THE PHONETICS OF STRESS CLASHES IN GREEK

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Abstract

The present paper examines the phonetic correlates of stress clash resolution in Greek. Two native speakers were recorded producing sentences with and without stress clashes. The data show that stress clashes are more often remedied by lengthening the first vowel in the clash, and less frequently by lengthening the following consonant. Phonological claims that stress clashes can be resolved by pause insertion or by pronouncing the clashing syllables at markedly different pitch levels were not supported by the data. In view of the present results the relation of rhythm and intonation in Greek is briefly examined.

1. Introduction

The question of stress clashes has been investigated in great detail in the last fifteen years. The reason for this interest arises from the fact that as clashes disrupt eurhythmy, the ways in which they are remedied shed light on the question of speech rhythm. However, the research that has been done to date has some serious limitations. First, most of the research has concentrated on one type of stress clash in English, namely those that can be remedied by the application of the Rhythm Rule (otherwise referred to as Iambic Reversal, Beat Movement, stress shift etc.), as in the much quoted

(1) thirtéen > thírteen mén

(see for example Liberman and Prince 1977, Selkirk 1984, Hayes 1984, Kager and Visch 1988, Nespor and Vogel 1989, Gussenhoven 1991). In contrast very little research has focused on the stress clashes which cannot be remedied by stress shift; these cases arise when there is no suitable syllable to which a stress may move either because the word containing the

first of the clashing stresses does not have another heavy syllable, as in (2), or is a monosyllable, as in (3):

(2) ballóon blówing > *bálloon blówing

(3) bád wéather.

A second limitation of the stress clash studies is that they have virtually never addressed the question of stress clash resolution in so-called syllable-timed languages. As far as I am aware the only study to address this question is Nespor and Vogel (1989) in which Italian and to a lesser extent Greek are examined from a phonological point of view.

A third limitation is that most of the research has concentrated on the phonological side of the stress clash issue, while little attention has been paid to the phonetic aspects of it. However, the few phonetic studies that have been done on stress clashes have not provided much evidence that the Rhythm Rule operates in the regular way phonological studies predict (e.g. Cooper and Eady 1986). Phonetic studies have also shown that intonation plays a part in stress clash resolution (Beckman *et al.* 1990, Shattuck-Hufnagel 1991). This interaction of rhythm and intonation has often been ignored in the phonological examination of stress clashes; e.g. Kager and Visch (1988: 29) state that "the explanatory force of [...] pitch accents [...] with respect to rhythmic adjustments is unclear for the time being. [It] will be left out of consideration in the remainder of this paper."

The present paper attempts to redress the balance by examining the phonetics of stress clashes in Greek, which is rhythmically different from English (e.g. Nespor and Vogel 1989 class it as syllable-timed), and does not use the Rhythm Rule in order to remedy stress clashes. To date stress clashes in Greek have not been investigated in great detail. In addition to Nespor and Vogel (1989), they are briefly mentioned in Mirambel (1959), Dauer (1980) and Malikouti-Drachman and Drachman (1980). These authors do not always agree with one another on the solutions available to Greek speakers, although they all accept that Greek does not use the Rhythm Rule, i.e. stress shifts are not permissible. They suggest three different strategies for

stress clash resolution in Greek: (a) the deletion of one of the stresses in the clash (Mirambel 1959, Dauer 1980, Malikouti-Drachman and Drachman 1980); (b) the insertion of phonological distance between the clashing syllables, an effect that can be achieved by lengthening either the vowel of the first one of the clashing syllables or the consonant following it, or by inserting a pause between the syllables (Malikouti-Drachman and Drachman 1980, Nespor and Vogel 1989); (c) the pronunciation of either the first or the second of the stressed syllables with high pitch and the other one with very low pitch (Nespor and Vogel 1989)[1].

