RHYTHMIC CATEGORIES: A CRITICAL EVALUATION ON THE BASIS OF GREEK DATA

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ABSTRACT

This paper endeavours to show, on the basis of Greek data, that accent organises rhythm in all languages that have accent, irrespective of its exact acoustic manifestation and the rhythmic category a language is said to belong to. A formalisation of this idea can be achieved by means of a hierarchical abstract representation of rhythm. Such a representation can account both for the rhythm of Greek, in which stresses are sparce, and for the alternating rhythm of English by showing that they are both based on the same principle, grouping created by accent. Thus rhythm is shown to have an acoustic basis (i.e. accent) rather than a purely perceptual one.

1. INTRODUCTION

The validity of the stress/syllable-timing distinction has often been questioned, due to the well-known lack of acoustic evidence in its favour (for a review see [5]). Several efforts have been made to rescue the notion of two rhythmic categories from oblivion, usually by appealing to the perceptual rather than acoustic basis of the distinction [5].

One of the latest efforts is that of Dauer [4] who proposed a system of "quantifying" rhythm on the basis of phonological and phonetic criteria, such as syllable weight and the acoustic correlates of accent. A language's "score" in this system is meant to show its rhythmic tendency towards either stress- or syllable-timing. Dauer's system is not accurate however: the "score" of Greek indicates that in this language accent (manifested as stress) is bearly perceptible; hence Greek has a tendency for syllable-timing. Yet Greek stress has a high functional load. Moreover, phonetic research on Greek has shown first, that stressed syllables in running speech are easily identified both by native speakers and non-native phoneticians [3]; second, that the acoustic and perceptual correlates of Greek stress are F0, duration and amplitude [2].

I believe that the problem with Dauer's system is that it attributes the same weight to factors which are relevant to the description of speech rhythm and others which, in my opinion, are not, such as the acoustic implementation of accent. Dauer's [4] insistence on phonetic correlates seems to be related to her opinion that the abstract phonological representation of rhythm, which is based on accent grouping, "tends to make all languages look [rhythmically] alike" (p. 447). I would like to suggest, instead, that this is an advantage of the phonological representation because it captures the fact that the main contributor to rhythm is always accent, irrespective of its acoustic correlates. Furthermore, I would like to propose that the differences between languages lie in the precise way in which accent achieves rhythmic grouping. My hypothesis is that the difference between Greek and English is that in Greek stresses are less frequent than in English, and that this is due to the lack of rhythmic stress in Greek. The latter part of my hypothesis disagrees with the proposals of Malikouti-

Drachman & Drachman [6] and Nespor & Vogel [7] who suggest that rhythmic stresses are used in Greek to create alternating rhythm. An experiment was conducted in order to test the above hypothesis.

2. METHOD

The experiment's material consisted of two sets of test words, although due to space limitations only the data from one set are presented here; there were no differences between the two sets.

The tetrasyllabic test words of each set were phonemically identical (see Table 1), but while (a) had antepenultimate primary stress, (b) had penultimate stress and (c) final stress. The differences in the carrier phrases resulted in different possibilities for rhythmic stress on each test word's first two syllables: (a) cannot carry rhythmic stress; (b) may have rhythmic stress on the initial syllable, while (c) may have rhythmic stress on the antepenult. Within a set, the initial syllable of (b), /.xa/, is compared to the unstressed initial syllables of (a) and (c). Also, the antepenult of (c), /.mo/, is compared to the antepenult of (a), /'mo/, and to the unstressed antepenult of (b), /mo/.

Table 1: The recording material.

(a) /'eleɣe xa'moɣela ka'la/
She/he used to say smiles (n.) well.
(b) /'ipe .xamo'ɣela kaθa'ra/
She/he said smile (imper.) clearly.
(c) /θa 'po xa.moɣe'la kanoni'ka/
I will say she/he smiles properly.

The test sentences were read 6 times each by 4 native speakers of Greek, from a randomised list typed in Greek. The speakers were in their twenties, spoke standard Greek and were naive as to the purposes of the experiment.

