of them agree as to the relative prominence of the two stresses. Most

investigators (Dauer 1980; Malikouti-Drachman and Drachman, 1980; Joseph and Warburton 1987) agree that the added stress is stronger than the host's lexical stress. Setatos (1974), however, followed by Nespov and Vogel (1986, 1989), claims that the host's lexical stress remains the strongest. Thus, a first point of disagreement emerges: namely, the prominence value of the SWFC-induced stress.

Botinis (1989) presents an entirely different analysis: influenced perhaps by work on Swedish prosody, he claims that the SWFC-induced stress of a host-and-clitic group is a "phrase stress." Botinis admits that "on acoustic grounds it is questionable if there is enough evidence to differentiate between word and phrase stress although they have quite different perceptual dimensions" (1989: 85). However, Botinis's claim that word and phrase stress are perceptually distinct could be attributed partly to incorrect manipulation of the F_0 contour in the synthesized stimuli of his perceptual experiment and partly to incorrect interpretation of this experiment's results (for details see Arvaniti 1990). In fact, Botinis's evidence suggests that the SWFC-induced stress is acoustically the most prominent in the host-and-clitic group.

Most of the studies (Dauer 1980; Fourakis 1986; Joseph and Warburton 1986) mention stress subordination only in relation to the host-and-clitic group stress addition, in which case they refer to "secondary stress." In other words, in most of the studies it is assumed that in Greek each word normally carries only lexical stress. Phonological studies (Malikouti-Drachman and Drachman 1980; Nespov and Vogel 1986, 1989), though, assume that, in addition to lexical stress, Greek exhibits rhythmic stresses which are added at the surface level. Thus, the presence of rhythmic stresses is the second point of contention among studies. Nespov and Vogel and Malikouti-Drachman and Drachman relate rhythmic stress to the "secondary" stress of host-and-clitic groups but in two different ways.

Nespov and Vogel, on the one hand, propose that rhythm is represented by the grid which is built "on the basis of the prosodic structure of a given string" (1989: 70). The grid shows prominence relations among stresses but it cannot show constituency. Nespov and Vogel (1989) suggest that in Greek rhythmic stresses appear only when there is a lapse in the first level of the grid; in other words, whereas a series of unstressed syllables constitutes a lapse that can trigger rhythmic stress, a series of lexical stresses of equal prominence does not constitute a lapse. When a lapse occurs, one of the syllables that has only one asterisk in the grid acquires a second asterisk, i.e. a rhythmic stress, through the beat addition rule. The placement of rhythmic stresses is regulated by two preference rules. As has been mentioned, Nespov and Vogel (1986, 1989) also maintain that the SWFC-induced stress (or "secondary stress," as they call it) is less prominent than the original lexical stress of the host; this "secondary stress" is of equal prominence to a

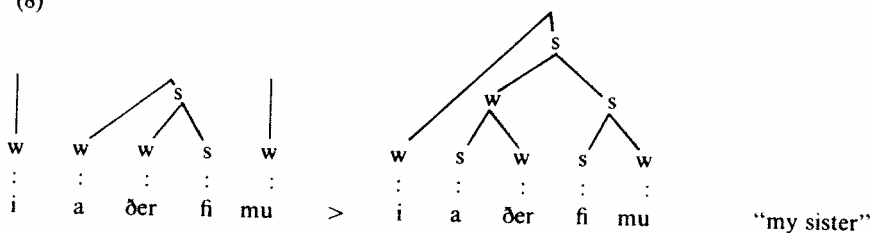
rhythmic stress. According to Nespor and Vogel (1989) the difference between a SWFC-induced stress and a rhythmic stress lies in the fact that the former is the result of an obligatory prosodic rule which operates within C (clitic group) while the latter is the result of *Beat Addition*, an optional rhythmic rule which operates in the grid. Examples from Nespor (forthcoming) and Nespor and Vogel (1989) suggest that rhythmic stress and "secondary" stress have the same phonetic realization since (a) they are both represented by two asterisks in the grid and (b) the grid cannot show constituency differences (i.e. the fact that "secondary stress" belongs to C). However, if this were correct then the following examples

- (6) [o 'ðaska, los tu]_C¹ ['anikse tin 'porta]_C
 "His teacher opened the door"
 (7) [o 'ðaskalos]_C [tu 'anikse tin 'porta]_C
 "The teacher opened the door to him"

could have the same rhythmic structure since the lapse in (7), i.e. the series of unstressed syllables /skalos tu/, can only be remedied by adding a rhythmic stress on /los/. This is not the case, however; the two examples are clearly differentiated in Greek. Indeed, the subjects who took part in the perceptual experiments reported in Botinis (1989) could distinguish even synthesized stimuli of similar structures to (6) and (7) in at least 91 percent of the cases. Thus, one of the two claims of Nespor and Vogel (1989) must be incorrect: if /los/ in (6) carries "secondary" stress then "secondary" and rhythmic stress must be presented in different ways in the grid, or else /los/ in (6) carries the main stress of the host-and-clitic group, not a "secondary" one.

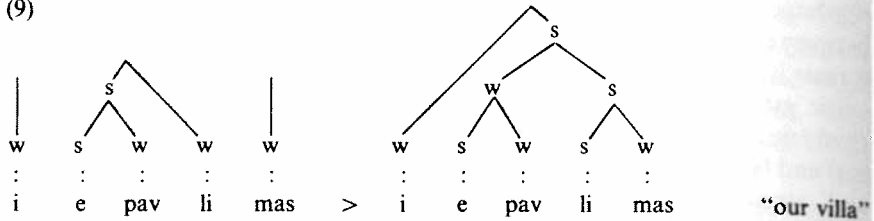
As has been mentioned, Malikouti-Drachman and Drachman (1980) also relate secondary and rhythmic stresses, but their approach differs from that of Nespor and Vogel, in that the former assume that the secondary stress in a host-and-clitic group is the weakened lexical stress of the host. Rhythmic stresses are added following the *Rhythm Rule* which states "Make a trochaic foot of any adjacent pair of weak syllables to the left of the lexical stress within the word [word + clitics] (iterative)" (1980: 284).

(8)



¹ The stresses on /ðaskalos/ are presented here with the prominence values assumed by Nespor and Vogel (1989).

(9)



As can be seen from examples (8) and (9), the *Rhythm Rule* applies not only to the left but also to the right of the lexical stress; this "refooting" explains the SWFC-induced stress. However, by equating the metrical structures of (8) and (9), this analysis cannot differentiate between a metrical tree with an optional rhythm-induced stress like (8), and a tree with an obligatory SWFC-induced stress like (9).