I will accept here that stress deletion, as described by Mirambel (1959) and Dauer (1980), is indeed a possibility in Greek, at least when one of the words involved in the clash is a function word or if the words in the clash form a widely used standard phrase. Stress deletion, however, is not investigated in the present experiment which deals with the two other solutions which have been proposed, namely phonological distance and pitch difference. In summary, the aim of the experiment reported here is to answer the following questions:

- Are phonological distance and pitch difference used for stress clash elimination in Greek and if so to what extent?
- How do rhythm and intonation interact in stress clashes?

2. Method

2.1. Material

To answer the above questions it was decided to compare sentences which contained stress clashes with sentences which did not. To do so, 10 pairs of test-sentences were constructed

[1]Nespor and Vogel consider pitch difference as another strategy for achieving phonological distance. Here, however, pitch difference will be examined separately because it relies on different acoustic means than the strategies grouped under (b).

(see Table 1). In each pair one of the sentences contains a stress clash; e.g.

(4) [i ma'ma 'mafise 'mono mu 'cefiγe] *Mum left me alone and went (away).*

These sentences will be referred to as SC (for Stress Clash); the relevant parts of these sentences are underlined in Table 1. The other test-sentence in each pair (henceforth NSC for No Stress Clash) is identical with the SC sentence [2] except for the fact that in the NSC one the clash is avoided by the insertion of a syllable between those clashing; e.g.

(5) [i ma'ma mu 'mafise 'mono mu 'cefiγe] *My mum left me alone and went (away).*

In 6 of the NSC sentences the inserted syllable is the possessive enclitic [mu] *my*, which in 4 of these sentences has been moved from a position after the noun it qualifies to a position after the adjectival adjunct of the same noun; these two possible positions of the possessive enclitic are equally common in Greek. In addition to the possessive enclitic, the definitive article [to] *the* is used in NSC test-sentence 9, the word [ma] *but* in NSC 3, and the word [pço] *more* in NSC 7. Finally, in test-pair 10 two different forms of the word *day* ['mera] and [i'mera] are used. Although ['mera] is a more common form in conversation, [i'mera], a somewhat more formal word, is by no means uncommon.

The test-sentences fall into five different categories. In test-pairs 1 and 2 the first of the clashing stresses falls on the final syllable of the subject NP, while the second stress falls on the first syllable of the following verb; thus, there is a syntactic and (possible) intonation boundary between the two stresses. In test-pairs 3 and 4 the two clashing stresses belong to the same phrase and are equally strong as neither is phrase-final[3]. In test-pairs 5 and 6 both clashing stresses belong to the same phrase, but the first one is weaker than the second, as the latter is the final one in the phrase. In test-pairs 7 and 8 the situation is the same as for pairs 5 and 6 with the difference that the second one of the stresses in the clash carries the sentence's nuclear pitch accent (since it is the final stress in the final phrase of the sentence). In test

[2] In test-pair 7 the two sentences are slightly different (see Table 1).

[3] I assume that the rhythmic structure model presented in Arvaniti (1991) is correct. In this model, in "neutral" cases the stresses of all the phonological words that belong to the same phonological phrase are [w] apart from the final one which is [s].