The material was low-pass filtered at 8 kHz and digitised at 16 kHz. F0, amplitude integral (AI), average amplitude (RMS) and duration measurements were obtained. F0 was measured using a signal-processing package which performed F0 measurements every 10 ms over a 32 ms Hamming window. AI was calculated automatically between specified points of the waveform which included the syllable nucleus. The original AI measurements, which were in arbitrary units given by the signal-processing package, were normalised; the values presented in Figures 2 and 3 are ratios of syllable to word AI expressed as percentages (for details see [1]). Two-way ANOVAs (stress type x speaker) were performed on the AI data.

RMS was measured and normalised in the same way as AI. Duration was measured from spectrograms. Although duration and RMS were analysed statistically, they will not be discussed here as their effect is reflected in AI, in which durational and average amplitude information are combined.

3. RESULTS

There is no evidence that syllables said to carry rhythmic stress are associated with F0 perturbations. Figure 1 shows that the F0 contour is determined solely by the position of primary stresses; F0 starts rising on a stressed syllable, reaching its peak on the beginning of the following unstressed one; at this point F0 starts falling until the next stressed syllable is reached.

AI yields very slim evidence for rhythmic stress. Figure 2 shows that the unstressed /xa/s and /.xa/ have the same AI ($F(2,40)=0.23$, n.s.), while Figure 3 shows that /.mo/ has lower AI than /'mo/ ($F(1,20)=189.23$). In the comparison of /.mo/ with /mo/ there is interaction between speakers and type of stress; while in VK's and SC's speech /.mo/ has the same AI as /mo/, in AA's and DT's speech /.mo/ has higher AI than /mo/ (VK: $F(1,20)=0.99$ n.s.; SC: $F(1,20)=0.04$ n.s.; DT: $F(1,20)=20.89$ $p<0.000$; AA: $F(1,20)=5.22$ $p<0.03$). DT's and AA's data are the only ones to show evidence for rhythmic stress.

In short, only in 2 out of 8 possible instances, does rhythmic stress materialise as high AI. These two instances are due to high RMS rather than duration.

4. DISCUSSION

The empirical evidence is very slim: rhythmic stress appears in a few cases in the speech of some speakers only, while its single acoustic correlate

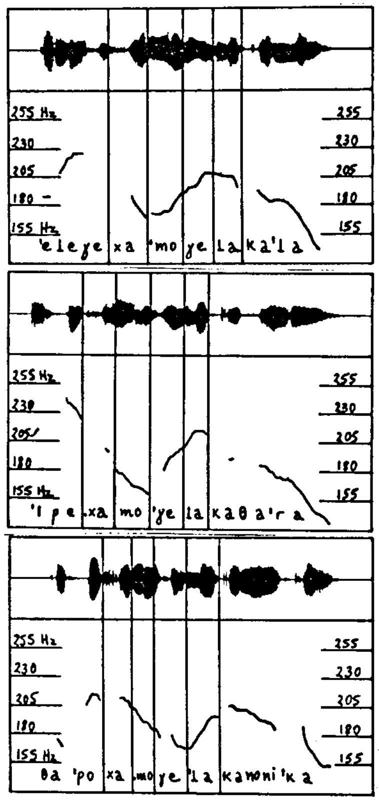


Figure 1: Typical F0 contours (smoothed) of /xa'moɣela/, /.xamo'ɣela/ and /xa.moɣe'la/; speaker DT.

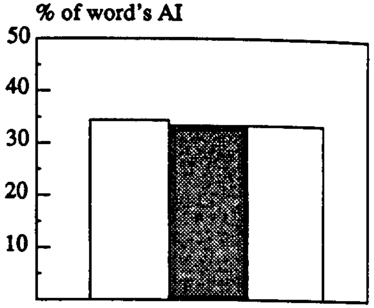


Figure 2: Mean values of amplitude integral of /xa/ for all subjects. Clear bars represent AI of the unstressed /xa/s of /xa'moɣela/ (left) and /xa.moɣe'la/ (right), dark shaded bar represents AI of /.xa/ of /.xamo'ɣela/.