To summarize, there seem to be two main interconnected issues that are addressed by researchers: namely, the presence and nature of rhythmic and SWFC-induced stress. In brief, Nespor and Vogel (1986, 1989) and Malik-outi-Drachman and Drachman (1980) alone agree that Greek exhibits rhythmic stress; and although they disagree as to which of the two stresses in a host-and-clitic group is the most prominent, they agree that the weaker one of the two is identical to rhythmic stress. Botinis (1989), on the other hand, does not mention rhythmic stresses but he proposes two distinct prosodic categories, i.e. word and phrase stress, to account for the SWFC-induced stress in host-and-clitic groups. The present paper is an attempt to examine these issues using acoustical and perceptual evidence rather than impressionistic data. First, two questions must be answered: (a) whether the stress added to a host-and-clitic group due to SWFC violation is the most prominent in the group; (b) whether this added stress is perceptually distinct from a lexical stress. When answers to these questions are established two more questions can be addressed: (c) whether "secondary" stress and rhythmic stress are perceptually and acoustically the same or not; (d) whether there is any evidence for rhythmic stress. The questions are investigated by means of two perceptual tests, and acoustic analyses of the data of the second experiment. Finally, an attempt is made to present the results formally within a broadly conceived metrical framework.

16.2 Experiment 1

16.2.1 Method

16.2.1.1 Material

The first experiment is a simple perceptual test whose aim is to see first whether the lexical stress of the host-and-clitic group is more prominent than

Table 16.1 *One of the two test pairs (1a and 1b) and one of the distractors (2a and 2b) in the context in which they were read. The test phrases and distractors are in bold type.*

1 (a) /tu 'ipa to ɣi'a 'ari'sta su ke 'xarike po'li/ "I told him about your 1st class mark and he was very pleased"
(b) /e'ɣo tu fo'nazo 'ari stasu ki a'ftos ðe stama'tai/ "I shout at him Ari stop but he doesn't stop"
2 (a) /pi'stevo 'oti 'ksero to 'mono 'loɣo ɣi'a a'fti tin ka'tastasi/ "I believe that I know the only reason for this situation"
(b) /ðen 'exo a'kusi pi'o vare'to mo'noloɣo sto 'θeatro/ "I haven't listened to a more boring theatrical monologue"

the SWFC-induced one as Setatos (1974) and Nespors and Vogel (1986, 1989) maintain, and second whether Botinis's phrase stress and word stress are two perceptually distinct stress categories as his analysis suggests.

Two test pairs were designed (see the parts of table 16.1, 1a and 1b, in bold type): in each test pair the two members are segmentally identical but have word boundaries at different places and are orthographically distinct in Greek. The first member, (a), of each pair consists of one word stressed on the antepenultimate and followed by an enclitic possessive pronoun. As this pattern violates the SWFC a stress is added on the last syllable of the word. The second member, (b), consists of two words which together form a phrase and which are stressed on the same syllables as member (a). Thus, the difference between members (a) and (b) of each test pair is that in (a) the phrase contains a lexical and a SWFC-induced stress whereas in (b) each one of the two words carries lexical stress on the same syllables as (a). According to Nespors and Vogel, the most prominent stress in (a) phrases is the lexical stress of the host while in (b) phrases it is the stress of the second word (i.e. the one that falls on the same syllable as the SWFC-induced stress in (a)) since the second word is the head of the phonological phrase Φ (1986: 168). Also, in Botinis's terms (a) and (b) phrases have different stress patterns, (a) containing one word and one phrase stress and (b) containing two word stresses; these stress patterns are said by Botinis to be perceptually distinct. If either Nespors and Vogel or Botinis are correct, (a) and (b) phrases should be distinguishable.

The test phrases were incorporated into meaningful sentences (see table 16.1). Care was taken to avoid stress clashes, and to design, for each pair, sentences of similar prosodic structure and length. Two distractor pairs were devised on the same principle as the test pairs (see table 16.1, 2a and 2b). The difference is that in the distractors one member contains two words, each one

with its own lexical stress (/ˈmono ˈloɣo/“only reason”), while in the other member the same sequence of syllables makes one word with lexical stress on a different syllable from those stressed in the first member (/moˈnolɔɣo/“monologue”).

The sentences were read by four subjects including the author. Each subject read the test sentences and the distractors six times from a randomized list, typed in Greek. The recorded sentences and the distractors were digitized at 16 kHz and then were edited so that only the test phrases and distractors were left. For each test phrase and distractor one token from each one of the four subjects was selected for the test tape. The tokens chosen were, according to the author's judgment, those that sounded most natural by showing minimum coarticulatory interference from the carrier phrase.

To make the listening tape, the test phrases and the distractors were recorded at a sampling rate of 16 kHz using computer-generated randomization by blocks so that each token from each subject was heard twice. Each test phrase and distractor was preceded by a warning tone. There were 100 msec. of silence between the tone and the following phrase and 2 sec. between each stimulus and the following tone. Every twenty stimuli there was a 5 sec. pause. In order for listeners to familiarize themselves with the task, the first four stimuli were repeated at the end of the tape, and the first four responses of each listener were discarded. Thus, each subject heard a total of seventy stimuli: 4 speakers × (4 test phrases + 4 distractors) × 2 blocks + 4 repeated items + 2 stimuli that consisted of two tones each (a result of the randomization program).

16.2.1.2 Subjects

As mentioned, four subjects took part in the recording. Three of them (two female, one male) were in their twenties and they were postgraduate students at the University of Cambridge. The fourth subject was a sixty-year-old woman visiting Cambridge. All subjects were native speakers of Greek and spoke the standard dialect. All, apart from the fourth subject, had extensive knowledge of English. None of the subjects had any history of speech or hearing problems. Apart from the author all subjects were naive as to the purpose of the experiment.

Eighteen subjects (seven male and eleven female) did the perceptual test. They were all native speakers of Greek and had no history of speech or hearing problems. Twelve of them were between 25 and 40 years old and the other six were between 40 and 60 years old. Fourteen of them spoke other languages in addition to Greek but only one had extensive knowledge and contact with a foreign language (English). All subjects had at least secondary education and fourteen of them held university degrees. All subjects spoke

Standard Greek, as spoken in Athens, where sixteen of them live. They were all naive as to the purposes of the experiment.