1	
[i ma'ma 'mafise 'monomu 'cefije]	*Mum left me alone and went.*
[i ma'ma mu 'mafise 'monomu 'cefije]	*My mum left me alone and went.*
2	
[ta pe'ðja 'mnazun sto ba'teratus]	*The children take after their father.*
[ta pe'ðja mu 'mnazun sto ba'teratus]	*My children take after their father.*
3	
[mas 'kerasan 'ena va'ri 'nostimo ɣli'ko]	*They treated us to a heavy tasty pudding.*
[mas 'kerasan 'ena va'ri ma 'nostimo ɣli'ko]	*They treated us to a heavy but tasty pudding.*
4	
[tu 'eðosa tus e'na 'mavrus marka'ðorus mu]	*I gave him my nine black markers.*
[tu 'eðosa tus e'na mu 'mavrus marka'ðorus]	*I gave him my nine black markers.*
5	
[i kane'ʎa 'ɣata mu 'jenise 'tria ɣa'taca]	*My brown cat had three kittens.*
[i kane'ʎa mu 'ɣata 'jenise 'tria ɣa'taca]	*My brown cat had three kitttens.*
6	
[to 'ifazma 'ine po'li 'liɣo ja 'ena 'forema]	*The fabric is too little for a dress.*
[to 'ifazma 'ine po'li pço 'liɣo a'poti 'nomiza]	*The fabric is much less than I thought.*
7	
[sto a'tiçima 'exasa to ariste'ro 'mati mu]	*In the accident I lost my left eye.*
[sto a'tiçima 'exasa to ariste'ro mu 'mati]	*In the accident I lost my left eye.*
8	
['kapços mu 'eklepse tin akri'vi 'ɣuna mu]	*Somebody stole my expensive fur coat.*
['kapços mu 'eklepse tin akri'vi mu 'ɣuna]	*Somebody stole my expensive fur coat.*
9	
[ðe do 'ftanis to vi'vlio] -	*Can't you reach the book? -*
['oçi ja'tine sto psi'lo 'rafi]	*No, because it is on the high shelf.*
[ðe do 'ftanis to vi'vlio] -	*Can't you reach the book? -*
['oçi ja'tine sto psi'lo to 'rafi]	*No, because it is on the high shelf.*
10	
['ipes 'oti θa 'minun 'pede 'meres] -	*Did you say they will stay five days?*
['oçi θa 'minun o'xto 'meres]	*No, they will stay eight days.*
['ipes 'oti θa 'minun 'pede i'meres] -	*Did you say they will stay five days?*
['oçi θa 'minun o'xto i'meres]	*No, they will stay eight days.*

Table 1: The test-sentence pairs; in test-pairs 9 and 10 the questions which triggered change of focus in the answers are included. The stress clashes are underlined.

pairs 9 and 10 focus is shifted so that instead of the second stress carrying the nuclear pitch accent, it is the first stress that does so. To achieve the desired effect, i.e. the shift of focus, test-sentences 9 and 10 were presented with a question preceding them (see Table 1). The inclusion of questions greatly facilitated the speakers in pronouncing the correct shifted focus.

Finally, in order to achieve smooth and continuous F0 contours, I tried, as far as possible, to use words which did not contain voiceless segments or stops. This is also the reason why the possessive enclitic [mu] *my* was preferred to the exclusion of others, like [su] *yours* or [tis] *hers*.

2.2. Speakers

The data presented here are based on the recording of two speakers, CN and AA. Both CN and AA are in their twenties, are native speakers of standard Greek and have no known speech or hearing problems. AA is the author; CN is a first year graduate student at Oxford who was naive as to the purpose of the experiment.

2.3. Procedure

The recordings took place in the recording booth of the Phonetics Laboratory, Oxford. Each speaker recorded the sentences 6 times, in random order, reading them from sheets typed in Greek. Speaker CN, who was unfamiliar with the material, was given some time to read the sentences before the recording. He was also instructed to read the sentences carefully, prior to enunciation, in order to make certain, for example, that he used the word ['mera] only where it was spelt *μέρα* and not where it was spelt *ημέρα*. He was also told to read the sentences at a rate he judged comfortable and natural for his speech. Both an audio and a laryngeal signal (by means of a laryngograph) were recorded. The laryngeal signal was used in order to obtain more reliable F0 curves.

2.4. Measurements

The material was digitized at 16 kHz and durational measurements were made from digital spectrograms following standard criteria of segmentation (see e.g. Peterson and Lehiste 1960). Two types of durational measurements were obtained: the duration of the vowel of the first syllable involved in the clash and of the equivalent syllable in the NSC condition, and the duration of the consonant of the second syllable in the clash and of its NSC equivalent. I decided to measure the duration of the first vowel rather than that of the whole syllable because previous stress clash data (Arvaniti 1991) showed that the duration of vowels was much more consistently affected by the stress clash than the duration of syllables[4]; these data agree also with Malikouti-Drachman and Drachman's suggestion[5]. In addition to durational measurements, F0 tracks were obtained using the pitch extraction routine of the spectrograph.

