# The effect of prosodic factors on vowel realization: evidence from Greek dialects

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*Περίληψη*

*Η ανάλυση εξετάζει την επίδραση τεσσάρων προσωδιακών παραγόντων στην πραγμάτωση της διάρκειας και ποιότητας των φωνηέντων σε αυθόρμητη ομιλία τοπικών διαλέκτων της Νέας Ελληνικής. Στο δείγμα εκπροσωπούνται οι βόρειες και νότιες διάλεκτοι. Τα αποτελέσματα επιβεβαιώνουν την παρουσία κάποιων φωνητικών καθολικών, όπως η τελική επιμήκυνση σε περιβάλλον επιτονικού ορίου ή η επίδραση του λεξικού τόνου στις διπλανές συλλαβές, ενώ, ταυτόχρονα, εντοπίζονται φαινόμενα αντίθετα προς τα καθολικά, όπως η τάση για «υπερ-πραγμάτωση» των φωνητικών στόχων, που σχετίζεται με το μήκος της λέξης-φορέα.*

*Λέξεις-κλειδιά: προσωδιακοί παράγοντες, πραγμάτωση φωνηέντων, ελληνικές διάλεκτοι, ακουστική ανάλυση*

## 1 Introduction

The aim of the study is to examine the effect of a number of prosodic factors of phonetic variation on Greek dialectal speech. In this context, four regional Greek dialects were chosen: the southern dialect of Corfu, and the northern dialects of Ioannina, Kozani and Evros. Northern dialects feature extensive vowel reduction, with the manifestation of categorical mid-vowel raising and frequent high-vowel deletion (see, for example, Kainada and Baltazani 2015). What has not been investigated so far, is whether the phonetics of Greek dialects interact with a set of prosodic factors usually analyzed in standard varieties such as Standard Modern Greek (SMG). What is more, this study analyzes spontaneous, every-day speech. Nicolaidis (2003) points out that spontaneous speech features extensive variability, with hypo- to hyper-articulated vowels, something attributed to various factors, some of which prosodic.

Numerous studies have documented the effect of the prosodic position of vowels on the realization of duration and quality, such as those of Cho et al. (2013), and Lee et al. (2014) for English, or Bassea-Bezantakou (2000) for the Greek dialects. A factor of particular influence are prosodic boundaries; a boundary in the vicinity of a vowel can affect parameters such as its duration or spectral realization. Firstly, various researchers concur on the role of boundary strength. Lee and Cole (2005) report that English vowels are longer next to IP boundaries as opposed to word boundaries, while Baltazani (2006) reports that SMG vowels are prosodically stronger next to "high level" boundaries, as they resist assimilation and retain their distinctive qualities. Secondly, boundary relative position is equally important. The phenomenon of *final lengthening* is one of the most pronounced examples of the effect of final boundaries. It has been found that final boundaries in SMG have a much stronger effect than initial boundaries (Kainada 2010).

Another factor is the length of the carrier-word. Labov and Baranowski (2006) find English vowels significantly affected by carrier-word length, arguing that there is a cross-linguistic tendency for vowels to be shorter in longer words, in a process of "compression" taking place on the word level. Mitterer (2008) similarly finds that German and Dutch vowels are more prone to deletion in longer words. Regarding SMG, Baltazani (2007) finds vowel duration and quality reduced in longer words.

A third factor of variation in MG and other languages has to do with the role of lexical stress. Crosswhite (2001), who examines various European languages, finds that vowels undergo "mild" quality reduction in pre-tonic positions, but "extreme" reduction in post-tonic positions. In SMG, vowels are found reduced after stressed syllables (Baltazani 2007); in particular, the stressed syllable has a strong carry-over effect, which makes post-tonic vowels shorter and more centralized than pre-tonic ones. For this reason, post-tonic positions are described as "prosodically weaker".

A fourth factor is the relative position of vowels in the carrier-word. Studies on different languages have shown that there is a measurable effect; however, some of these results are contradictory. For example, there is strong evidence that vowels are longer (due to the *final lengthening* phenomenon), centralized, and devoiced word-finally (Hajek and Stevens 2011), however, other studies show that vowels centralize word-initially (Crosswhite 2001) or delete more frequently word-medially rather than word-initially or word-finally (Mitterer 2008). Greek vowels (SMG) seem to follow the first trend, as Arvaniti (2001) finds them reduced word-finally.

## 2 Method

Sixty-five men and women were interviewed, representing the four dialects and the two genders almost equally. The informants had lived in the place of interest for decades and were typical members of their local societies. Their demographic characteristics classified them as members of highly homogenous speaker groups. Moreover, they were all healthy in terms of the perception and production of oral speech. The acoustical data were collected at the four dialectal areas, with the speakers being in the comfort of their own place and among other dialectal speakers. The type of speech collected was spontaneous and genuinely dialectal, with the least possible interference or noise from the environment.