16.2.1.3 *Procedure*

The subjects did the test in fairly quiet conditions using headphones and a portable Sony Stereo Cassette-Corder TCS-450. No subject complained that their performance might have been marred by noise or poor-quality equipment. The subjects were given a response sheet, typed in Greek, which gave both possible interpretations of every stimulus in the tape (70 × 2 possible answers). The task was explained to them and they were urged to give an answer to all stimuli even if they were not absolutely certain of their answer. The subjects were not allowed to play back the tape.

16.2.2 *Results*

The subjects gave a total of 576 responses excluding the distractors (18 subjects × 32 test phrases/answer sheet). There were 290 mistakes, i.e. 50.34 percent of the responses to the test phrases were wrong (identification rate 49.66 percent). The number of mistakes ranged from a minimum of nine (one subject) to twenty-one (one subject). By contrast, the identification rate of the distractors was 99.1 percent; out of 18 subjects only two made one and four mistakes respectively. Most subjects admitted that they could not tell the test phrases apart although they found the distractors easy to distinguish. Even the subjects who insisted that they could tell apart the test pairs made as many mistakes as the rest.

Thus the results of experiment 1 give an answer to the first two questions addressed here. The results clearly indicate (see table 16.2) that, contrary to Setatos (1974) and Nespor and Vogel (1986, 1989), the SWFC-induced stress is the most prominent in the host-and-clitic group, whereas the original lexical stress of the host weakens. This weakening is similar to that of the lexical stress of a word which is part of a bigger prosodic constituent, such as a Φ , without being its head. Also, the results show that in natural speech Botinis's "phrase stress" is not perceptually distinct from word stress as he suggests.

16.3 *Experiment 2*

16.3.1 *Method*

16.3.1.1 *Material*

Experiment 2 includes a perceptual test and acoustical analyses of the utterances used for it. With the answers to questions (a) and (b) established, this experiment aims at answering the third question addressed here: namely, whether rhythmic stress and the weakened lexical stress (or "secondary

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Table 16.2 *Experiment 1: contingency table of type of stimulus by subject response.*

Response	Type of stimulus		Total
	"1 word" stimulus	"2 word" stimulus	
(a) Observed responses			
"1 word"	113	115	228
"2 word"	175	173	348
Total	288	288	576
(b) Expected responses (and deviances)			
"1 word"	114 (0.008)	114 (0.008)	
"2 word"	174 (0.005)	174 (0.005)	

Note. Total deviance (χ^2) = 0.026 1df. The difference between the relevant conditions is not significant.

stress") of the host in a host-and-clitic group are perceptually and acoustically the same as Malikouti-Drachman and Drachman suggest. In addition, this experiment is an attempt to find acoustical evidence for rhythmic stress.

Four pairs of segmentally identical words with different spelling and stress patterns were chosen (see the parts of table 16.3 in bold type). One word in each pair has lexical stress on the antepenultimate – (1a) in table 16.3 – and the other on the last syllable – (1b) in table 16.3. These pairs were incorporated into segmentally identical, but orthographically distinct sentences in which they were followed by a possessive enclitic (see table 16.3). For clarity, (a) test words will be referred to as SS (for "secondary stress") and (b) words as RS (for rhythmic stress), thus reflecting the terms used by various analyses but not necessarily the author's opinion on the nature of stress in Greek. These two terms will be used throughout with the same caution. The addition of the enclitic results in a change in the stress pattern of SS words as required by the SWFC. Thus, these words have a "secondary stress" on their antepenultimate syllable (i.e. the weakened lexical stress) and primary stress (i.e. the added stress) on their last syllable. According to Malikouti-Drachman and Drachman, RS words also have this stress pattern since (a) polysyllabic words with final stress carry rhythmic stress on their antepenultimate syllable and (b) rhythmic stress and "secondary stress" are not distinguished. If their claims are correct, then the SS and RS words of each test pair are segmentally and metrically identical and therefore indistinguishable.

Four pairs of distractors incorporated into identical sentences were also included (see table 16.3, 2a and 2b). These were devised on the same pattern

Table 16.3 *One of the test sentence pairs and one of the distractor sentence pairs of experiment 2. The test words and distractors are in bold type.*

1 (a) / mu 'eleye 'oti 'vriski ton ,eni'ko tis po'li enoxliti'ko/ "S/he was telling me that s/he finds her tenant very annoying"
(b) / mu 'eleye 'oti 'vriski ton eni'ko tis po'li enoxliti'ko/ "S/he was telling me that s/he finds her "singular" [nonuse of politeness forms] very annoying"
2 (a) /i a' poxi tus 'itan po'li me'yalɪ/ "Their hunting-net was very big"
(b) /i apo'xi tus 'itan po'li me'yalɪ/ "Their abstention was very big"

as the test sentences, the difference being that the word pairs in the distractors differed in the position of the primary stress only; /a'poxi/ "hunting net": /apo'xi/ "abstention". The sentences were read by six subjects, in conditions similar to those described for experiment 1, from a typed randomized list which included six repetitions of each test sentence and distractor. The first two subjects (EI and MK) read the sentences from hand-written cards three times each.

A listening tape was made in the same way as in experiment 1. The stimuli were the whole sentences not just the test word pairs. The tape contained one token of each test sentence and distractor elicited from each subject. There were 3 sec. of silence between sentences and 5 sec. after every tenth sentence. The first four sentences were repeated at the end of the tape, and the first four responses of each listener were discarded. Each subject heard a total of 100 sentences: 6 speakers \times (8 test sentences + 8 distractors) + 4 repeated stimuli.

16.3.1.2 *Perceptual experiment*

The same speakers that recorded the material of experiment 1 did the recording of experiment 2. In addition, two more female subjects (EI and MK) of similar age and education as three of the subjects of experiment 1 took part in the recording. All the subjects that took part in perceptual test 1 performed test 2 as well. The responses of one of the subjects who did not understand what she was asked to do and left most test pairs unmarked were discarded. The procedure was the same as that described in experiment 1. The answer sheet gave 200 possible answers i.e. 100 stimuli \times 2 alternatives.

16.3.1.3 *Acoustical analyses*

All three tokens of each test sentence of the original recording of EI and

MK and the first three tokens of HP's recording were digitized at a sampling rate of 16 kHz and measurements of duration, amplitude, and F_0 were obtained. Comparisons of the antepenultimate and final syllables of the SS words with the equivalent syllables of the RS words are presented here (see figures 16.1–16.4, below). For instance, the duration, F_0 and amplitude values of /e/ in SS word /eni'ko/ "tenant" were compared to those of /e/ in RS word /eni'ko/ "singular."