3. Results

3.1. Phonological distance

Mean durations and standard deviations of first vowels in the clash can be seen in Figure 1. The durations of SC and NSC vowels were compared by means of 2-way repeated measures analyses of variance (stress clash condition x speaker), the results of which are shown in Table 2. On the whole, there was very good agreement between speakers and there were no factor interactions.

First vowel lengthening was used quite regularly. Specifically, it was observed in test-pairs 5,

[4]Syllable durations remained unaffected by the stress clash in more than half of the relevant data, possibly because of consonant shortening.
[5]In contrast to Nespor and Vogel who talk about syllable lengthening, Malikouti-Drachman and Drachman explicitly refer to vowel lengthening.

6, 8, 9 and 10, i.e. in half of the data. The other half showed two different trends: in test-pairs 1, 2 and 3 no durational difference was observed between NSC and SC first vowels; in test-pairs 4 and 7 the duration of the SC first vowel was shorter than that of the equivalent NSC vowel.

	F(1,10)	p
SC - NSC		
1. ma'ma - ma'ma mu	0.48	n.s.
2. pe'ða - pe'ða mu	0.09	n.s.
3. va'ri - va'ri ma	0.74	n.s.
4. e'na - e'na mu	91.46	0.000••
5. kane'ʎa - kane'ʎa mu	35.36	0.000•
6. po'li - po'li pço	38.14	0.000•
7. ariste'ro - ariste'ro mu	17.49	0.002••
8. akri'vi - akri'vi mu	37.6	0.000•
9. psi'lo - psi'lo to	220.82	0.000•
10. o'xto - o'xto i(meres)	10.3	0.009•

Table 2: F-ratios and probability levels from 2-way ANOVAs for comparison of durations of first vowels in SC and NSC conditions, for both speakers together. The syllables whose vowel durations are compared are underlined. Single dots indicate significant vowel lengthening in the stress clash condition, while double dots indicate significant vowel shortening.

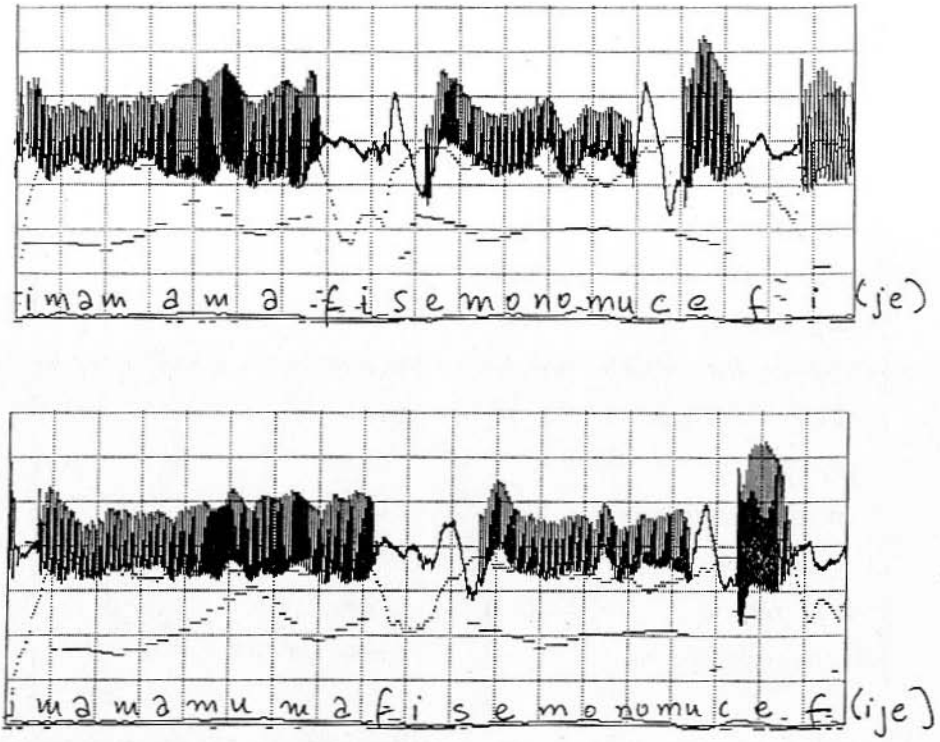

Figure 3: Laryngographic signals and F0 contours for test-pair 1: [i ma'ma 'mafise 'mono mu 'cefije] (top) : [i ma'ma mu 'mafise 'mono mu 'cefije] (bottom). Speaker CN.

