6. THE PHONOLOGY OF GREEK RHYTHM

6.1 A BRIEF SUMMARY OF THE RESULTS

In the previous four chapters, Greek stress, on which Greek rhythm is primarily based, has been studied. The examination of the acoustic and perceptual characteristics of Greek stress has been done by means of Experiments 1, 2, 3, 4 and 5. The results of these experiments can be summarised as follows.

1. The acoustic correlates of primary stress are amplitude integral and F0. The amplitude integral of stressed syllables is higher than that of unstressed ones; the difference is usually due to both longer duration and higher average amplitude, although it is possible to use only one of these parameters to achieve the higher amplitude integral of stressed syllables.

2. The main stress in a host-and-clitic group which violates the SWFC is not the lexical stress of the host, but the added enclitic stress.

3. The host's stress (secondary stress) is perceptually and acoustically identical to a subordinate lexical stress.

4. Although secondary stress has often been equated to rhythmic stress, syllables with secondary stress are acoustically and perceptually distinct from syllables thought to have rhythmic stress.

5. Very little evidence in support of rhythmic stress was found. Syllables that can have rhythmic stress are acoustically identical to unstressed syllables, although in the speech of certain speakers the former are sometimes differentiated from the latter by having higher amplitude integral due to their higher average amplitude. The higher RMS of rhythmically stressed syllables, however, does not render their AI equal to that of syllables with primary stress. Moreover, the difference between the AI of rhythmically stressed and unstressed syllables is not perceived by listeners.

Now that the characteristics of Greek stress have been studied, another question must be addressed: how does stress create rhythm in Greek, i.e. what are the features of Greek rhythm? These characteristics can best be revealed by examining the ways in which Greek remedies two phenomena which have always been considered disruptive of rhythm, namely stress clashes and lapses.
6.2 RHYTHMIC FEATURES OF GREEK

6.2.1 STRESS CLASHES

Stress clashes in Greek have not been examined in as much detail as lapses, although several phonological and phonetic studies of Greek mention them (Mirambel 1959; Dauer 1980a; M-DD; NV 1989; Botinis 1989; Condoravdi 1990). All researchers agree on one point, namely that in Greek the Rhythm Rule does not operate; in other words it is not possible to remedy a stress clash by moving leftwards the first one of the clashing stresses. Some researchers do not mention clashes further (Botinis 1989; Condoravdi 1990), while others state that there are other strategies, apart from the Rhythm Rule, that can be used in Greek to eliminate stress clashes (Mirambel 1959, Dauer 1980a, M-DD, NV 1989).

Mirambel (1959), in a rather controversial account, claims that the rhythm of Greek is ternary; i.e. a stressed syllable precedes or follows two unstressed ones. Consequently, according to Mirambel, stress clashes arise not only when two stresses fall on successive syllables, but also when two stresses are separated by only one unstressed syllable. Mirambel claims that both types of “stress clash” are eliminated by omitting the first of the stresses involved in the clash. It is not possible to accept Mirambel’s suggestion, however, as sequences like

(1) /po'li plo'ki/ met. great plot,

and

(2) /poliplo'ki/ complication

are easy to distinguish. If the stress of /po'li/ were removed in (1), (1) would sound the same as (2). Mirambel’s account is notable, however, for suggesting (a) that the rhythm of Greek is not binary, and (b) that in Greek even long sequences of unstressed syllables, which may be created by removing a stress involved in a clash, are acceptable.

Mirambel’s suggestion concerning stress clashes proper is accepted by most researchers, who agree that stress clashes can be eliminated in Greek by omitting one of the stresses, although not necessarily the first as Mirambel suggests (Dauer 1980a, M-DD)¹. Dauer (1980a) asked 6 phonetically naive native speakers of Greek to mark stresses in the recording of an extract from a Greek novel read by a native speaker of Greek. Although the agreement among the listeners was generally very good, stress clashes created considerable disagreement: some subjects marked both clashing stresses, but the majority marked only the first or the second one. Dauer obtained similar stress markings from two trained phoneticians, one of whom (Dauer herself) spoke Greek. Dauer’s data provide evidence that listeners usually hear only one of the clashing stresses; however, as they do not always agree on which stress is omitted, their responses are not a safe guide to the acoustic manifestation of stress clashes.

Interestingly, Dauer (1980a) also notes that if there is some “distance” between the clashing stresses it is possible to retain both; such distance can be a syntactic boundary, which allows the

¹ This view is not shared by NV (1989).
insertion of a pause, as in

(3) /'tala pe'6ja /'ketreksel/ ...the other children and she ran,

or simply the presence of final consonants in the first of the clashing syllables, as in

(4) /'ixa po'lus 'filus/ I had lots of friends.

Examples (3) and (4) indirectly support M-DD’s and NV’s (1989) proposals that a stress clash can be eliminated by the insertion of a pause between stresses, as in (3), or the lengthening of the first syllable involved in the clash, as in (4). Example (4) and the results of Experiment 1 show that lengthening can be achieved by either having a final consonant in the syllable, as in (4), or by lengthening the vowel of a CV syllable, as in /pa'pa/ in Experiment 1.

A possible explanation for these two types of lengthening could be related to Greek F0 patterns. As the F0 contours from all experiments presented here show, F0 is low and rising on a stressed syllable; this rise is followed by a fall, which starts on the following unstressed syllable and continues until the beginning of the next stressed syllable. In other words, there must be a trough between two F0 rises for the syllables with which the rises are associated to be perceived as stressed. This trough is obviously difficult to achieve between clashing CVCV syllables; thus, either one stress is eliminated, or the first vowel is elongated so as to acquire enough length to include the F0 trough. It seems that intervening consonants can help keep both stresses by assuming the same role as an elongated vowel: this can be achieved by having the FO fall on the consonants (if these are nasals or glides) or, possibly, by creating enough distance between the vowels (if the consonants do not belong to either of the above categories) to allow the F0 of the next vowel to start at a low level. In other words, the lengthening of the vowel or the extra syllable-final consonants provide the temporal interval for the F0 trough to take place. Obviously this is only speculation, but the question could be empirically tested by examining the course of the F0 between clashing stresses in CVCV and CVCCV sequences. By using voiceless consonants in some cases, and nasals or glides in others, as middle consonants in CVCCV words, it would be possible to test whether different types of consonants help eliminate the stress clash by affecting the F0 course in different ways (see above). If the above explanation of syllable lengthening proves correct then syllable lengthening aims not so much at separating the stresses (i.e. creating alternating rhythm), as at ensuring that both stresses can be fully realised acoustically.

The idea that F0 may play a part in stress clash elimination in Greek is also presented by NV (1989), who suggest that it is possible to eliminate a stress clash in Greek by pronouncing one of the syllables involved in the clash on a very low tone and the other one on a very high tone. As

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2 Similar ideas are expressed by Bolinger (1965a and 1965b). Bolinger (1965a) states that English readily-accentable monosyllables (roughly content words) lengthen only when they occupy the first position in a stress clash. Bolinger suggests that this lengthening does not happen in order to keep interset stress intervals isochronous, but in order to enable the pitch contour of the monosyllable to be realised. Bolinger (1965b) also noticed that the adverb in constructions like zoom off is more likely to be perceived as de-accented than the adverb of constructions like scurry off, he suggests that this is due to the fact that in zoom off there is no unaccented syllable to carry the F0 trough which is necessary between two accents. It is worth noting that in the English examples it is the second word that is de-accented, while in the Greek examples it is usually the first word.
this particular strategy has not been documented in acoustic studies, more detailed and systematic investigation is necessary.

However, there is one important observation about stress clashes in Greek which usually attracts very little attention; namely that Greek does not use the Rhythm Rule which, according to phonological accounts, operates in many languages, such as English, German and Masoretic Hebrew (LP), Polish (Hayes and Puppel 1985), Catalan and Italian (NV 1989)\(^3\) in order to eliminate stress clashes and thus promote eurythmy. Most studies suggest that the Rhythm Rule does not operate in Greek because Greek stress has a high functional load; by moving the stress to another syllable the speakers would risk being misunderstood. Although this is a valid reason why the Rhythm Rule does not operate in Greek, I believe that there is an additional explanation. In the grid, the operation of the Rhythm Rule consists in moving leftwards a X from its original position to another position; given that a grid whose columns have gaps is not well formed, a X can only move from a column of n Xs to a column of n-1 Xs; e.g.

\[(s)\]

\[
\begin{array}{cccccccccccc}
  & x & x & x & x & x & x & x & x & x & x & x \\
\end{array}
\]

Mississippi legislature > Mississippi legislature

(NV 1989:97). In addition, a X cannot move to a stressless syllable. Such a syllable would be marked [-stress] in LP's model and have only one X in their grid like, for example, the underlined syllable in (6).

(6) Michèlle Róbinson > *Michelle Róbinson

Thus, for the Rhythm Rule to operate it is necessary for another syllable, where a X may move, to exist. This is why, in my opinion, the Rhythm Rule cannot operate in Greek; because in Greek there is only one strong syllable per word, i.e. only one syllable that has more than one Xs. Thus, if we assume that the strong syllable of a co has 3 Xs (as NV 1989 suggest), then moving the top one to another syllable would result in a malformed grid which would contain a gap, as in (7a); if we assume that the strong syllable of a co in Greek has two Xs (a suggestion that will be discussed in section 6.5.2), the top X cannot move because it would have to move to a position with only one X, as in (7b).