The recordings took place around 2010 and lasted several months. Professional equipment such as the Maranz PMD660 and the Sony ICD P620 recorders were used, with the sampling rate set at 44,1KHz. The final number of unstressed vowel tokens used in the analysis were 4375, although the interviews had provided a lot more. Stressed vowel tokens, tokens adjacent to glides or other vowels were excluded, as their segmentation could be problematic. In addition, all tokens with non-neutral intonation or otherwise acoustically inappropriate were also excluded. *Praat* was used for the acoustical analysis of the data; there, vowel duration was measured manually, and formants F1 and F2 were measured from the vowel mid-point automatically, by means of custom-made scripts.

| Vowel category | Dialect | | | |
|---|---|---|---|---|
| | Corfu | Ioannina | Evros | Kozani |

| | | | | |
|---|---|---|---|---|
| a | 366 | 398 | 319 | 326 |
| e | 270 | 313 | 220 | 239 |
| i | 247 | 163 | 192 | 130 |
| o | 217 | 256 | 227 | 206 |
| u | 104 | 62 | 75 | 45 |
| **Totals** | 1204 | 1192 | 1033 | 946 |
| | 4375 | | | |

**Table 1| The distribution of the unstressed vowel tokens of the study**

The variation in vowel duration and quality was measured by multivariate and univariate analyses of variance. Thus, the three dependent variables are vowel duration and formants F1 and F2 from the spectrum. The four independent variables relate to the prosodic position of vowels. First, *prosodic boundary*, which covers the type and relative position of a boundary; the first two levels of the variable, *IP-initial* and *ip-initial*, refer to an intonational or intermediate boundary that precedes target-vowels, whereas *IP-final* and *ip-final* refer to a corresponding boundary that follows target-vowels. A fifth level of the variable (*no boundary*) refers to the condition where there is no boundary in the environment of the target-vowel and is used for reference. The second prosodic variable is *carrier-word length* and has 5 levels: words from 1 to 5 syllables long[1]. The third variable is *pre-/post-tonic position*, and refers to the position and distance (in syllables) of the target-vowel relative to stressed syllable; thus, there are 4 basic levels (*pre1*, *pre2*, *post1*, and *post2*) and a fifth level (*no stress*) covering words bearing no stress, such as monosyllabic functional words, and used for reference. The fourth variable is labeled *position in carrier-word* and refers to the relative position of the target-vowel. The unit of measurement is the syllable, and the levels are: *initial*, *intermediate*, and *final*; again, an additional level of the variable, labelled *1-syllable* (covering monosyllabic words), is used for reference and a better understanding of the variable. Apart from the four prosodic variables, *vowel category* is treated as an additional independent variable where necessary. All data were weighed for speaker gender and dialect where necessary.

## 3 Results

Observing the differences between dialects and across the various prosodic conditions under analysis, two main trends are detected. Firstly, unstressed Corfiot vowels are always much longer (79ms) than the corresponding vowels in northern dialects (average: 60ms). In addition, the differences between the three northern dialects are in every case non-significant ($p>.05$). A similar pattern is observed regarding vowel quality, with Corfiot vowels being more peripheral and more fronted than northern vowels. Moreover, there is extensive, i.e., categorical, mid-vowel raising in the three northern dialects. However, there are some differences within northern dialects, such as the more fronted vowels of Ioannina and Kozani compared to those of Evros. The second trend is that all within-dialect differences do not interact significantly with the four prosodic variables under analysis. Specifically, the average strength of the interactions (across the

[1] Typologically, these 5 levels cover around 99% of the words in the sample.

independent and dependent variables) is very low, accounting for around .5% of the variation observed. Therefore, the results for vowel duration and quality below are presented across dialects.

### *3.1 Prosodic boundary*

The multivariate analysis revealed a significant effect of boundary (level *no boundary* is used for reference). Thus, the result for *prosodic boundary* is Pillai's Trace=.011, F(12, 13110)=4.13, p<.001, partial $\eta^2$=.004. These results express the overall effect on duration, F1, and F2.