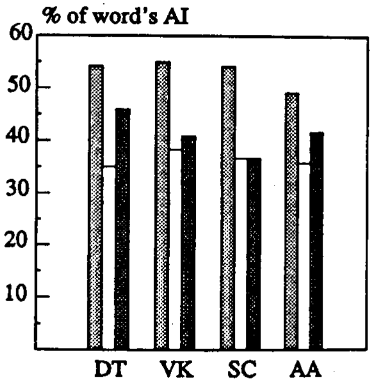


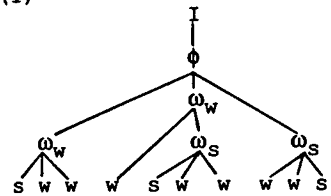
Figure 3: Mean values of amplitude integral of /mo/ for each subject separately. Light shaded bars represent AI of /'mo/ of /xa'moɣela/, clear bars AI of /mo/ of /.xamo'ɣela/, and dark shaded bars AI of /.mo/ of /xa.moɣe'la/.

is amplitude which Botinis [2] has shown to be the least reliable perceptual cue to stress. Moreover, the native speakers of Greek are not aware of the presence of rhythmic stress. Thus, there is no justification for representing phonologically stresses other than the primary stress of each word.

The fact that there is only one stress per word in Greek, combined with the high number of syllables per word, leads to the conclusion that stresses in Greek are indeed sparce. Does this, however, justify classifying Greek as having a tendency for syllable-timing? I believe that such a classification is irrelevant, and also incorrect because it ignores the importance of stress in Greek rhythm.

The rhythmic features of Greek can be more adequately represented by an abstract formalisation which takes the form of n-ary branching trees. As shown in (1), these trees follow the Strict Layer Hypothesis and comprise only 4 prosodic levels: the syllable (σ), the phonological word (ω) (a compound domain which includes clitics), the phonological phrase (φ), and the intonational phrase (I). Thus, Greek has a "flatter" rhythmic structure than English, i.e. fewer degrees of stress. In particular, Greek has no foot structure. The lack of foot structure explains why the Rhythm Rule does not operate in Greek; as English examples show, this rule does not operate when there is no strong position within a word to which a stress may move; e.g. *mároon júmper. As Greek has only one strong syllable per word, the stress cannot move from this syllable.

(1)



kitaza ton enastro urano
I was looking at the starry sky

This structure captures the fact that in Greek stresses, without being as frequent as they are in English, are still the prominences around which rhythm is organised. In addition, this structure shows that Greek rhythm is not based on binary patterning, since long sequences of unstressed syllables are not eliminated by means of rhythmic stress.

The fact that the rhythm of Greek is not binary has important consequences for the phonology of rhythm, as it has often been assumed that rhythmic patterns are universally binary. I believe that this superficial disagreement between theory and empirical data stems from the confusion between the phenomena linguists attempt to describe (and if possible explain) and the representations used for this purpose. While the phenomena, such as the rhythmic organisation of speech, are universal, formalisms need not be. As the present data suggest, binary branching, which successfully represents the alternating rhythm of English, is not adequate for the representation of Greek rhythm as well. If, however, the constraints on the formalism are relaxed so that binary branching is not the only option, both languages with binary rhythmic patterns and languages with n-ary ones will be adequately represented by abstract structures of the form presented in (1).

Relying on an abstract representation does not mean that the search for the acoustic manifestation of rhythm is not a legitimate target; indeed there are compelling reasons for such as step, like the implementation of speech synthesis and automatic speech recognition models. However, using the acoustic features of rhythm as a means of describing languages as stress- or syllable-timed (or as having a tendency for either) does not serve any purpose apart from classifying languages according to the impressions of non-native speakers.

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