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\(^3\) However, Farnetani & Kori (1990) found no acoustic evidence that the Rhythm Rule operates in Italian.
The clashes considered up to now involve phrases with only two constituents. In English, however, the Rhythm Rule can also operate in longer phrases, as in *good-looking tutor* or *almost hard-boiled egg*, by making *good* and *hard* stronger than *looking* and *boiled* respectively. This is also an area in which the Rhythm Rule cannot operate in Greek, for the same reason as in example (7); i.e. because there is no suitable position to which a X may move. This is because in a Greek φ with more than two constituents, all constituents apart from the designated terminal element (DTE) have the same prominence. For example, in

\[(7a) \quad \text{many friends} \]

\[(b) \quad \text{poli fili > *poli fili} \quad \text{poli fili > *poli fili} \]

\[x \quad x \]
\[x \quad x \quad x \quad x \]
\[x \quad x \quad x \quad x \quad x \quad x \quad x \quad x \]
\[\text{poli fili > *poli fili} \quad \text{poli fili > *poli fili} \]

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\[(8) /a'prasa 'tris akrives 'fustes/ I bought three expensive skirts, \]
\[/tris akrives 'fustes/ forms one φ in which the stresses of the first two constituents are of the same level; the grid according to NV (1989) is shown in (9a), while a simplified grid is shown in (9b).

\[(9a) \quad \text{tris akrives fustes} \]
\[x \quad x \quad x \quad x \quad x \quad x \quad x \quad x \quad x \quad x \quad x \quad x \quad x \quad x \quad x \quad x \quad x \quad x \quad x \quad x \quad x \quad x \quad x \quad x \quad x \quad x \quad x \quad x \quad x \quad x \quad x \quad x \quad x \quad x \quad x \quad x \quad x \quad x \quad x \quad x \quad x \quad x \quad x \quad x \quad x \quad x \quad x \quad x \quad x \quad x \quad x \quad x \quad x \quad x \quad x \quad x \quad x \quad x \quad x \quad x \quad x \quad x \quad x \quad x \quad x \quad x \quad x \quad x \quad x \quad x \quad x \quad x \quad x \quad x \quad x \quad x \quad x \quad x \quad x \quad x \quad x \quad x \quad x \quad x \quad x \quad x \quad x \quad x \quad x \quad x \quad x \quad x \quad x \quad x \quad x \quad x \quad x \quad x \quad x \quad x \quad x \quad x \quad x \quad x \quad x \quad x \quad x \quad x \quad x \quad x \quad x \quad x \quad x \quad x \quad x \quad x \quad x \quad x \quad x \quad x \quad x \quad x \quad x \quad x \quad x 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acoustic realisation of both stresses rather than the creation of a more eurhythmic pattern, since
the stresses remain very close to each other. The lack of binary rhythmic patterns in Greek is
supported by the fact that the Rhythm Rule does not operate in Greek: at each level there is only
one strong constituent, while its sisters are all at the next level down; i.e. there is no deep
embedding of stresses which would allow the movement of beats from one position to a more
eurhythmic one.

6.2.2 STRESS LAPSES

As noted in Chapter 1, section 1.6, although most phonological and phonetic studies of Greek
do not mention either stress lapses or rhythmic stresses, some deal in great detail with these
aspects of Greek rhythm\(^5\). The existence of rhythmic stress is most strongly argued for by M-DD
and NV (1989), while Joseph & Philippaki-Warburton (1987) present a more moderate view of
the matter. However, as Experiment 5 has demonstrated, there is no evidence that rhythmic stress
is regularly present in the acoustic signal, a finding which explains, among other things, why
rhythmic stress is not perceived by native listeners.

There are, though, other processes in Greek which affect rhythm. One such mechanism, which
has already been mentioned, is high vowel reduction, whose effect is to shorten the interval
between adjacent stresses. A rhythmic effect, similar to that of vowel reduction, seems to be
achieved by certain sandhi rules which reduce the number of syllables in words, thus bringing
stresses closer. These are vowel degemination and vowel deletion, both of which operate at word
boundaries, when one word ends in a vowel and the next one begins with one. As the names
imply, vowel degemination involves identical vowels, and vowel deletion different ones. Neither
degemination nor deletion takes place when its output would result in a stress clash (Nespor
1986, Condoravdi 1990). Apart from this rhythmic consideration, however, the operation of both
processes does not seem to depend on rhythm; instead it seems to be regulated by prosodic
constituency\(^6\), although the precise prosodic domains in which deletion operates are still a matter
of controversy (see e.g. Kisse 1977, Condoravdi 1990). The rules of vowel deletion and
degemination and their domains are beyond the scope of this thesis; what is of interest here is the
fact that these two processes reduce the number of unstressed syllables in an utterance.

Thus, although high vowel reduction and vowel degemination and deletion are not
rhythmically motivated, they have an effect on rhythm. However, this effect is limited by their
nature. For any of these processes to take place certain conditions must exist; these are either

\(^5\) This contrasts with the situation in English studies which deal almost exclusively with the question of stress
clashes. It is tempting to speculate that the different degree of attention given to clashes and lapses in the studies
of the two languages reflects the inherent characteristics of their rhythm. In English, in which stresses are
frequent, rhythmic alternation is disrupted by clashes, while in Greek, in which stresses are sparse, alternation is
disrupted by lapses.

\(^6\) The term *prosodic* is used according to NV's (1986, 1989) definition. Prosodic structure represents both abstract
prominence patterns and the domains of sandhi rules. Prosodic structure is mapped onto *rhythmicmetrical*
structure, represented in NV (1989) by a grid. Whether this differentiation between prosodic and rhythmic
structure is necessary will be discussed in sections 6.5.1 and 6.5.4.
acoustic in nature, as in high vowel reduction (see Chapter 5, section 5.3), or prosodic, as in vowel degemination and deletion. It is obvious that these conditions cannot be present with any regularity. Thus, the operation of high vowel reduction and vowel degemination and deletion has only limited rhythmic consequences. The small rhythmic effect of these processes combined with the lack of acoustic evidence for rhythmic stress indicates that lapses are tolerated to a large extent in Greek.

The above observations are based mainly on the data from Experiment 5 and concern lapses at the lowest level of the grid, i.e. series of unstressed syllables within and across words. In English, however, a series of [w] nodes at higher levels can also attract rhythmic stress. For instance, LP (p. 325 ff.) say that phrases with two (or more) consecutive [w] nodes to the left of the [s] node, like

(11) three red shirts,

can have additional [s] nodes in order to break up "a sequence of otherwise equal ‘upbeats’" (LP:327). Obviously the more [w] nodes there are to the left of the original [s] node, the more likely is this strategy to occur; (11), however, is a good example as it has its exact parallel in Greek. Thus, (11) can have the grid in (12). In contrast, the same sequence in Greek, will have the grid in (13a).

(12)  

\[
\begin{array}{cccc}
\text{x} & \text{x} & \text{x} \\
\text{x} & \text{x} & \text{x} \\
\text{x} & \text{x} & \text{x} \\
\text{three red shirts}
\end{array}
\]

(13a)  

\[
\begin{array}{cccc}
\text{x} & \text{x} & \text{x} & \text{x} \\
\text{x} & \text{x} & \text{x} \\
\text{xx} & \text{x} & \text{x} & \text{x} & \text{x} \\
\text{tria kokina pukamisa} & \text{pukamisa}
\end{array}
\]

As shown in section 6.2.1, adding a X to /tria/ in order to eliminate the lapse would result in a φ without a head, since the stresses of /'tria/ and /'pukamisa/ would be at the same level. Moreover, in Greek it would not be possible to add extra Xs to /'tria/ and /'pukamisa/, as in (13b), in order to keep their relative prominence intact, while making /'tria/ more prominent than /'kokina/. If extra prominence is given to /'tria/ the result is contrastive stress: I said THREE red shirts (not four). It is interesting to note that NV (1989) who propose that lapses at the first level of the grid are remedied by the addition of rhythmic stresses, agree that in Greek lapses can only be defined at the first level of the grid; i.e. NV do not consider a series of stresses of equal strength a lapse.
In Greek.

In short, the evidence from both clashes and lapses strongly suggests that it cannot be maintained that Greek has binary rhythm. Obviously in Greek, like in other languages, clashes and lapses are not welcomed, yet their effect on rhythm seems to be sufficiently small to allow the speakers of Greek not to eliminate clashes and lapses with the consistency and stringency observed in languages like English. In other words, the relative prominence of constituents within and across words cannot be modified so that an alternating rhythmic pattern can be created. The rhythmic structure of Greek, although more free in a sense, is also more rigid than that of English. In English the strongest requirement is for speech to conform to an alternating rhythm and many processes take place so that speech can abide by this requirement. In Greek the requirement is not so much for a certain rhythmic pattern, be it binary or otherwise, but rather for stress to fall always on the same syllable of each word, the syllable designated as stressed in the lexicon. Binary patterns will of course appear, but they are not compulsory, and the structure of the language will not be altered in order to preserve or create them.

6.3 THE PERCEPTION OF RHYTHM

Positing that Greek has non-binary rhythmic structure appears to contradict both phonological theories of rhythm and psychological evidence on rhythm perception. The phonologists' predilection for binary rhythm is well-documented (LP, Hayes 1981 and 1984, NV 1989). At most, in addition to binary patterns phonologists are prepared to accept ternary ones (i.e. swwswwsww); for instance, Selkirk (1984:52) claims that the rhythm of all languages follows the Principle of Rhythmic Alternation which has two clauses:

"a. Every strong position on a metrical level n should be followed by at least one weak position on that level.

b. Any weak position on a metrical level n may be preceded by at most one weak position on that level.”