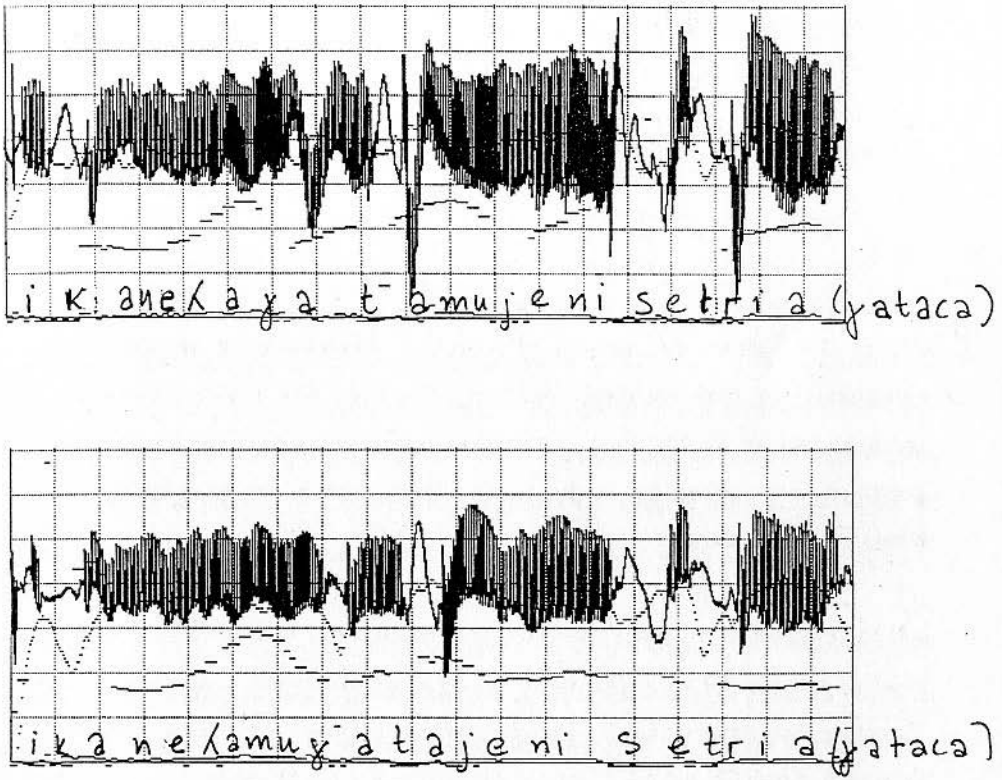

Figure 4: Laryngographic signals and F0 contours for test-pair 5: [i kane'ʎa 'ɣata mu 'jenise 'tria ɣa'taca] (top) : [i kane'ʎa mu 'ɣata 'jenise 'tria ɣa'taca] (bottom). Speaker CN.