Duration was measured from spectrograms. The error range was one pitch period (about 4–5 msec. as all three subjects were female). Measurements followed common criteria of segmentation (see Peterson and Lehiste 1960). VOT was measured as part of the following vowel.

Three different measurements of amplitude were obtained: peak amplitude (PA), root mean square (RMS) amplitude, and amplitude integral (AI). All data have been normalized so as to avoid statistical artifacts due to accidental changes such as a subject's leaning towards the microphone etc. To achieve normalization, the PA of each syllable was divided by the highest PA in the word in question while the RMS and AI of each syllable was divided by the word's RMS and AI respectively; thus the RMS and AI of each syllable are presented as percentages of the word's RMS and AI respectively. All results refer to the normalized data. All original measurements were in arbitrary units given by the signal processing package used.

For peak amplitude, measurements were made from waveforms at the point of highest amplitude of each syllable nucleus. RMS and AI were measured using a computer program which made use of the amplitude information available in the original sample files.² To calculate the RMS, the amplitude of each point within the range representing the syllable nucleus was squared and the sum of squared amplitudes was divided by the number of points; the square root of this measurement represents the average amplitude of the sound (RMS) and is independent of the sound's duration. AI measurements were obtained by simply calculating the square root of the sum of squared amplitudes of all designated points without dividing the sum by the number of points. In this way, the duration of the sound is taken into account when its amplitude is measured, as a longer sound of lower amplitude can have the same amplitude integral as a shorter sound of higher amplitude. This way of measuring amplitude is based on Beckman (1986); Beckman, indeed, found that there is strong correlation between stress and AI for English.

Fundamental frequency was measured using the F_0 tracker facility of a signal processing package (Audlab). To ensure the reliability of the F_0 tracks, narrow-band spectrograms were also made and the contour of the

² I am indebted to Dr. D. Davies and Dr. K. Roussopoulos for writing the program for me.

Table 16.4 *Experiment 2: contingency table of type of stimulus by subject response.*

Response	Type of stimulus		Total
	SS stimulus	RS stimulus	
(a) Observed responses			
SS	402	17	419
RS	6	391	397
Total	408	408	816
(b) Expected responses (and deviances)			
SS	209.5 (176.87)	209.5 (176.87)	
RS	198.5 (186.68)	198.5 (186.68)	

Note: Total deviance (χ^2) = 727.10 1df. The result is significant; $p < 0.001$

harmonics tracked and measured. Discontinuities in the F_0 tracks were smoothed out by hand to correspond to the contour of the harmonics in the narrow-band spectrograms. No actual measurements of F_0 are presented here since what is essential is the difference between the contours of SS and RS words.

16.3.2 Results

16.3.2.1 Perceptual experiment

The subjects gave a total of 816 responses excluding the distractors (16 subjects \times 48 responses/answer sheet). Nine subjects made no mistakes in the test words and the other seven made a total of 23 mistakes; the test's identification rate was 97.2 percent. Of the subjects that made mistakes, five made between 1 and 3 mistakes (2 mistakes on average). Only two subjects made 6 and 7 mistakes respectively. The distractors' identification rate was very similar (98.2 percent). Only four people made 1, 2, 3, and 9 mistakes each in the distractors. The persons who made the highest number of mistakes in the test words made the highest number of mistakes in the distractors as well. The results clearly show (see table 16.4) that rhythmic and "secondary stress" can be easily distinguished by native speakers of Greek; thus, it is incorrect to equate them as Malikouti-Drachman and Drachmando.

16.3.2.2 Acoustical analyses

Duration. For each test word the duration of two syllables is presented here, that of the antepenultimate syllable ("secondary" or rhythmic stress) and that of the last syllable (primary stress). Results for all subjects together are shown in figure 16.1.

Prosody

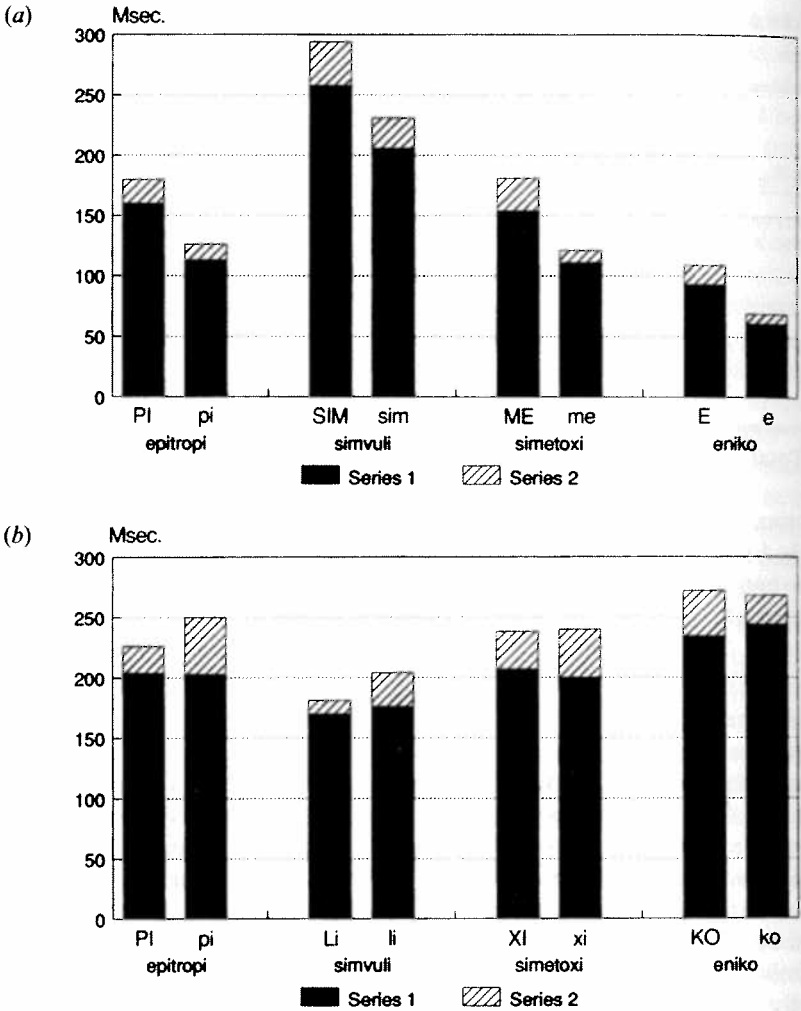


Figure 16.1 (a) Means (series 1) and SDs (series 2) of the duration, in msec., of antepenultimate syllables of SS words (left, upper case) and RS words (right, lower case) for all subjects. (b) Same measurements for final syllables

The data from the three subjects are pooled, as t-tests performed on each subject's data separately showed no differences across subjects. One-tailed t-tests for the data of all three subjects show that, for antepenultimate syllables, the duration of the antepenult of SS words is significantly longer than that of RS words in all word pairs (see table 16.5 for the t-test results). For vowel durations, one-tailed t-tests show that the duration of the

Table 16.5 Results of one-tailed *t*-tests performed on the durations of the antepenultimate syllables of SS and RS words of all test word pairs. In all cases, $df=16$. The syllables that are being compared are in upper case letters.