Phonologists often accept that the binary rhythmic patterns they predict are not always present in the acoustic signal (e.g. Hayes 1981:16). They claim, however, that speech is perceived as having such patterns, because the listeners impose them on the signal. Selkirk (1984:39), for example, asserts that she gives “full credence to the impression of isochrony - to the impression of rhythm - as revealing something about how the mind grasps the organization of speech in time”.

The argument of phonologists like Selkirk is that binary rhythmic structure is required by the psychological propensities of humans. However, there is no psychological evidence for this strong claim that binary rhythmic patterns may not be acoustically present, but are created by a perceptual tendency of listeners to hear binary rhythms. Assertions on the proclivities of humans in relation to rhythm and timing in general have been based mostly on the work of the psychologists Woodrow (1951) and Fraisse (1963), who are often cited as presenting evidence that humans have a natural predilection for binary rhythms. But nowhere do either Fraisse or
Woodrow claim that subjects perceive exclusively, or even more frequently, binary patterns. For instance Woodrow (1951:1233) writes: “[p]rovided the rate at which the series [of identical stimuli] is run off is neither too slow nor too fast, the subject will ordinarily perceive a series of groups, with some member of each group carrying an accent [...]. The number of members grouped together in one rhythmical measure is increased from two to six, or more, with increasing rate. In a subjective grouping by four, with the first member accented, the third member is apt to be given a lesser, secondary accent [...]. In general, however, subjective rhythms show considerable variation in the position of the accented members.” This extract is interpreted by Martin (1972), who was the first to suggest a hierarchical organisation for speech based on binary patterns (a model remarkably similar to that of LP), as evidence that the “natural pattern” of speech rhythm is exclusively trochaic, while “more complex patterns are patterns within patterns” (Martin 1972:490); in other words that groupings of more than two syllables are always reduced to binary patterns. As the above extract from Woodrow shows, however, Martin (1972) makes a very strong claim for binary rhythm from very little evidence.

A point that is often not given sufficient consideration when interpreting Woodrow’s and Fraisse’s findings is that these concern exclusively series of identical stimuli in which what has been called subjective rhythm is imposed by the subjects. In speech, however, we are not dealing with identical stimuli, but with stimuli (i.e. syllables in this case) which are already rhythmically grouped: for instance, stressed syllables are acoustically more prominent than unstressed ones, in languages like English some unstressed syllables are further reduced compared to other unstressed syllables, and so on. The argument of many scholars seems to be that if stresses do not appear on every other syllable, the unstressed syllables become the equivalent of a series of identical stimuli upon which subjective rhythm is imposed. This may be happening in English under the influence of the predominantly binary stress patterns. Since Greek is not under such influence, however, there is no reason to assume that the complex rhythm of Greek is reduced to a binary one by the listeners.

A further point which is not considered is the possibility that psychological experiments which use non-speech material as stimuli cannot provide accurate information about the way in which speech rhythm is perceived. Moore (1989:267) quotes Stevens & House (1972) as saying that “[s]ounds are perceived as either linguistic or as nonlinguistic entities.” Therefore, the results of experiments which involve pure tones or clicks, as psychological experiments usually do, may not be relevant to speech rhythm perception because their stimuli were listened to in a non-speech mode (see also Chapter 1, section 1.3.1).

The gap between the perception of speech and non-speech stimuli is quite clear in Bell’s (1977) study. His stimuli consisted of series of tones in which duration, frequency and intensity were manipulated in order to give more prominence to some of the tones, thereby creating rhythmic patterning. The stimuli were presented to native speakers of languages with different
dominant accent patterns; e.g. French and Persian (final accent), Polish (penultimate stress), English ("free" stress). Bell’s hypothesis was that in grouping the stimuli rhythmically, the subjects would be influenced by the stress patterns found in their respective languages. No such trend was found. Bell’s results contrast with those of Berinstein (1978) who, as mentioned in Chapter 1, section 1.2.2, used speech stimuli and found that her subjects were influenced by the dominant stress pattern of their native language. Bell’s and Berinstein’s studies suggest that more caution is required when evidence from psychological experiments is projected onto speech. Psychological experiments can reveal that human perception tends to rely on rhythmic patterning, but this does not mean that this tendency is manifested in exactly the same way in speech perception as in the perception of non-speech stimuli. For instance, as mentioned in Chapter 1, section 1.3.1, the JNDs for speech stimuli are higher than those appropriate for non-speech stimuli (Lehiste 1977).

If, however, the psychological evidence is accepted as an indication of general trends in rhythm, it shows that rhythmic patterns are not necessarily binary. As mentioned, Woodrow’s subjects (subjectively) grouped stimuli in groups of up to at least six stimuli. Such long groups are possible if their overall duration falls within the limits of what has been called the psychological present, i.e. "[...] the maximal physical time over which may extend a temporal stimulus pattern, the successive parts of which are perceived as a whole [...]" (Woodrow 1951:1230). Different studies show a great deal of variability concerning the upper limit of the psychological present, with times ranging from 2.3 to 13 sec (see Woodrow 1951 and Fraisse 1963). Even the most conservative estimate of the maximal length of the psychological present, approximately 1.8 sec (see Fraisse 1982), can include at least 2 stressed and 10 unstressed Greek syllables, given that a stressed syllable has an average duration of 200 ms and an unstressed one of 140 ms or less. These twelve syllables can easily form two groups of 6, in which the stressed syllables are separated by 5 unstressed ones; e.g.

(14) /o kataπlιtki'kos taxισaktιlur'γυς/ the amazing juggler.

This is probably an extreme case, but it illustrates the point that such grouping is perceptually viable. Moreover, Woodrow notes that the number of stimuli that can be grouped together depends to a large extent on the rate of presentation (tempo): the faster the tempo, the larger the possible number of elements in a group. This agrees well with the observation that in Greek the speech rate is very fast (compared to English) when measured in syllables per second: Dauer (1980a) reports that Greek is spoken at a rate of 7-8 syllables per second, while English is spoken at a rate of 5-6 syllables per second. The reason why Greek is spoken at so fast a tempo, namely that syllable structure is predominantly CV (70% of syllables in Dauer’s data), is not of as much importance as the fact that this fast rate facilitates the grouping of more syllables.

Thus, I propose that rhythm is created in Greek by grouping regulated by the stressed syllables. Stressed syllables are linked to unstressed syllables in groups of non-uniform structure, i.e. groups which do not contain a fixed number of syllables, since stressed syllables do not recur
at regular intervals. The lack of regularity in the patterns does not pose a problem for the perception of rhythm, as psychologists agree that to perceive rhythm it is sufficient for successive groups to be of “similar pattern and experienced as repetitive” (Woodrow 1951:1232). For these conditions to be achieved, it is enough for speakers of Greek to know that stressed syllables recur at intervals. The impression of periodicity is presumably reinforced by the undulating F0 pattern which is so characteristic of Greek. The role of fundamental frequency should not be underestimated; as Fraisse (1982) notes, rhythm does not depend exclusively on the duration of stimuli, but also on their intensity and fundamental frequency.

It is not yet possible to say whether or not in Greek stressed syllables occupy a certain position in the stress group. In English, for instance, it is postulated that stress feet (i.e. stress groups) are formed by linking together a stressed syllable and all the following unstressed ones up to the next stressed syllable (e.g. Abercrombie 1967); i.e. the stressed syllable is always in the initial position of the stress group. Given that most Greek words are preceded by unstressed proclitics and that stress may fall only on the last three syllables of a word, stress is unlikely to occupy the initial position in the stress group. Anecdotal evidence from linguistic games of rhythm suggests that grouping in which the stressed syllable does not occupy the initial position is preferred; e.g. the repetition of [sws] meters of the same phonological material results in the listener’s perception of [wsw] meters instead; similarly, the repetition of [sws] meters is perceived as a repetition of [ws] meters. It is equally likely that the grouping of stressed and unstressed syllables in speech must be interpreted in a rather loose manner.

Supporting evidence comes from other aspects of rhythmic behaviour, in particular Greek poetry and music. Recent studies show that Greek poetic rhythms cannot be adequately described as repetitions of simple meters; instead they seem to be primarily based on syllable count, while stress may appear on every third or fourth syllable in a line and may move to different syllables (within limits) without disrupting the line’s rhythm (Stavrou 1974, Garantoudis 1989). Similarly, it is often impossible to mark bars in the transcription of Greek folk songs, indicating that the rhythm of such songs cannot be reduced to repetitions of a simple pattern (Baud-Bovy 1983). When the meter of folk songs can be determined, further similarities between speech and music are found. Like speech, music shows a predilection for non-binary rhythms. For instance, Baud-Bovy (1983) gives examples of Greek folk songs in 3/4, 5/4 and 9/4, 3/8 and 7/8, and 7/16, 9/16 and 11/16; in contrast, binary meters are rarer and much less variable in Greek folk music (2/4, 4/4, 6/4 and 6/8).

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7 For instance, the marking of stresses in a 16-line paragraph from a Greek novel (C.Tachisis' To ξοβερό Ρημα *The terrible step*), based on my auditory transcription of my own reading shows that the paragraph contains 78 interstress intervals: 18 of them contain one unstressed syllable, 21 contain 2 unstressed syllables, 23 contain 3 unstressed syllables, 12 contain 4 unstressed syllables, and 4 contain 5 and 6 unstressed syllables (two of each); there are also 4 stress clashes.