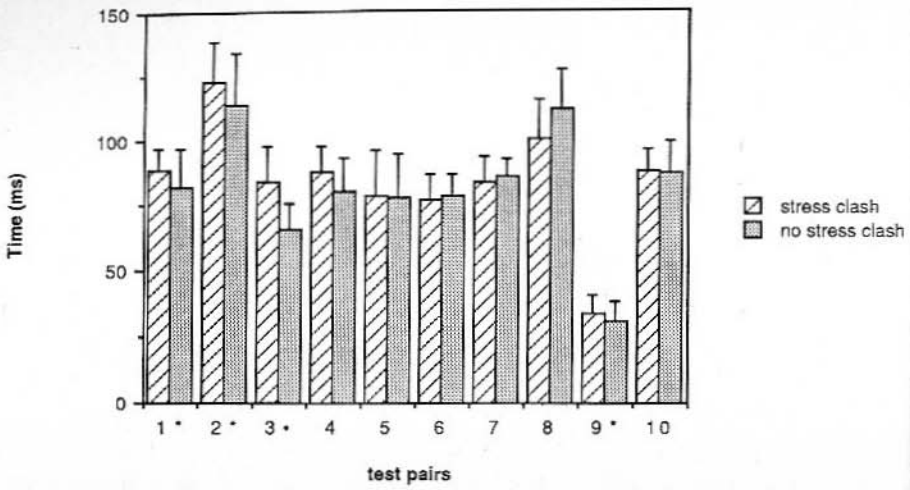

Figure 2: Mean durations and standard deviations of second syllable consonants for both speakers together. Numbers 1-10 indicate test-sentence pairs as shown in Table 1. Asterisks indicate speaker and stress clash condition interaction; dots indicate significant consonant lengthening in the stress clash condition.

It is at present difficult to find a satisfactory explanation of first vowel shortening which was observed in test-pairs 4 and 7. Perhaps this is only an accidental result which would disappear if more speakers were examined. However, it was a rather robust effect and it was present in the speech of both CN and AA. One possible explanation, for the results of test-pair 4 only, could be that [eˈɲa] *nine*, being a numeral adjective, is not considered particularly important by the speakers and consequently loses its stress in order that the clash be avoided. At the same time, however, the final syllable of [eˈɲa] has a clear F0 rise (i.e. a pitch accent) both in the SC and the NSC case, like stresssed syllables in all other test-pairs. This discrepancy could possibly imply that the intonation and rhythmic structures operate independently of one another in cases of stress deletion. This is only a hypothesis at the moment; a clearer picture could emerge if more cases in which stress deletion is possible were investigated.

3.2. Pitch difference

On the whole the two speakers showed very good agreement regarding F0 contours. The main difference between them was that CN's data showed a greater declination effect than AA's, whose F0 remained generally high. Also, AA's F0 curves seemed to be more prone to local effects, i.e. small drops of F0 during nasal consonants and [j] and [ɣ]; as a result CN's contours are much smoother.

At first glance it would appear that the pitch difference strategy was used quite often in the present data; in many cases the first syllable in the clash is pronounced with rising F0 which reaches a high peak, while the second syllable in the clash is pronounced with low and often falling F0 which rises only towards the end of this syllable (see the top graphs of Figures 3 and 4). However, the same pattern in also observed in the data that do not contain a stress clash, as the bottom graphs of Figures 3 and 4 show. This tendency is particularly clear in CN's data (because his F0 contours showed less local effects) and can be easily accounted for by what is known of Greek intonation.

Specifically, in Greek stressed vowels which carry pitch accents are associated with distinct F0 rises[6]. A very marked characteristic of these F0 contours is that although the rise may begin on the stressed syllable, if there is an unstressed syllable following, the F0 peak is found on this unstressed syllable (Arvaniti 1991; see also Botinis 1989 for similar results). This is exactly what happens in the present data, as Figures 3 and 4 show. In these figures it can be clearly seen that while in the SC case the F0 peak is reached at the end of the first of the clashing syllables, in the NSC case it is reached on the intervening unstressed syllable ([mu] in both Figures 3 and 4). However, it is important to observe that while the second one of the stressed syllables starts with falling F0 in both SC and NSC sentences, F0 rises towards the end of this syllable's vowel and the rise continues during the next unstressed syllable; in other

[6]This is of course the case when neutral "declarative" intonation is used, as in the present examples.