Test pair	<i>t</i>	<i>p</i> <
1 ePItropi	5.94	0.0005
2 SIMvuli	3.58	0.005
3 siMEtoxi	4.47	0.0005
4 Eniko	5.6	0.0005

Table 16.6 Results of one-tailed *t*-tests performed on the durations of the vowels of antepenultimate syllables of SS and RS words of all test word pairs. In all cases, $df=16$. The vowels that are being compared are in upper case letters.

Test pair	<i>t</i>	<i>p</i> <
1 ePItropi	6.83	0.0005
2 SIMvuli	5.75	0.0005
3 simEtoxi	8.22	0.0005
4 Eniko	5.6	0.0005

antepenultimate vowel is also significantly longer in SS words, in all test word pairs (see table 16.6 for *t*-test results). By contrast, no significant differences were found between SS and RS words either in the duration of their final syllables or in that of final vowels when two-tailed tests were performed.

Amplitude Results of amplitude measurements were not pooled; the measurements differed extensively between subjects so that pooling the data could result in statistical artifacts. Of all measurements only AI shows relatively consistent correlation between stress and amplitude for subject HP only. PA and RMS measurements did not yield any significant results for any subject.

AI results for HP's data are shown in figure 16.2. One-tailed *t*-tests showed that all SS antepenults have significantly higher AI than their RS counterparts although the statistical results are not as strong as those of durational data (see table 16.7 for details). On the other hand, two-tailed *t*-tests on the

Prosody

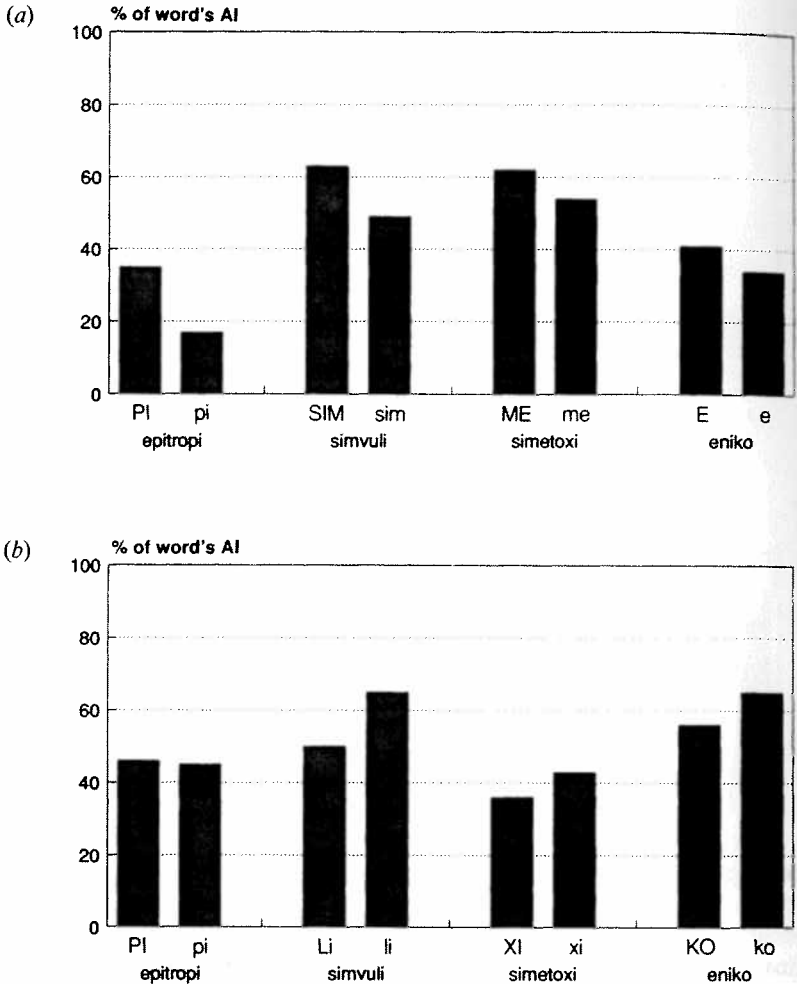


Figure 16.2 (a) AI means, expressed as percentages, of antepenultimate syllables of SS words (left, upper case) and RS words (right, lower case) for subject H.P. (b) Same measurements for final syllables

final syllables of SS and RS words do not show significant differences between them. The results of AI measurements for MK, whose data do not show any correspondence between amplitude and stress, are presented in figure 16.3.

Subject to further investigation, the results suggest that perhaps amplitude is not a strong stress correlate in Greek. Botinis (1989) however, found that,