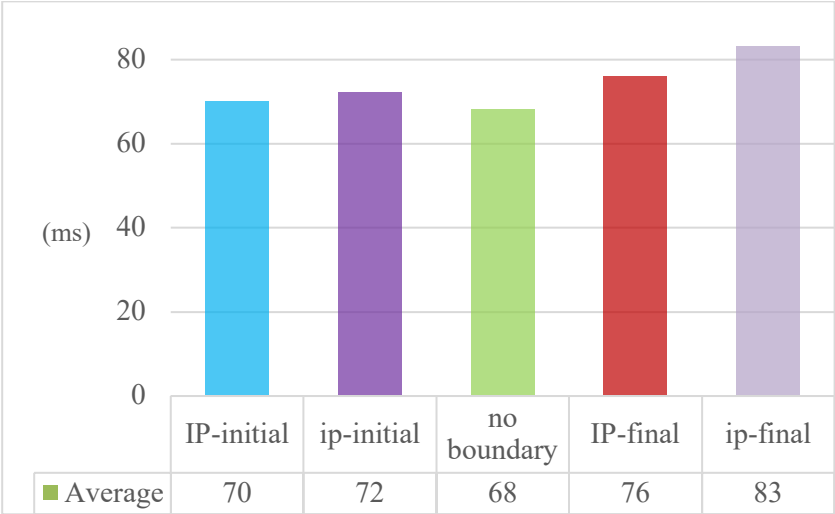


**Figure** 1 | **Mean vowel duration by prosodic boundary condition**

Vowels across dialects are longer in the environment of final boundaries, something which is indicative of the *final lengthening* taking place in the dialects. The comparison with the *no boundary* condition suggests that the final lengthening effect is clearly more pronounced compared to the marginal initial lengthening effect present in the data. Within final boundaries, vowels are longer at the end of an intermediate rather than an intonational phrase. Within initial boundaries, vowels are also longer after an intermediate phrase boundary. Both these findings indicate that there is no correlation between boundary strength and vowel duration.

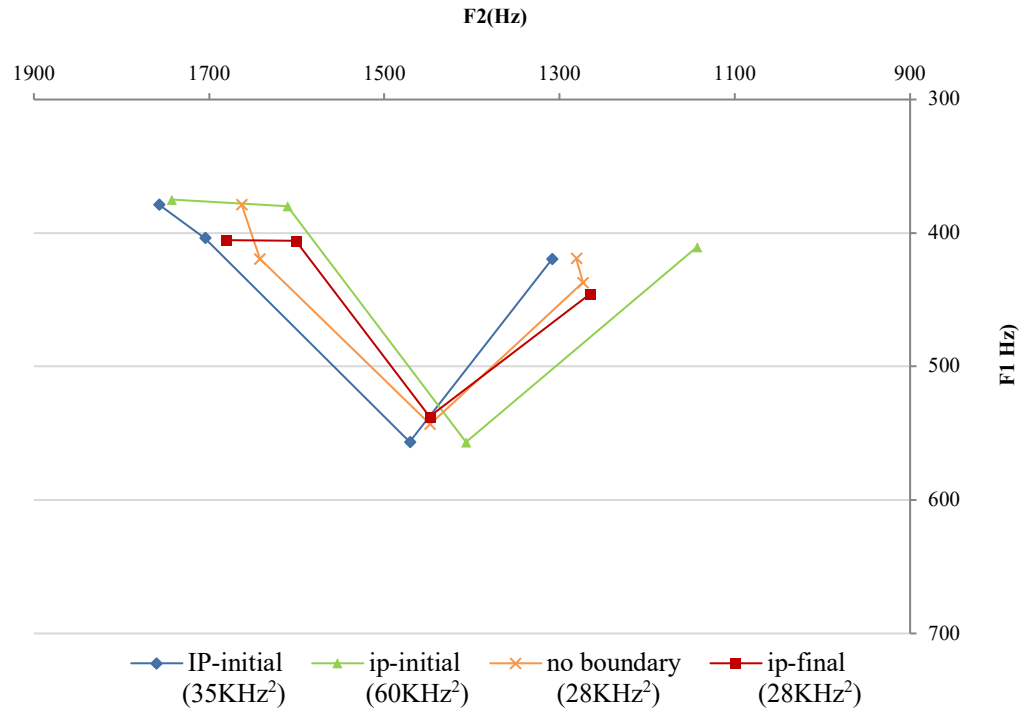


**Figure 2 | Vowel quality (and vowel area) by prosodic boundary condition**

The sample does not contain enough tokens for the analysis of the *IP-final* boundary. According to the results, [i] and [a] across dialects do not feature any significant quality contrast, meaning their quality is not affected by the presence or the type of boundary in their environment. On the other hand, there is significant height difference for [e], as it is raised by 39Hz in the environment of an *ip-initial* boundary (380Hz) as opposed to the environment without boundaries. As for [o], there is significant variability on F2 axis, with *ip-initial* [o] being much further back (1144Hz) than [o] in *IP-initial* (1308Hz) and *no boundary* (1273Hz) environments. Unfortunately, there are not sufficient data for [u]. Generally, it seems that vowels in an *IP-initial* environment are somewhat fronted, while vowels in an *ip-initial* environment show a tendency to be further back than vowels in other environments. Moreover, the type of initial boundary seems to play a significant role. Finally, vowel area[2] measurements indicate that initial boundaries are associated with prosodically stronger vowels. Again, the type of boundary is very important for the size of the area.