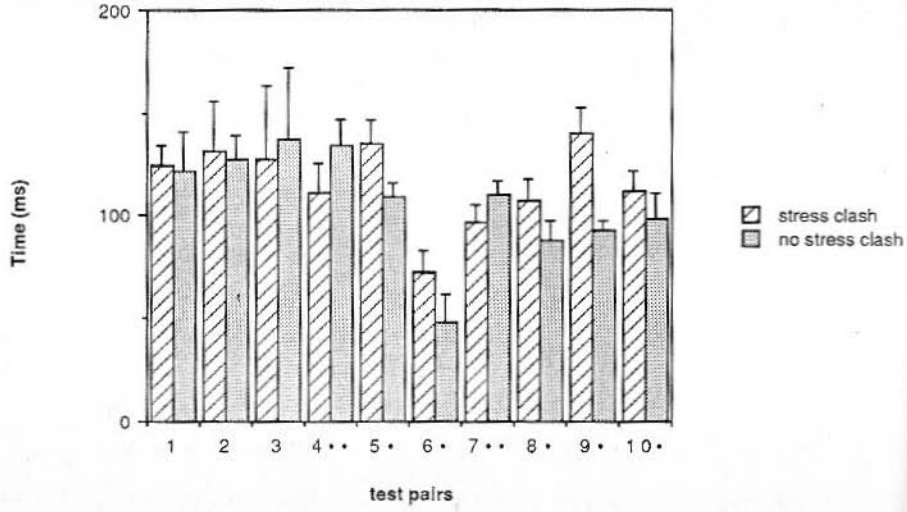

Figure 1: Mean durations and standard deviations of first syllable vowels for both speakers together. Numbers 1-10 indicate test-sentence pairs as shown in Table 1. Single dots indicate significant vowel lengthening in the stress clash condition, while double dots indicate significant vowel shortening.

As mentioned, instead of lengthening the first vowel in the clash it is possible to lengthen the consonant(s) intervening between the stressed vowels. It was expected that this strategy would be used mostly in the 5 cases which did not show first vowel lengthening. The results offer only weak support to this hypothesis; the second consonant was lengthened by both speakers only in test-pair 3 ($F(1,10)=27.82$, $p\leq0.000$), which is among those that did not exhibit first vowel lengthening (see Figure 2 for the means and standard deviations of second consonants). Second consonant lengthening was also observed, in AA's data only, in test-pairs 1, 2 and 9 ($F(1,10)=6.96$, $p\leq0.02$, $F(1,10)=5$, $p\leq0.047$, $F(1,10)=6.15$, $p\leq0.03$ respectively); of these, 1 and 2 showed no first vowel differences.

Thus, in 6 of the 10 test-pairs both speakers resolved the stress clash by increasing the distance between the clashing stresses either by lengthening the first vowel in the clash or the following consonant, although the latter strategy seems more rare. AA used second consonant lengthening to a larger extent than CN: temporal distance in her data was used in 8 out of 10 test-pairs.

The third way in which it has been suggested that phonological distance can be achieved, namely the insertion of a pause, was not observed at all in AA's speech. CN did sometimes insert pauses but this happened both in the SC and NSC sentences of test-pairs 1, 2 and 3 in positions in which an intonation boundary could be inserted: in test-pairs 1 and 2 after the subject NP ([ma'ma] *mum* -[ma'ma mu] *my mum* , and [pe'ðja] *children* - [pe'ðja mu] *my children* respectively), and in test-pair 3 between the two consecutive adjectives ([va'ri] *heavy* and ['nostimo] *tasty*) even when they were separated by [ma] *but*, as in the NSC sentence. Since the pauses are inserted only at intonation boundaries, it seems that the stress clash is not resolved by the pause but rather by the intonation boundary (which can also be indicated by other means, such as rising F0). This idea, which is consistent with Beckman *et al.*'s (1990) findings for English stress clashes, could explain why CN did not use lengthening in test pairs 1 and 2: because he resolved the clash by inserting an intonation boundary between the clashing stresses.

words, in both SC and NSC sentences F0 follows the usual pattern for Greek pitch accents.