8 The evidence comes from children’s games in which the repetition of the sequences */nisamu/* my *Nisa* (woman’s name) and */tosomal* a *cologne brand* gives rise to rude alternatives with the stress patterns [wsw] and [ws] respectively.
In conclusion, psychological evidence suggests that binary rhythm is not the only option available to speech. Greek shows that it is possible for a language to have a more complex and variable rhythm which is not based on the repetition of a simple pattern. The evidence from Greek speech is supported by the rhythms attested in Greek poetry and music; as in speech, these rhythms are not binary and seem to be based on a more loose interpretation of rhythmic patterning than Western music and poetry would suggest.

6.4 THE STRESS-/SYLLABLE-TIMING DISTINCTION

Phoneticians, like phonologists, have used the results of psychological research to support their theories of speech rhythm; in particular to retain the idea that languages belong to two different rhythmic categories, stress- and syllable-timing, despite the lack of acoustic evidence in favour of this distinction. The most notable effort in this direction is that of Lehiste (1977) who suggested that rhythm is based on perceptual rather than acoustic isochrony. As mentioned in Chapter 1, section 1.3.1, her idea is based on Allen (1975), who in turn based his proposals on Woodrow's (1951) and Fraisse's (1963) work, and in particular on the finding that listeners seem to overestimate the duration of short stimuli and underestimate the duration of long ones. This perceptual isochrony explains why interstress intervals of unequal durations are perceived as more isochronous than they are. Perceptual isochrony also implies that, in French, syllables of unequal durations are perceived as isochronous (since French is considered syllable-timed).

As mentioned in Chapter 1, section 1.3.1, though, Scott et al. (1985) found that in a tapping experiment French and English listeners responded in very similar ways to French and English stimuli. It was suggested then that perceptual isochrony as observed in tapping experiments is not related to the rhythmic category a language belongs to, but to speech in general. I would like to take this hypothesis further and suggest that Scott et al. obtained their results because rhythm is based on accent in all languages, whether syllable- or stress-timed (Dauer 1983, NV 1989).

The idea that rhythm is based on accent is not new; it was first expressed by European functionalists, according to whom accent is "la mise en relief culminative" (Trubetsky 1949:221; italics as in the text). Beckman (1986:21) summarises this view aptly when she suggests that accent's "primary function is to set up syntagmatic contrasts among the prosodemes of the utterance, and to thereby organize the utterance around the location of the units that are marked by the prominences." In contrast with British and American scholars, for the European functionalists accent can be manifested phonetically through a variety of means; stress is just one such manifestation. In other words, accent in all its acoustic forms contributes to rhythm; it follows that the rhythm of languages like French is based on accent, not on syllable succession. The finding that F0 and intensity play an important part in the creation of rhythm (Fraisse 1982, see section 6.3) supports the suggestion that accent is the main contributor to rhythm irrespective

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9 As noted in Chapter 1, section 1.3.1, perceptual isochrony has been observed in experiments with both speech and non-speech stimuli. It seems, however, that perceptual isochrony is more pronounced in speech (among others, Lehiste 1977).
There are further arguments in favour of the idea that rhythm is based on accent in all languages. To begin with, subjective rhythm (which, interestingly, is very rarely referred to by phoneticians) is incompatible with the idea of syllable-timing; this is because syllable-timing is based on the succession of identical stimuli, while the function of subjective rhythm is to impose a prominence pattern on such stimuli. Thus, even if it could be accepted that duration alone is the main contributor to rhythm and that in a language like French all syllables have the same duration, the listeners would impose rhythmic structure on them, i.e. would perceive some syllables as more prominent than others.

However, no evidence that syllables are isochronous in French has been found. Moreover, recent research has demonstrated that French is not rhythmically as different from English as was previously thought. For instance, Dell (1983) has shown that the metrical structure of French is based on the same principles as the metrical structure of English: rhythmic alternation (though not as strict as in English), secondary stress on polysyllabic words and the Rhythm Rule. Fletcher's (1989) acoustic study also shows that French shares rhythmic features with English; accented syllables in French are longer than unaccented ones, and accents occur at a rate similar to English (1.4-2 per second). It is not therefore surprising that French subjects responded very similarly to English subjects in Scott et al.'s (1985) tapping experiment; rhythm is based on accent in French as well as in English.

In addition, the above view of the relationship between stress, accent and rhythm can perhaps explain what most theories of rhythm leave unanswered; namely why studies of Japanese provide evidence for mora-timing, while studies of syllable- and stress-timed languages fail to provide evidence for these categories. The difference between Japanese and other languages is related to the fact that Japanese has pitch-accent. According to Beckman (1986) duration plays only a minor part in the production and perception of accent in Japanese, while pitch plays the most important part. Since rhythm is based on accent, Japanese rhythm must be based on pitch prominence rather than durational patterns; thus, the duration of morae can be stable since it is not influenced by accent. In contrast, in languages with stress-accent, like English, Spanish and Greek, duration is a strong correlate of accent. Therefore it is perhaps wrong to expect isochrony in languages with stress-accent because, due to their accentual system, they cannot by definition exhibit isochrony.

However, if rhythm is based on accent grouping in all languages the stress-/syllable-timing distinction is unnecessary and incorrect. It only remains to be seen how this distinction has arisen and why languages with similar accent systems, like English, Greek and Spanish, have been classified in different rhythmic categories. I would like to suggest that the different classification of the above languages is related to factors like those put forward by Dauer (1987): for example, in English the stressed syllables are proportionally much longer than the unstressed ones, while in Greek and Spanish the difference is smaller; similarly, English has syllable weight distinctions, while Spanish and Greek do not. These factors, however, are not of great consequence from the
native speaker's point of view; for the native speaker it is accent grouping, rather than the means by which it is realised, that is essential for rhythm. Factors like those put forward by Dauer (1987) can only explain why English-speaking phoneticians perceive the rhythm of Spanish or Greek as being different from the rhythm of English. In other words, the stress-/syllable-timing distinction reflects the rhythmic impression a language gives to non-native speakers. It is useful to recall Roach's (1982) observation that the languages which have been called syllable-timed have been characterised so by native speakers of Germanic languages.

Thus, from the point of view of phonetics and the study of rhythm the stress-/syllable-timing distinction is both irrelevant, because it does not actually tell us anything useful about the rhythmic organisation of speech, and incorrect because it wrongly assumes that there are languages in which rhythm exists without patterning (syllable-timing). The only way out is to abandon the stress-/syllable timing distinction whose purpose seems to be the reinforcement of non-native impressions of the rhythm of languages. Instead, I think it is worth devising an abstract representation of rhythm. Dauer's (1987:477) criticism of such a representation, namely that it "tends to make all languages look rhythmically alike", is in my opinion its strength: an abstract representation has the advantage of capturing the rhythmic features of individual languages and showing at the same time that the rhythm of all languages is based on the same principle, accent grouping. Relying on an abstract representation does not mean that the search for the acoustic manifestation of rhythm is not a legitimate target, however; indeed the acoustic evidence is necessary for the elaboration of the abstract representation and also for other purposes, like the implementation of speech synthesis and automatic speech recognition models. Despite its usefulness, however, the acoustic evidence alone cannot fully account for rhythm.

6.5 A POSSIBLE METRICAL REPRESENTATION

6.5.1 WHICH FORMALISM?

Now that it has been shown that in Greek binary rhythm is far from being the norm, a further question arises: what type of formalism can best represent the rhythm of Greek? The options include grids, or trees of binary or n-ary branching, or a combination of both. Although all these formalisms follow the same principles of hierarchical structure and non-recursiveness, some of them are clearly less appropriate for Greek than others. For instance, a grid-only representation would be insufficient for Greek, which has several sandhi rules, because it cannot explicitly show the constituent structure on which the operation of these rules depends. (Having said that, Selkirk (1984) did propose the Silent Demibeat Addition mechanism in order to define domains of sandhi rule application in the grid.) Similarly, binary trees would be inappropriate for Greek, since Greek does not have binary rhythmic patterns (see also Chapter 1, section 1.4.3 on binary branching).

A possible candidate is the formalism presented by Pierrehumbert & Beckman (1988). The authors propose a prosodic representation based on n-ary branching trees. Pierrehumbert & Beckman suggest that these prosodic trees are close to the surface and do not represent abstract
prominence patterns but possible phonetic realisations of such patterns. The authors’ aim is to use these trees as the basis for the calculation of algorithms for phonetic realisation. Pierrehumbert & Beckman say that, given our present knowledge of prosody, it is not possible to assert that the prosodic trees they propose are the only prosodic representation, or whether they are mapped from an abstract representation which is more closely linked to syntax and phonology; i.e. whether or not it is necessary to postulate a distinction equivalent to that between trees and grids in LP, and that between prosodic and metrical structure in NV (1989). However, the authors do point out that, in their view, if it is necessary to have two representations, the one closer to the surface is not a grid, as LP and NV propose, but a tree.

The present data suggest that in Greek two different representations may indeed be necessary, since prosodic domains, which are needed for the correct interpretation of sandhi rules, do not correspond to differences in relative prominence among constituents. For instance, Condoravdi (1990) proposes that the various rules of vowel deletion can best be accounted for if another category, which she calls minimal phrase (z), is added in the prosodic hierarchy between ω and φ. The algorithm according to which z is defined is not of great relevance here; suffice it to say that it is based on syntactic structure, and groups into a z all constituents of a syntactic phrase up to the phrase’s head; the rest of the syntactic phrase forms a separate z. The important point is that the z level does not contribute to the rhythmic structure of Greek.