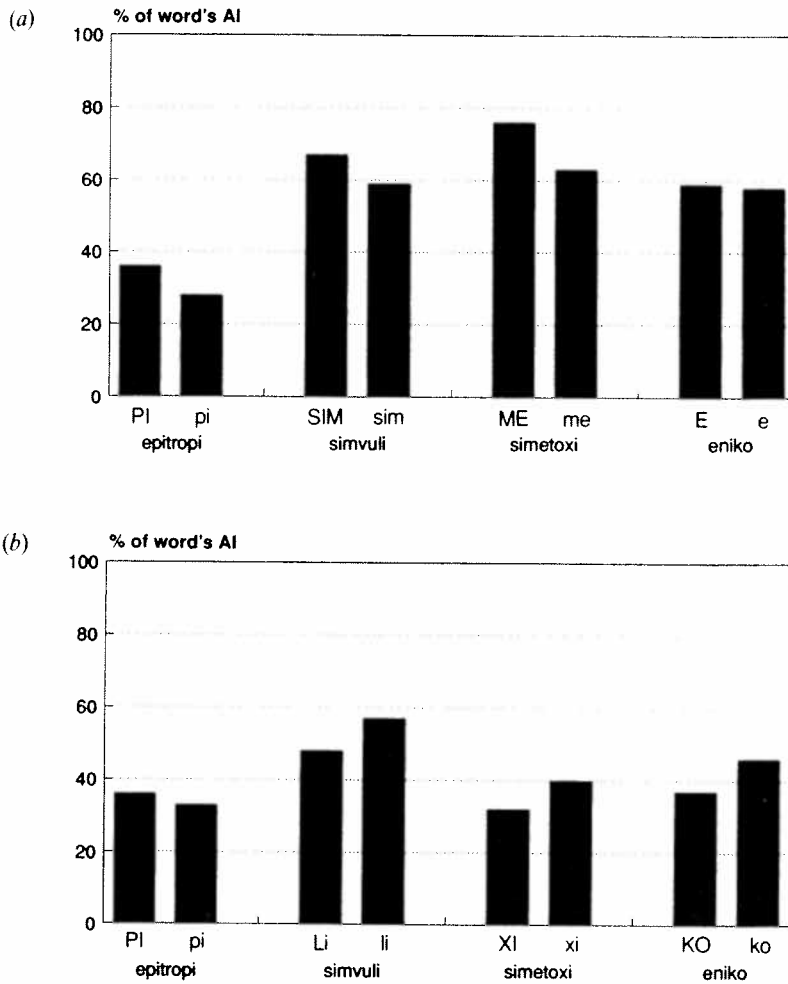


Figure 16.3 (a) AI means, expressed as percentages, of antepenultimate syllables of SS words (left, upper case) and RS words (right, lower case) for subject M.K. (b) Same measurements for final syllables

in his data, stressed syllables had significantly higher peak amplitude than unstressed syllables. On the other hand, he also reports that in perceptual tests amplitude changes did not affect the subjects' stress judgments. These results could mean that as amplitude is not a robust stress cue, its acoustical presence is not necessary and some speakers might opt not to use it. Clearly, both a more detailed investigation into how to measure amplitude, and data

Prosody

Table 16.7 Results of one-tailed *t*-tests performed on the AI of the antepenultimate syllables of SS and RS words of all test word pairs, for subject HP. In all cases, *df* = 4. The syllables that are being compared are in upper case letters

Test pair	<i>t</i>	<i>p</i> <
1 ePItropi	6.62	0.005
2 SIMvuli	3.58	0.025
3 siMEtoxi	6.45	0.005
4 Eniko	3.73	0.025

elicited from a larger number of speakers are needed before a conclusion is reached.

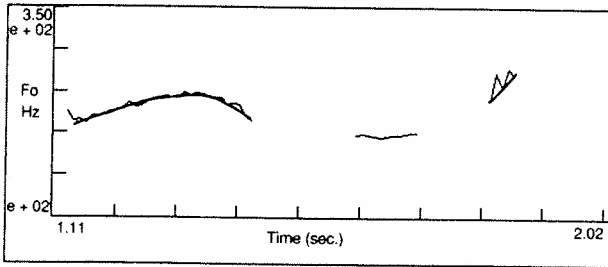
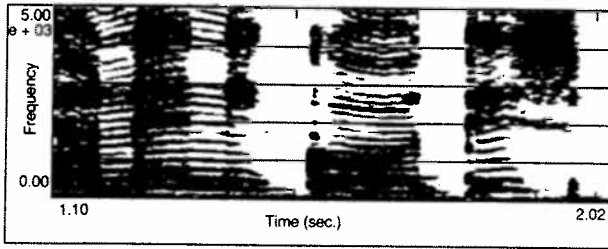
Fundamental frequency Characteristic F_0 plots are shown in figure 16.4. There were no differences either within each subject's data or across subjects. The F_0 contours show a significant difference between SS and RS test words. In SS words, F_0 is high on the antepenult whereas in RS words, F_0 is very low and relatively flat. No important differences between the contours of last syllables of SS and RS words were found. They all started with slightly low F_0 that rose sharply to a high value. One noticeable effect is that in many cases the F_0 high is not associated with the beginning of the stressed syllable but rather with its end and the beginning of the following, unstressed syllable. This seems to be a characteristic of Greek stress as the results of Botinis (1989) confirm.

16.4 Discussion

The results of the first experiment show that native speakers of Greek cannot differentiate between the rightmost lexical stress of a phrase and a SWFC-induced stress which fall on the same syllable of segmentally identical phrases. This implies that, contrary to the analyses of Setatos (1974) and of Nespov and Vogel (1986, 1989), the SWFC-induced stress is the most prominent stress in a host-and-clitic group, in the same way that the most prominent stress in a Φ is the rightmost lexical stress. This conclusion agrees with the description of the phenomenon by most analyses of Greek, both phonological (e.g. Joseph and Warburton 1987; Malikouti-Drachman and Drachman 1980) and phonetic (e.g. Botinis 1989), and also with the basic requirement of the SWFC; namely, that the main stress must fall at most three syllables to the left of its domain boundary. Moreover, the results

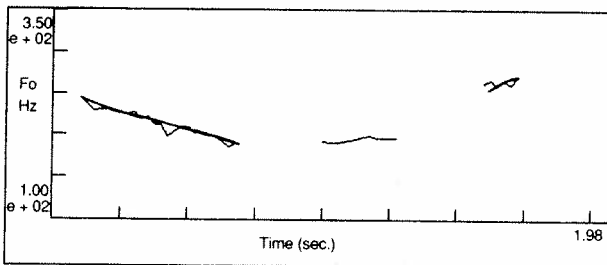
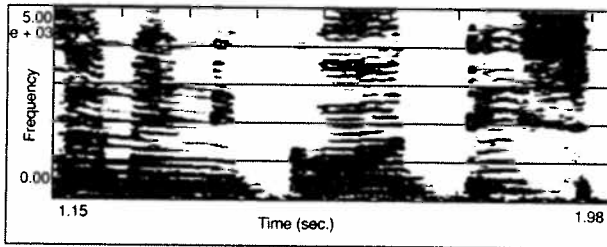
16 Amalia Arvaniti

(a)



hp /tonenikotis/SS

(b)



hp /tonenikotis/RS

Figure 16.4 Characteristic F_0 contours together with the corresponding narrow band spectrograms for H.P.'s /ton eniko tis/; (a) SS word (b) RS word. The thicker line on the plot represents the smoothed contour

indicate that Botinis's proposal that the SWFC-induced stress belongs to a perceptually distinct prosodic category is incorrect.