The F0 patterns observed in the present data could partly explain why Nespor and Vogel (1989) report a pitch difference between the clashing syllables: the patterns observed here could be interpreted as high F0 on the first syllable and low F0 on the second one by a trained phonetician (Nespor and Vogel recorded native speakers reading sentences with clashes and transcribed them); native ears, however, would be more likely to concentrate on the oncoming rise than on the initial fall of the second syllable's F0 because native speakers know that in Greek there is a time lag between stress and F0 rises. (This suggestion, however, leaves unexplained Nespor and Vogel's claim that it is equally possible for the second syllable in the clash to have high pitch and the first one to have low pitch.) The present results also show that it is worth comparing paradigmatically sentences with and without stress clashes: although the F0 pattern of the SC sentences may appear unusual to one who is unfamiliar with Greek F0 patterns, it is important to realise that it is exactly the same as that of NSC sentences.

4. Discussion and Conclusion

It is now possible to answer our first question, namely what strategies, among the many that have been proposed, are used for stress clash resolution in Greek and which are the most common. First, the present data show no evidence that pitch difference is used in Greek. (No evidence for stress deletion was found either, but this reflects the type of sentences used in the experiment rather than the frequency of stress deletion occurrence in Greek.)

Second, the data show that the strategy which was used in most cases was the increase of the distance between the clashing stresses; this was achieved in most cases by lengthening the first vowel in the clash, and more rarely by lengthening the second consonant. There was no strong evidence, however, that the speakers used pauses in order to create phonological

distance between the clashing syllables. Although pauses did occur in CN's speech, they were determined by intonation phrasing not the stress clash. This does not of course mean that inserting a pause does not remedy the clash, but rather that a pause would not be inserted in order to resolve a clash unless it could be placed at a suitable intonation boundary. Moreover, pauses were rather rare: there were 7 occurrences in all, only 4 of which were in SC sentences.

The present results on lengthening as a stress clash resolution are supported by Arvaniti (1991), who in an experiment on stress, which inadvertently included a stress clash, found that the stressed final vowel of disyllables, like [pa'pa] *priest,* which was involved in the clash, was significantly longer than the stressed initial vowel of disyllables like ['papa] *pope.* When the experiment was repeated with different carrier phrases in order to avoid the stress clash, four out of five speakers did not show any length difference between initial and final stress.

The Greek data seem to show lengthening more consistently than English data on stress clashes which cannot be remedied by stress shift. The results of the English studies are rather inconclusive; for example, both Lehiste (1972) and Rakerd *et al.* (1987) found that in such cases the first syllable involved in the clash is regularly lengthened, while Beckman *et al.* (1990) found no evidence of lengthening in their data.

The difference between Greek and English may be due to greater interaction between rhythm and intonation in English than in Greek. In contrast to the English data referred to in the introduction, the present data suggest that in Greek rhythm and intonation are fairly independent of one another. In theory there could be two ways in which rhythm and intonation could interact: if Nespor and Vogel's pitch difference strategy were used, intonation would be influenced by rhythmic considerations since a pitch accent would be lost (by virtue of F0 remaining low) in order that the stress clash be remedied; if on the other hand intonation overrode rhythm, one would expect a similar phenomenon to that observed in English, namely no stress clash resolution if one of the stresses carried nuclear pitch accent (Liberman and

Prince 1977, Selkirk 1984, Beckman et al 1990). The present data do not provide evidence for either hypothesis. First, intonation is not influenced by the position of the stresses in that each one of the syllables that must be accented retains its accent regardless of the stress clash. It is even tempting to speculate that the reason for the lengthening in most of the stress clash cases is to give enough time to F0 to achieve its course, i.e. the two rises associated with the two stresses in the clash. Second, the data show that the resolution of the clashes is not greatly influenced by intonation; e.g. there is no difference between the resolution of stress clashes involving nuclear pitch accent and those that do not, as there is in English. The only interaction between stress clash resolution and intonation is that an intonation boundary between the clashing syllables resolves the clash, as it does in English (Beckman *et al.* 1990). This (relative) lack of rhythm and intonation interaction in Greek is most likely to be due to the fact that the phonetic means of resolving clashes is duration, which is manipulated separately from intonation.

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