Thus, on the one hand, the prosodic structure of Greek is relatively complicated and characterised by fairly deep embedding. On the other hand, the rhythmic structure of Greek is much flatter. Therefore, using the same structure for both rhythm and sandhi rules would require one either to posit more stress levels than necessary or to account for sandhi rules incompletely. It follows that Greek needs both a prosodic and a rhythmic representation. The prosodic representation is prior to the rhythmic one; the latter is derived from the former by mapping which simplifies the prosodic structure. A double representation is probably not necessary in all languages. For instance, it is likely that in English the same metrical structure can account both for stress patterns and sandhi rules, as English requires very deep embedding for stress and has relatively few sandhi rules.

NV (1986) have already presented a partial prosodic analysis of Greek, referring particularly to its ω and C domains. In my opinion a new analysis is necessary, however, as one of the assumptions on which NV have based their analysis are incorrect, namely the relative prominence

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10 This way of constructing z means that, in some cases, Condoravdi’s z corresponds to NV’s (1986) φ, and her φ to NV’s I level. For example, the sequence I won thirteen thousand has the prosodic structure in (a) according to NV, and that of (b) according to Condoravdi.

(a) [ [['kerbíusa]o [ékéas'ris xi'íjaðes]φ]]
(b) [ [['kerbíusa]z [ékéas'ris xi'íjaðes]z]]

In addition, as Condoravdi’s rules of z formation differ from those of NV’s rules of φ formation, in some cases the two models yield different prosodic structures for the same sequence, even allowing for differences due to the z level; (c) and (d) show the prosodic structure of I hurriedly read the letter according to NV’s and Condoravdi’s rules respectively.

(c) [ [['òjivasasa]φ [västis’ka]φ to ’prama]φ]]
(d) [ [['òjivasasa]z [västis’ka to ’prama]z]].
of the two stresses in a host-and-clitic group. The following discussion concentrates on the foot, the phonological word, the Clitic group and, to a much lesser extent, on the phonological phrase\textsuperscript{11}, as I believe that it is at these levels that the relative prominence of constituents makes its greatest contribution to rhythm. Consequently, this discussion does not include the levels of intonational phrase (I) and phonological utterance (U).

6.5.2 THE FOOT

In NV's (1986) model, the syllables of a word are linked into feet (Σ) whose heads (i.e. strong syllables) can be either in initial or final position. This way of constructing feet is suitable for a language which has fixed initial or final stress, or more than one stresses in each word. The drawback of this formula is that if it is used for the representation of a language like Greek, in which the single stress of a word may not be in initial position, it makes the incorrect prediction that the word will have an additional stressed syllable; e.g.

\begin{equation}
\begin{array}{c}
\omega \\
\Sigma \\
\sigma \\
vivliopolio
\end{array}
\end{equation}

\textit{bookshop}

Although NV (1986:89 ff.) argue that it is highly unlikely for polysyllabic words in any language to have only one stress, they admit that the structure in (15) is a disadvantage of n-ary branching trees; in contrast, a binary branching tree, as in (16), would give the correct stress pattern of the word /vivliopo'lio/ (but at the cost of positing 4 unnecessary nodes).

\textsuperscript{11} Syllables are beyond the scope of this thesis, especially since in Greek they do not seem to affect metrical structure.
NV suggest that the problem of (15) could be solved by having a low-level phonetic rule which would turn all extra [s]s to [w]s at the surface (NV 1986:89 ff.). This is, however, equally awkward since it demonstrates that the foot structure is totally gratuitous in (15) and similar cases. A purposeless foot structure is against one of the principles of prosodic phonology; namely that a prosodic category is posited only if there are rules which have this category as their domain of operation, or if this category is the domain of relative prominence (NV 1986:27 ff.). In English, for instance, foot structure regulates secondary stresses within words and the aspiration of voiceless stops.

A first argument against foot structure in Greek is that, as mentioned, each Greek word has only one stress. Therefore, the foot structure is not necessary in Greek for stress purposes. If, however, there are other rules which use the foot as their domain, then the foot structure should be retained; this would not pose a problem for the present model, in which foot structure would be simplified during the mapping from the prosodic to the rhythmic representation. Let us examine whether there are any reasons apart from prominence patterns for postulating foot structure in Greek.

NV (1986) present a possible reason for foot structure, which relates to poetry. They give examples of rhymes in Dutch and say that the structure of these rhymes can be most efficiently explained by a foot representation: rhyming elements “consist of the final foot of a word minus the onset of the first syllable” (NV 1986:102). For example,

(17) hogere - drogere  
    higher - drier  
(NV 1986:102), which are both stressed on the antepenult.

At first sight, this seems to be a good argument for feet in Greek as well. In Greek, lines are considered to rhyme “when their last stressed vowels and all the following phones, if there are any, sound exactly the same” (Stavrou 1974:104; my translation). However, although many examples show that the relevant “phones” usually belong to the same word, they need not do so; if the rhyming elements do not belong to the same word, they cannot possibly belong to the same
foot, according to NV (1986); e.g.

(18) /san 'amul/ - /vasa'na mu/ like sand - my worries\(^\text{12}\).

The differences between the foot structures of the two words in (18) can be clearly seen in their prosodic trees, which are drawn in (19a) and (19b) following NV’s (1986) suggestions\(^\text{13}\).

\[\text{(19a)}\]

\[
\begin{array}{cccc}
\text{w} & \text{s} & \text{w} & \text{w} \\
\text{\text\_\text\_} & \text{\text\_\text\_} & \text{\text\_\text\_} & \text{\text\_\text\_} \\
\text{\text\_\text\_} & \text{\text\_\text\_} & \text{\text\_\text\_} & \text{\text\_\text\_} \\
\text{s} & \text{\text\_\text\_} & \text{\text\_\text\_} & \text{\text\_\text\_} \\
\text{\text\_\text\_} & \text{\text\_\text\_} & \text{\text\_\text\_} & \text{\text\_\text\_} \\
\text{san} & \text{amu} & \text{vasana} & \text{mu} \\
\end{array}
\]

\[\text{(b)}\]

\[
\begin{array}{cccc}
\text{s} & \text{w} & \text{w} & \text{w} \\
\text{\text\_\text\_} & \text{\text\_\text\_} & \text{\text\_\text\_} & \text{\text\_\text\_} \\
\text{\text\_\text\_} & \text{\text\_\text\_} & \text{\text\_\text\_} & \text{\text\_\text\_} \\
\text{s} & \text{\text\_\text\_} & \text{\text\_\text\_} & \text{\text\_\text\_} \\
\text{\text\_\text\_} & \text{\text\_\text\_} & \text{\text\_\text\_} & \text{\text\_\text\_} \\
\text{like sand} & \text{my worries} \\
\end{array}
\]

Example (18) also shows that the rhyme need not start with a stressed syllable, i.e. at a foot boundary. On the contrary, the rhyme is considered richer if it starts before the stressed vowel as in (18) and (20) (Stavrou 1974:106).

(20) /xriso'neta/ - /so'neta/ gild them - sonets.

It is even possible to rhyme a final stressed vowel with a final unstressed one, although this is not considered to be good practice. For example,

(21) /ni'sa/ - /c'perasa/ islands - I went by.

In short, rhyming in Greek is not necessarily based on stress, but rather on syllable structure. As mentioned in section 6.3, support for this interpretation of rhyming comes from Garantoudis (1989) who proposes that Greek poetic rhythms are primarily based on syllable count, rather than meter.

As there are no other rules in Greek which have the foot as their domain, Greek does not need foot structure. This does not mean that NV’s (1986) proposal of a foot level should be rejected altogether: although the foot level is not necessary in Greek, it is useful in the prosodic description of other languages, such as English.

6.5.3 THE PHONOLOGICAL WORD AND THE CLITIC GROUP

As demonstrated in Chapter 3, it is possible to represent enclitic stress without reference to the Clitic Group (henceforth C), which is the prosodic domain between the \(\omega\) and the \(\phi\), used by NV (1986) to explain, among other things, enclitic stress in Greek. The analysis in Chapter 3, section 3.4 shows that C is not necessary for the prosodic structure of Greek. However, it is worth

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\(^\text{12}\) All examples of rhymes presented here come from well-known poems used as examples in Stavrou (1974); the emboldening which shows the rhyming elements is as in Stavrou (1974).

\(^\text{13}\) Details on this structure are presented in section 6.5.3.
reviewing NV’s arguments for enclitic stress, and considering the other arguments which lead them to propose that both $\omega$ and C are necessary for the prosodic representation of Greek. (For simplicity, in the following discussion I use the terms $\omega$ and C according to NV’s definition of these domains.)

By far the most important argument for positing C as a prosodic level in Greek is the presence of enclitic stress in host-and-clitic groups in which the host is stressed on the antepenult. According to NV, such groups have the prosodic structure shown in (22), in which the last syllable of the host forms a separate foot (see also (19b)).