These results are corroborated by those of experiment 2. Starting with Malikouti-Drachman and Drachman's assumption that "secondary stress" (i.e. the weakened lexical stress of the host) and rhythmic stress are phonetically identical, it was shown that they are in fact very different both acoustically and perceptually. On the one hand, the syllables that carry "secondary stress" were shown to be acoustically more prominent than syllables thought to carry rhythmic stress. On the other hand, no acoustical evidence for rhythmic stress was found; syllables thought to carry rhythmic stress exhibited durations and F_0 contours similar to those of unstressed syllables. Finally, the data corroborate those of experiment 1 in that the final syllables in all test word pairs exhibited no acoustical differences between SS and RS words. These results indicate that the stress of both final syllables is primary whether lexical or SWFC-induced.

I propose to account for the present results in the following way. Word (or lexical) stress placement is a lexical process while the SWFC-induced stress in host-and-clitic groups is the result of postlexical application of the SWFC. This difference becomes clear if one considers, again, cliticization and affixation. Although syllable addition is common to both of these processes they yield different results: whereas affixation results in a shift of the main stress as in

(10) /'maθima/ "lesson" > /ma'θimata/ "lessons"

cliticization results in a stress addition, as in

(11) /'maθima tu/ > /,maθi'ma tu/ "his lesson"

This is precisely because affixation takes place within the lexical component, whereas cliticization is a postlexical process. Thus, by leaving the lexical component all words, except clitics, form independent stress domains, like the final form in (12).

(12)

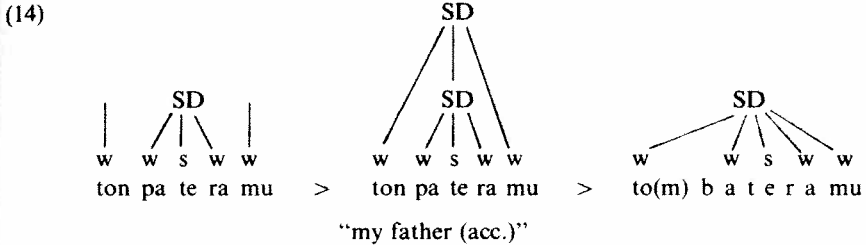
$\begin{array}{c} \text{SD} \\ \swarrow \quad \quad \searrow \\ \text{s} \quad \text{w} \quad \text{w} \\ \text{pi} \quad \text{ra} \quad \text{ma} \end{array}$	>	$\begin{array}{c} \text{SD} \\ \swarrow \quad \downarrow \quad \downarrow \quad \searrow \\ \text{s} \quad \text{w} \quad \text{w} \quad \text{w} \\ \text{pi} \quad \text{ra} \quad \text{ma} \quad + \quad \text{ta} \end{array}$	>	$\begin{array}{c} \text{SD} \\ \swarrow \quad \downarrow \quad \downarrow \quad \searrow \\ \text{w} \quad \text{s} \quad \text{w} \quad \text{w} \\ \text{pi} \quad \text{ra} \quad \text{ma} \quad \text{ta} \end{array}$
"experiment"	>	"experiment + s"	>	"experiments"

The fact that all words constitute independent stress domains is true even of monosyllabic "content" words. The difference between those and clitics becomes apparent when one considers examples like (13):

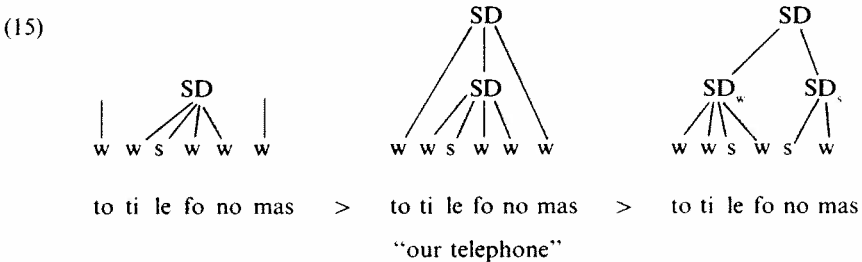
(13) /'anapse to 'fos/ "turn on the light"

which shows that SWFC violations do not arise between words because these form separate stress domains.

Clitics, however, remain unattached weak syllables until they are attached to a host postlexically. In this way, clitics extend the boundaries of words, i.e. of stress domains (SDs); clitics form compound SDs with their hosts. For example,



The stress domain formed by the host and its enclitic still has to conform to the SWFC. When cliticization does not result in a SWFC violation no change of stress pattern is necessary. When, however, the SWFC is violated by the addition of enclitics, the results of the violation are different from those observed within the lexical component. This is precisely because the host has already acquired lexical stress and constitutes an independent stress domain with fixed stress. Thus, in SWFC violations the host's stress cannot move from its position, as it does within the lexical component. The only alternative, therefore, is for another stress to be added in such a position that it can comply with the SWFC, thus producing the stress two syllables to the right of the host's lexical stress. In this case the compound SD is divided into two SDs.



In this way, the subordination of the first stress is captured, as well as the fact that both stresses still belong to one stress domain, albeit a compound one, and therefore they are at the same prosodic level. The disadvantage of

this proposal is that there is no motivation for choosing between /fonomas/ and /nomas/ as the second constituent of the compound SD.

Finally, another question that emerges from the experimental results is whether Greek metrical structure needs to present rhythmic stresses at all. Experimental data indicate that there is no acoustical evidence for rhythmic stress in Greek and that what has been often described as "secondary stress" is a weakened lexical stress. This statement may, at first, seem self-evident; however, it must be remembered that a weakened lexical stress and the subordinate stresses of words have not always been considered the same. Liberman and Prince (1977), for instance, refer to Trager and Smith (1951), who "argued for a distinction between nonprimary stresses within a word, and subordinated main stresses of independent words, a distinction that could be expressed by a one-level downgrading of all nonprimary stresses within the confines of a given word; thus

3 1 2 1
Tennessee but Aral Sea."