(22)

```
/|\  /|\  /|\  /|\  C
/ | \ / | \ / | \ / | \  \\
/ | \ / | \ / | \ / | \  \\
w s w s w \omega
| | | | | |
/ | \ / | \ / | \ / | \  \\
w s w s w \Sigma
| | | | | |
/ | \ / | \ / | \ / | \  \\
w s w w w \sigma
| | | | | |
```

_o pi na kas mu_ > _o pi na kaz mu_

*my painting*

NV’s argument is that the clitics cannot be considered part of their host’s $\omega$, because in cases of SWFC violation their effect on the stress pattern of the host is different from that of processes which operate within $\omega$, like suffixation and compounding. These are (correctly) presented as $\omega$ processes in NV’s model, because the result of their operation is a new $\omega$ which conforms to the SWFC14 (see also Chapter 1, section 1.5 and Chapter 3, section 3.4 on suffixation). To achieve the correct stress pattern, certain suffixations can move the stress from its original position. For example,

(23) /$\delta$ike´oma/ + /$\delta$/ >> /$\delta$ike´omata/ _right+s_ > _rights_,

(24) /$\theta$elima/ + /$\theta$/ >> /$\theta$e´limatos/ _errant+gen._ > _of an errant._

(Note that examples 25 and 26 are missing.)

NV agree that cliticisation is not completely unrelated to suffixification and compounding, since host-and-clitic groups must also conform to the SWFC. NV’s argument, however, is that unlike

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14 Unlike English compounds, Greek compounds form a single $\omega$, whose stress pattern is not related to that of the compound’s component words (for details see NV 1986:112 ff.).
suffixation, for example, cliticisation does not move the stress of the host, but adds a secondary stress two syllables to its right. Obviously, NV's argument would be correct if the stress of the host remained the most prominent in a host-and-clitic group (as NV suggest). Experiment 3, though, has shown that in a host-and-clitic group the enclitic stress is more prominent than the host's stress. If the prominence values of the host-and-clitic group stresses are interpreted correctly, i.e. according to the results of Experiment 3, it is shown that cliticisation shares a common point with suffixation: it can move a word's stress to another syllable so that the resulting stress pattern conforms to the SWFC. In other words, the host-and-clitic group behaves as one as regarding stress. The difference between suffixation and compounding on the one hand, and cliticisation on the other is that the former operate lexically, while the latter operates post-lexically; i.e. it cannot remove the host's stress since this stress belongs to the original o. The result is that in post-lexical SWFC violations compound os have two stresses, an exceptional pattern for Greek.

As mentioned, NV (1986) also argue that there are several sandhi rules whose operation requires separate o and C levels. The first two of these rules are Nasal Assimilation (NA) and Stop Voicing (SV), which occur together. Briefly, NA and SV operate in order to assimilate a nasal before a voiceless stop for place of articulation and to voice the voiceless stop. Usually (and this is sociolinguistically determined) the nasal is deleted after SV has taken place. According to NV, these rules are obligatory within o, but optional within C. As a native speaker I would like to oppose this view and state instead that NA and SV are equally obligatory within o and C.

The apparent contradiction between NV's (1986) and my position lies in the fact that the operation of NA and SV is more complicated than the picture presented by NV suggests, and is linked to the status of the voiced stops, /b, d, g/, in Greek. Specifically, Greek seems to be in the process of changing as far as voiced stops are concerned. Thus, there is one class of words, usually common simplex words, which are considered by native speakers as having a voiced stop. Such words often form minimal pairs with words with voiceless stops. For example,

(27a) /'pleko/ : (b) /'bleko/ I knit : I confuse,
(28a) /'topja/ : (b) /'dopja/ balls : native, neut. pl.,
(29a) /'kama/ : (b) /'gama/ dagger : range.

Since examples (27b), (28b) and (29b), and many others like them, have a voiced phoneme, rather than a nasal+voiceless stop sequence, it is incorrect, in my opinion, to use such words, as NV (1986:111, ex. (1a) and (2a)) do, to show the obligatoriness of NA and SV within o; in such words NA and SV have ceased to operate.

There is, however, a second class of words, in which NA and SV are still operative. These words are always derivatives of Katharevousa origin15, whose first component is a preposition

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15 Katharevousa is an artificial purist form of Greek, which is distinct from Dhemotiki, the mother tongue of Greeks. Because Katharevousa was the official language of education until 1974 and of the state until 1981, there are still many Katharevousa words in Greek.
followed by a noun or verb stem; these words are still felt to be compounds. For example,

(30) /sinpararo'γi/ > /simpararo'γi/ > /simbaraγo'γi/ > /sibararo'γi/ co-production,

(31) /sinte'lo/ > /sinde'lo/ > /side'lo/ I contribute,

(32) /sinkata'tiθeme/ > /sinkata'tiθeme/ > /sinkata'tiθeme/ > /sinkata'tiθeme/ I consent.

In words like (30), (31) and (32) SV may not operate in careful and slow speech. This contrasts with examples (27b), (28b) and (29b) in which it is not possible to pronounce the initial voiced phoneme as /mpl/, /nt/ or /nk/ respectively. The conditions of NA and SV operation in os like those in (30) to (32), including the possibility of non-operation of SV in careful speech, are exactly the same in C; e.g.

(33) /ton pro'kalesa/ > /tompro'kalesa/ > /tombro'kalesa/ > /tobro'kalesa/ I provoked him,

(34) /ton te'raton/ > /tonde'raton/ > /to'de'raton/ monsters, gen.,

(35) /tin kopila'sia/ > /tingkopila'sia/ > /tingpilasia/ > /tingpila'sia/ rowing, acc.

The only difference between examples (30) to (32) and examples (33) to (35) is that in the former nasal assimilation is represented in the spelling, while in the latter spelling retains /nt/ (v) in all cases. In speech, however, there is no difference between the two sets of examples, indicating that prepositions as affixes and clitics are on a par in relation to NA and SV. Therefore, NA and SV do not provide evidence that the host and its clitics should be considered separate os; rather NA and SV support the present proposal that hosts and their clitics form one o.

There are, however, two other rules, discussed by NV (1986), which appear to operate within C but not within o. The first rule is Mirror Image Deletion (MID), first presented by Kaisse (1977), who claims that the non-high vowels of Greek, /e, a, o/, are deleted if a proclitic ends in one of these vowels and its host begins with another. According to Kaisse, /e/ deletes when followed or preceded by /a/ or /o/, and /a/ deletes when followed or preceded by /o/. This rule does not operate within o (as defined by NV); e.g.

(36) /ea'tflos/ self,

(37) /δeos/ awe,

(38) /ac'tos/ eagle,

(39) /po'ra/ mournfully,

(40) /aoplos/ unarmed,

(41) /o'ario/ ovum.

However, it is not clear that MID, as described by Kaisse, operates within C either. The aspect of MID that casts doubt on its being a C rule is that MID does not operate in all circumstances. In particular, while /e/ always deletes when it is followed by /a/ or /o/, it does not always delete when it is preceded by /a/ or /o/. In these cases, /e/ deletes only if it is part of the verb /'exo/ to

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16 NA is obligatory in all environments, possibly because lack of assimilation would be practically impossible from an articulatory point of view.
have, or of a past tense beginning with /e/; /e/ does not delete if it is part of the host’s stem. Thus, (42) to (47) are possible, but (48) to (51) are not.

(42) /me anatro’fi/ > /manatro’fi/ /with good manners,
(43) /me o’di’yun/ > /mo’di’yun/ they lead me,
(44) /ta ‘exo/ > /’taxo/ I have them,
(45) /to ‘evales/ > /’ovales/ you put it (/’vazo/ to put),
(46) /ta ‘efere/ > /’tafere/ you brought them (/’fero/ to bring),
(47) /to ‘edosa/ > /’to’dosa/ I gave it (/’dino/ to give),
(48) /ta epa’nelava/ > */tapa’nelava/ I repeated them (/epanalam’vano/ to repeat),
(49) /to e’lafi/ > */to’lafi/ the deer,
(50) /to ek’di’d/ > */to’k’di’d/ I publish it,
(51) /ta ‘edoma/ > */’tadoma/ the insects.

Also, Kaisse is wrong in stating that /a/ deletes before /o/. On the contrary, when /o/ precedes /a/, it is /o/ that is deleted. For example,

(52) /to apo’fasisa/ > /tapo’fasisa/ (not */topo’fasisa/) I have made up my mind on this,
(53) /to a’gori/ > /’ta’gori/ (not */to’gori/) the boy.

On the other hand, when /a/ precedes /o/ deletion does not take place; e.g.

(54) /ta ‘onira/ > */tanira/ (nor */tonira/ as Kaisse’s rule would predict) the dreams,
(55) /ta o’di’go/ > */ta’di’go/ (nor */to’di’go/) I lead them.

As has been noted, the rules of vowel deletion in Greek are extremely complicated. The examples above clearly demonstrate that the structural description of MID is not met by simply describing a hierarchy according to which vowels delete and C as the rule’s domain. The correct formulation of this rule is beyond the scope of this thesis; nevertheless, as the above examples show, MID does not provide evidence that C is necessary for its operation.

The second rule which seems to operate within C is Nasal Deletion (ND). ND takes place when a proclitic which ends in a nasal is followed by a host which begins with a fricative, as in

(56) /tin ‘o’alasa/ > /ti ‘o’alasa/ the sea acc.,
(57) /tin ‘filises/ > /ti ‘filises/ you kissed her.

According to NV, ND is obligatory within C, but optional and very rare within o. I have some reservations about the obligatoriness of ND within C, as the operation of ND seems to depend to a large extent on the proclitic. For instance (56) and (57) are obligatory (and indeed it is prescribed by standard grammars that they should be spelt without the final /n/), but whether ND takes place in

(58) /ton ‘filisa/ I kissed him
or
(59) /ton ‘filon mas/ our friends, gen.

\[17\] One of the characteristics of the two past tenses of Greek is that all forms must be stressed on the antepenult; if the verb has only two syllables, an initial /e/ is added to carry the antepenultimate stress; e.g. /’trexol/ to run, /’trexamel/ we used to run, and /’treksamel/ we ran, but /’etrexal/ I used to run, and /’etrekxsal/ I ran.
is uncertain, and certainly not obligatory. Nevertheless, it is correct that ND is much more common within C than within \( \omega \).

In brief, the examination of sandhi rules shows that, on the one hand, host-and-clitic groups behave like one \( \omega \) as far as stress placement and NA and SV are concerned; on the other hand, ND seems to be a rule predominantly operating between hosts and their clitics, i.e. in the domain NV call C. The operation of ND, however, is not sufficient evidence on which to posit C as a separate prosodic category. As explained in Chapter 3, section 3.4, \( \omega \)s are formed in the lexicon according to NV’s (1986) definition, and their boundaries are extended post-lexically, when clitics are attached to them. Therefore the operation of ND is accounted for, without reference to the C level, by suggesting that the clitics are not attached to the \( \omega \) of their host straight away, but form a compound domain with it.

Thus, NV (1986) do not seem to have strong arguments for postulating three prosodic categories between \( \sigma \) and \( \phi \) in Greek. The foot, the phonological word and the Clitic Group are neither separate domains of relative prominence, nor domains of prosodic rules. These three categories can be replaced by a compound phonological word, a domain which adequately represents not only stress patterns below the phonological phrase in Greek but sandhi rules as well.

However, one may question whether introducing a compound \( \omega \) in the prosodic tree is a way of indirectly re-introducing C as a domain, since both C and the compound \( \omega \) include a host and its clitics. The crucial difference is that in the compound \( \omega \) the clitics do not have \( \omega \) status as they do in C. This means that when the clitics are added to the host, the resulting compound \( \omega \) still functions as one \( \omega \) with respect to certain rules, like NA and SV, and with respect to stress and focus placement (see Chapter 3, section 3.4). On the other hand, the fact that the clitics are linked to their host at the compound \( \omega \) level means that ND, which predominantly operates between hosts and their clitics, has the appropriate domain in which to operate. Moreover, in SWFC violations, splitting the compound \( \omega \) into two separate \( \omega \)s ensures that the stress of the host is represented as a subordinate lexical stress, not as the secondary stress of a word (see Chapter 4, section 4.4). In short, the compound \( \omega \) has a flexibility which is lacking in C. This flexibility is necessary as, in manner typical of clitics, host-and-clitic groups behave sometimes as a simple \( \omega \) and sometimes as two \( \omega \)s.

Finally, it is worth noting that Pierrehumbert & Beckman (1988) propose a similar solution to that presented here regarding elements like clitics. Specifically, Pierrehumbert & Beckman suggest that, while following the Strict Layer Hypothesis (SLH), it is possible to have extrametrical syllables which can “skip” one level and be joined with their sisters at the next level up. An obvious question is whether this structure could be used in Greek, instead of compound \( \omega \)s; if the domains of Greek are \( \sigma \), \( \omega \) and \( \phi \), it could be argued that it would be easier to join clitics to their hosts at the \( \phi \) level, rather than posit a compound \( \omega \).
Although the analysis of Pierrehumbert & Beckman is appealing, I see two reasons why it would not be suitable for Greek. First, enclitics are not extrametrical in Greek since they can create new stress patterns. Second, this analysis cannot adequately account for the stress patterns observed in adjectival phrases, in which an enclitic possessive pronoun can be placed between the adjective and the noun. In these cases, if the adjective is stressed on the antepenult, enclitic stress appears on its last syllable; as NV (1986) observe, the enclitic is syntactically attached to the noun but is phonologically attached to the adjective; e.g.

(60) /ta 'omorfa tu 'matja/ > /ta .omor'fa tu 'matja/ his beautiful eyes.

The drawback of representing clitics as being linked to their host in a φ is that sequences like (60) must form two separate φs; this solution is not intuitively satisfactory, and disagrees both with the overall stress pattern of such structures (see section 6.5.4) and with NV's (1986) rules of φ formation and Condoravdi's (1990) rules of z formation (in NV's model (60) would be one φ, while in Condoravdi's model it would be one z).

To conclude, it has been shown that the stress pattern of host-and-clitic groups which violate the SWFC, as well as the various sandhi rules which operate between a host and its clitics, cannot be adequately explained if clitics are represented as separate Ωs which are linked to the Ω of their host at the C level; in contrast, if clitics are seen as weak unattached syllables which are linked with their host's Ω to a compound Ω, both the sandhi rules and the host-and-clitic group's stress pattern are more satisfactorily accounted for. The advantage of this structure is that it can explain why host-and-clitic groups behave as one Ω with respect to some rules, but as two Ωs with respect to others.

6.5.4 THE MAPPING OF PROSODIC STRUCTURE TO RHYTHMIC STRUCTURE

In the previous section, it was demonstrated that the prosodic structure of Greek requires the syllable, Ω, compound Ω and φ levels, and possibly the z level18 between the Ω and φ. This relatively deep embedding provides the correct domains for the operation of the numerous sandhi rules of Greek, and accounts for abstract prominence patterns. It now remains to be seen how this structure can be mapped onto a flatter rhythmic structure.

Following the proposal of Pierrehumbert & Beckman (1988) I hypothesise that the prosodic tree is mapped onto a simpler and flatter n-ary branching tree which represents rhythm (henceforth rhythmic tree). This rhythmic tree has only 5 levels: σ, Ω, φ, I and U. In other words, the compound Ω and z levels are not mapped onto the rhythmic tree; instead, the sister Ωs of a compound Ω or z are linked directly to the appropriate φ. The compound Ω and z levels are not part of the rhythmic tree because the rules that use these domains operate in the prosodic component. Moreover, excluding the compound Ω and z levels from the rhythmic tree ensures, first, that words with enclitic stress have the same rhythmic structure as words with only one

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18 The z level is provisionally accepted here as correct. A validation of z is beyond the scope of the thesis and irrelevant from the point of view of rhythmic structure. For this reason z will not normally be included in the prosodic trees.
stress, and second, that φs which include more than one z have the same rhythmic structure as φs
which are formed by one z only.

In the rhythmic tree, the prominence value of the φs that belong to the same φ is determined
by a rule which was informally discussed in sections 6.2.1 and 6.2.2. According to this rule,
which I will call Right Prominence Rule (RPR), at any given level of the rhythmic tree (above σ)
the rightmost constituent within a node is marked [s], while all its sisters are marked [w]. The
prominence value of a node with a single constituent is determined by its position relative to the
next level up. The operation of RPR is illustrated in (61b); (61a) shows the prosodic tree from
which the rhythmic tree in (61b) is mapped.

(61a)  

(61b)  

His beautiful eyes were shining.

Example (61) shows that the two stresses of /omor'fa tu/ are represented in the same way as
the single stress of /matja/. (61) also shows that when the host-and-clitic group is not the
rightmost element in a φ the abstract prominence pattern of the compound ω is not realised in the
rhythmic tree; the underlined [s] node of the prosodic tree becomes [w] in the rhythmic tree. Thus
the rhythmic structure of (61b) is the same as that of (62b), although (61) and (62) have different
prosodic trees, shown in (61a) and (62a) respectively.
The first five days are gone

If, however, the compound \( \omega \) is the DTE of a \( \phi \), then its abstract prominence pattern is realised in the rhythmic tree, as shown in (63).

Finally, (61) shows that when a \( \phi \) contains a single \( \omega \) the prominence value of this \( \omega \) will depend on the \( \phi \)'s position within I. In (61) '/elaban/' is the rightmost \( \phi \) in I, and therefore it is marked [s]. In (62) and (63), '/perasan/' and '/plirasan/' respectively are also marked [s] for the same reason. In contrast, in

(64) '/keröisa śeka'trs xi'ljašes/ I won thirteen thousand,

'/keröisa/' is not the rightmost \( \phi \), and therefore it is marked [w]. This is so, whether the prosodic tree is constructed according to NV's algorithm, as in (65a), or according to Condoravdi's algorithm, as in (66a). Although the rhythmic trees in (65b) and (66b) are slightly different, '/keröise/' is marked [w] in both cases.
I won thirteen thousand

In addition to representing the relative prominence of constituents the rhythmic tree can represent other phenomena related to rhythm, such as the strategies for stress clash elimination and the effect of vowel degemination and deletion. Stress clashes are defined as two consecutive [s] syllables which belong to consecutive ωs. When stress clashes are eliminated by lengthening, then a [w] node is placed between the two clashing stresses, and is joined to the first ω (see also Selkirk 1984 and NV 1989); e.g.

(67)

When, on the other hand, a stress clash is eliminated by omission of the first stress then the two
ωs are joined into one ω. For example,

(68)

\[
\begin{align*}
\text{kali oreksi} & > \text{kalioreksi} \\
\text{good appetite}
\end{align*}
\]

A possible problem with this model could be the representation of the effect of vowel degemination and vowel deletion. As these two processes depend on prosodic constituency, they operate on the prosodic tree. Their effect is resyllabification which crosses word boundaries. This would not be a problem if resyllabification involved consonants moving to the onset of following syllables, as in Spanish: e.g.