(Liberman and Prince 1977: 255). If this line of argument is followed in the Greek examples, then the lexical stress of the host should become a "3 stress" rather than a "2 stress" since it becomes a subordinate stress within a word. This, however, does not happen; on the contrary, the lexical stress of the host remains strong enough to be perceptually identical to a subordinate main stress, as experiment 1 showed. In my opinion, these results cast doubt on the presence of "secondary stress," and consequently rhythmic stress, in Greek. Although further investigation is necessary before a solution is reached, there are strong arguments, in addition to the acoustical evidence, for proposing that Greek does not in fact exhibit rhythmic stress.

Since experimental results fail to show any evidence for rhythmic stresses the only argument for their existence appears to be that they are heard. However, in certain cases, different investigators have conflicting opinions as to the placement of rhythmic stresses. For instance, on a phrase like

(16) /me'ɣali katastro'fi/ "great destruction"

the rhythmic stress should be on /ka/, according to the rules of Nespor and Vogel (1989) while, according to Malikouti-Drachman and Drachman (1980), the rhythmic stress should fall on /ta/. Differences between the two analyses become greater as the number of unstressed syllables between lexical stresses increases.

Moreover, only phonological analyses suggest that Greek exhibits rhythmic stress. Phonetic analyses either do not mention the matter (Dauer 1980; Botinis 1989), or fail to find evidence for rhythmic stress; for instance, Fourakis (1986) concludes, on the basis of durational data, that Greek seems

to have a two way distinction: \pm stress with no gradations. Although more detailed research into the presence of rhythmic stress is necessary there is fairly strong support for postulating an n -ary branching analysis in which no rhythmic stresses are marked. If further evidence confirms the present results, then the universality of binary rhythmic patterns could be questioned.

16.5 Conclusion

It has been shown that the Greek Stress Well-Formedness Condition applies both lexically, moving lexical stress to the right of its original position, and postlexically, adding a stress two syllables to the right of the host in a host-and-clitic group. In the latter case, the SWFC-induced stress becomes the most prominent in the group; this stress was shown to be perceptually identical to a lexical stress. The weakened lexical stress of the host was shown to be acoustically and perceptually similar to a subordinate lexical stress and not to rhythmic stress as has often been thought. The experimental evidence together with the absence of strong phonological arguments to the contrary suggest that Greek might not exhibit rhythmic stresses at all.

Appendix 1

The test phrases (bold type) of experiment 1 in the context in which they were read

- 1(a) /tu 'ipa γi'a to 'ari'**sta su** ke 'xarike po'li/
“I told him about your first-class mark and he was very pleased.”
- (b) /e'γo tu fo'nazo 'ari' **stasu** ki a'ftos ðe stama'tai/
“I shout at him Ari stop, but he doesn't stop.”
- 2(a) /pso'nizi 'panda a'po to **psa'raði'ko tus**/
“S/he always shops from their fishmongery.”
- (b) /'ixan a'nekaθen **psa'ra ði'ko tus**/
“They have always had their own fishmonger.”

Appendix 2

The distractors (bold type) of experiment 1 in the context in which they were read

- 1(a) /pi'stevo 'oti 'ksero to '**mono** 'loɣo ɣi'a a'fti tin ka'tastasi/
“I believe I know the only reason for this situation.”
- (b) /ðen 'exo a'kusi pi'o vare'to **mo'noloyo** sto 'θeatro/
“I haven't listened to a more boring theatrical monologue.”
- 2(a) /ðe 'θelo '**pare** 'ðose me a'fto to 'atomo/
“I don't want to have anything to do with this person.”
- (b) /'ksero 'oti to **pa'reðose** stus ðike'uxus/
“I know that he delivered it to the beneficiaries.”

Appendix 3

*The test sentences of experiment 2.
The test words are in bold type*

- 1(a) /i e, **pitro'pi mas** 'itan a'kurasti/
"Our commissioners were indefatigable."
(b) /i **epitro'pi mas** 'itan a'kurasti/
"Our committee was indefatigable."
2(a) /pi'stevo 'oti i ,**simvu'li tu** 'itan so'fi/
"I believe that his counsellors were wise."
(b) /pi'stevo 'oti i **simvu'li tu** 'itan so'fi/
"I believe that his advice was wise."
3(a) 'no'mizo 'oti i **si,meto'xi tu** 'ine e'ksisu apa'retiti/
"I think that his co-participants are equally necessary."
(b) /no'mizo 'oti i **simeto'xi tu** 'ine e'ksisu apa'retiti/
"I think that his participation is equally necessary."
4(a) /mu 'eleye 'oti 'vriski **ton ,eni'ko tis** po'li enoxliti'ko/
"S/he was telling me that s/he finds her tenant very annoying."
(b) /mu 'eleye 'oti 'vriski **ton eni'ko tis** po'li enoxliti'ko/
"S/he was telling me that s/he finds her 'singular' [nonuse of politeness forms] very annoying."

lix 4

*The distractor sentences of experiment 2.
The distractors are in bold type*

- 1(a) /ma a'fto 'ine **porto'kali**/
"But this is an orange."
(b) /ma a'fto 'ine **portoka'li**/
"But this is orange."
2(a) /i a'**poxi tus** 'itan po'li me'γali/
"Their hunting-net was very big."
(b) /i **apo'xi tus** 'itan po'li me'γali/
"Their abstention was very big."
3(a) /teli'ka to 'kerðise **to me'talio**/
"Finally he won the medal."
(b) /teli'ka to 'kerðise **to meta'lio**/
"Finally he won the mine."
4(a) /stin omi'lia tu ana'ferθike **stus 'nomus tus**/
"In his speech he referred to their laws."
(b) /stin omi'lia tu ana'ferθike **stus no'mus tus**/
"In his speech he referred to their counties."

Appendix 4

The distractor sentences of experiment 2. The distractors are in bold type

- 1(a) /ma a'fto 'ine **porto'kali**/
"But this is an orange."
(b) /ma a'fto 'ine **portoka'li**/
"But this is orange."
- 2(a) /i a'**poxi tus** 'itan po'li me'ɣali/
"Their hunting-net was very big."
(b) /i **apo'xi tus** 'itan po'li me'ɣali/
"Their abstention was very big."
- 3(a) /teli'ka to 'kerðise **to me'talio**/
"Finally he won the medal."
(b) /teli'ka to 'kerðise **to meta'lio**/
"Finally he won the mine."
- 4(a) /stin omi'lia tu ana'ferθike **stus 'nomus tus**/
"In his speech he referred to their laws."
(b) /stin omi'lia tu ana'ferθike **stus no'mus tus**/
"In his speech he referred to their counties."