(69) las aves the birds \(> \) /las aβes/ \(> \) /la sa βes/,

(70) la sabes you know her \(> \) /la sa βes/

(the examples are taken from NV 1986:68). In Greek, however, resyllabification because of vowel deletion or degemination obviously involves vowels. For instance, a phrase like

(71) /maˈrɪa aˈtɔræs e na aftɔˈkinito/ Maria bought a car

becomes

(72) /maˈrɪaˈtɔræse na aftɔˈkinito/

after vowel degemination has operated. The structure in (72) is the one that is mapped onto the rhythmic representation. It is evident that the constituent structure of (72) must be represented with the italicized syllables belonging to two nodes of the rhythmic tree at the same time (the obvious analogy would be ambisyllabic consonants). This is indeed predicted by Pierrehumbert and Beckman (1988), who posit that it is possible to link two nodes to one substantive element, which in this case would be equivalent to a syllable. Thus, the rhythmic structure of (72) would be that presented in (73).
The disadvantage of (73) and similar trees is that in some cases an ω is represented as having two [s] syllables. In (73) this happens in /ayorase/ in which both /ay/ and /orase/ are marked [s]. This complication raises the question of whether constituent structure is necessary for the representation of Greek rhythm, or whether it would be preferable for the rhythmic representation not to show constituency.

The above problem could be solved if grids rather than trees were used for the representation of Greek rhythm, since grids do not explicitly show constituency. As with rhythmic trees, grids would be based on the information provided by the prosodic tree, without taking into account the compound ω and z domains. For instance, the tree in (73) would be equivalent to the grid in (74):

```
(74)

x
x
x x x x x
x x x x x x x x
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Maria bought a car

As mentioned, Pierrehumbert & Beckman (1988) reject the idea of the grid as the rhythmic representation, mainly on the grounds that the grid is not suitable for the mapping of intonational structure. This may well be true in languages which have more complicated rhythmic or intonational structures, like Japanese, the language studied by Pierrehumbert & Beckman. We are not in a position at the moment to assert whether or not the grid is indeed suitable for the mapping of intonation in Greek. However, I venture to suggest that since in Greek the stress levels are rather few and the intonational structure relatively straightforward, the mapping of the intonational structure to the grid on the basis of stress level should be possible; roughly, each grid position with more than one X would be associated with an F0 fluctuation, and with a durational and amplitude change proportional to its stress level. This is only a preliminary suggestion, however. Further investigation into the relationship between rhythm and intonation is needed,
involving the study of Greek rhythm-to-intonation mapping as well as material from a variety of other languages.

In summary, it has been proposed that Greek has a relatively complex prosodic structure which can be represented by an n-ary branching tree that includes 7 levels: $\sigma$, $\omega$, compound $\omega$, $\zeta$, $\phi$, I and U. The prosodic tree is based on the syntactic tree, although the two do not have a one-to-one relationship. After the operation of all prosodic rules, which include rules of abstract prominence, the information of the prosodic tree is mapped onto a simpler rhythmic representation which has only 5 levels: $\sigma$, $\omega$, $\phi$, I and U. Although it cannot be ascertained whether rhythm would be best represented by a grid or a tree, it is clear that Greek needs both a prosodic and a rhythmic representation. This double structure ensures, on the one hand, that all sandhi rules have the appropriate environment in which to operate and that focus is correctly assigned in host-and-clitic groups; on the other, that the flat rhythmic structure of Greek is correctly represented.

6.6 SOME IMPLICATIONS FOR THE PHONOLOGY OF RHYTHM

The present results and the suggested phonological representation of Greek rhythm have important consequences for the phonology of rhythm in general. Metrical and prosodic phonology have assumed that rhythm follows binary patterns in all languages. As noted, this is clearly expressed in Hayes (1981), NV (1989), Selkirk (1984) and others. Yet in many cases this conviction is based either on English data alone, or on impressionistic accounts of other languages sometimes by non-native (and usually English-speaking) phoneticians (e.g. Hayes 1981).

However in order to prove that a certain principle, such as the binarity of rhythmic structure, is valid, it is necessary to show that there are no languages which do not follow this principle, rather than that there are many which do follow it. The present data demonstrate that Greek does not have binary rhythmic structure. However, this does not necessarily mean that Greek, or the present analysis, is at odds with phonological theory. I suggest, instead, that the problem lies in the widespread confusion between linguistic phenomena and representations. It is often assumed that not only the phenomena which linguistic theory purports to describe but the formalisms used for this purpose have psychological reality (e.g. Hayes 1981:16, Selkirk 1984:39); it is this confusion that prompts Chomsky and Halle (1968:25) to claim that the speaker who uses the stress rules they postulate, hears as many degrees of stress as the rules predict. This is, however, confusing the representation of a phenomenon with the phenomenon itself; in the case of Chomsky & Halle, it is confusing the fact that there are more than one degrees of stress in English with their overgenerating mechanism which represents this observation.

The same line seems to be followed by recent phonological studies of rhythm. Binary structure was first posited by LP as a means of regulating the number of degrees of stress predicted by SPE. Later, however, the scope of binary branching expanded to the extent that it is now often taken for granted that not only metrical structure (i.e. the formalism) but rhythm itself (i.e. the
phenomenon under investigation) follows binary patterns. If, however, formalisms and the phenomena they purport to represent are kept distinct, it may be possible to relax the constraint that exactly the same formalism should be universally used for the description of a phenomenon such as rhythm. Thus, binary branching trees may be appropriate for the representation of English rhythmic structure but they are unsuitable for the representation of Greek rhythmic structure. Similarly, it appears that English prosodic and rhythmic structure can be represented by the same formalism, whereas in Greek this is not possible.

In addition, by insisting on using the same formalism for the representation of all languages, phonologists are forced to either use an inappropriate formalism for the representation of some languages or to postulate that such languages do not have "natural" rules (e.g. Hayes 1981). The disadvantage of this strategy is that it does not do justice to the universal principles on which the structure of all languages is based, since some languages are said to have unnatural rules. In contrast, by relaxing somewhat the constraints on the details of formalisms, it may be possible to accentuate the universals, which are reflected in the principles on which formalisms are based. The universals are principles common to all languages, although different languages may use them in such ways as to require different formalisms for the successful, adequate and elegant representation of their structure. Thus, the universal principle is that speech is a rhythmically organised activity, but a representation which is adequate for one type of speech rhythm may be inadequate for another. Yet the fact that rhythm is based always on the same principle, hierarchical grouping by accent, implies that all formalisms, regardless of differences in details, will be based on the same principle, i.e. non-linear representation.

6.7 WHAT NEXT?

Certain questions about Greek rhythm remain unanswered and others have not been investigated in great detail. One issue that requires further study is the elimination of stress clashes. The present data show that at least one of the postulated strategies for the elimination of clashes, namely first syllable lengthening, is indeed used in Greek. However, there are two more strategies, omission of one of the stresses and pitch raising, which have not been phonetically investigated in any detail. For instance, it would be worth examining how the use of pitch raising for clash elimination would interact with intonation if the requirements of rhythm and intonation on a sequence were different. Moreover, it is not yet known whether the choice between different strategies for stress clash elimination is regulated by prosodic or phonetic factors or by a combination of both.

A second issue relates to processes which have an effect on rhythm, such as high vowel reduction and vowel degemination and deletion. Concerning high vowel reduction, further work on its causes, with more speakers and more varied material than that used by Dauer (1980b), is needed. As Dauer (1980b) suggests that high vowel reduction is affected mostly by phonetic environment, the study of this phenomenon should include primarily phonetic considerations, such
as aerodynamic and articulatory factors, but also phonological considerations, such as the possible influence of prosodic domains on high vowel reduction. Concerning vowel deletion, further work relating to the prosodic domains in which the various rules of vowel deletion operate is still needed; particularly in relation to the $z$ level, put forward by Condoravdi (1990).

A third issue concerns the prosodic domains I and U which have not been investigated here, and which have been very little studied elsewhere. The role of I, in particular, is related to another issue which requires more systematic study, namely the relation of rhythm and intonation in Greek. As has been noted, the relation of rhythm and intonation could provide evidence as to whether the grid or the tree is more suitable for the representation of Greek rhythm. In addition, a better understanding of the relationship between rhythm and intonation would open possibilities for better synthesis of Greek speech and intonation; both types of synthesis have been investigated only from the engineering point of view (e.g. Yiourgalis & Kokkinakis 1990).

Finally, another issue which requires more systematic study is the perception of Greek stress. Despite Botinis's (1989) fairly detailed study, there are still aspects which require further investigation, such as the role of amplitude integral in stress perception, in particular in relation to the position of a word vis-à-vis the nucleus of the utterance.

6.8 CONCLUSION

This study of Greek stress and rhythm has shown that although Greek has hierarchical stress structure, it has fewer levels of stress than English, and lacks rhythmic stress. The lack of rhythmic stress indicates that Greek does not have binary rhythmic structure, a feature which current phonological theory claims is universal. The Greek data show that this is not the case and indicate that a relaxation of the constraints on the formalisation of rhythmic structure is necessary, if all languages are to be represented by similar structures. Using the same principles for the representation of rhythmic structure in all languages would have the advantage of correctly implying that rhythm in all languages is based on the same principles, even though implementation of these principles may differ widely from one language to another. The fact that rhythmic structure is based on accent grouping also suggests that the phonetic distinction of languages into syllable- and stress-timed is both irrelevant for the description of rhythm and also incorrect, as it assumes that different languages use widely different rhythmic principles.
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