### *3.2 Carrier-word length*

The role of the length of the carrier-word on vowel realization is also found to be statistically significant (Pillai's Trace=.013, F(18, 13104)=3.171, p<.001, partial $\eta^2$=.004).

[2] Vowel space is measured for [i, e, a, o] due to the lack of data for [u]. Heron's formula is used.

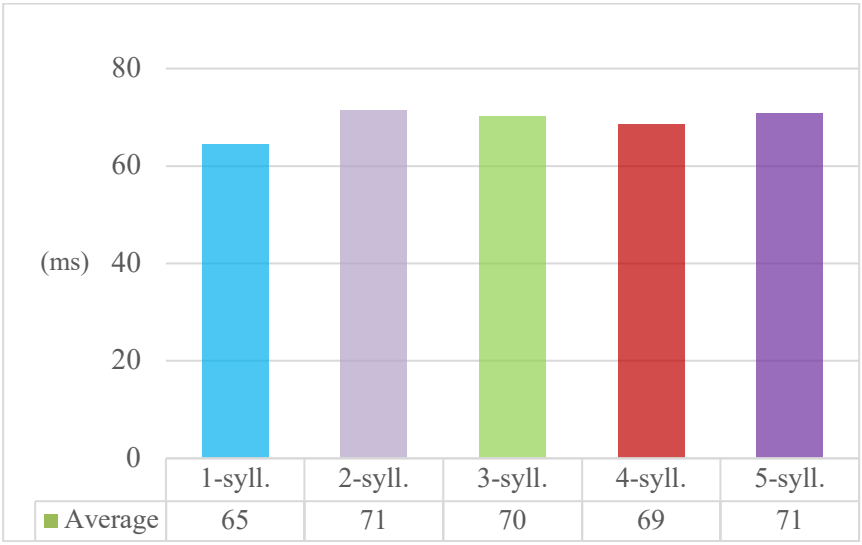


**Figure 3 | Mean vowel duration by carrier-word length**

Across dialects, vowels in 1-syllable words are clearly the shortest (65ms), while vowels in 2-syllable and 5-syllable words are the longest (both 71ms). Due to the ordinal nature of the variable, the *word length*vowel length* correlation was measured, with the determination coefficient reaching $R^2$=.4. This suggests a medium to low positive correlation, showing that vowel duration generally increases in longer carrier-words. As a result, the compression hypothesis on the word level, as set forth by Labov and Baranowski (2006) –among others, cannot be supported.

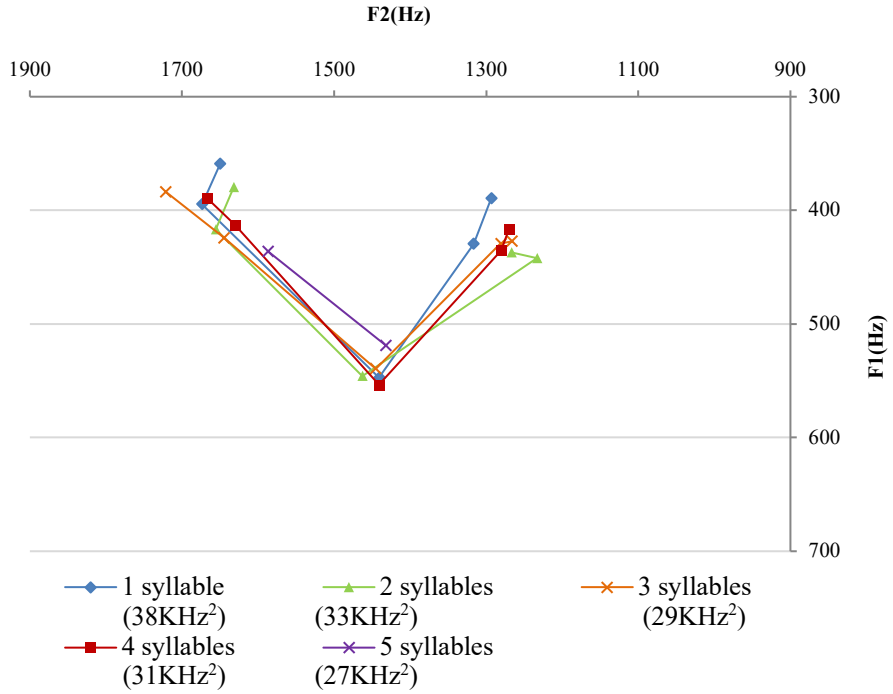


**Figure 4 |Vowel quality (and vowel area) by carrier-word length**

Regarding vowel quality, the only category without enough data for analysis is the *5-syllable*words, for which the results only cover [e] and [a]. The low vowel [a] does notfeature significant differencesbetween the 5 different types of carrier-word. On the other hand, [i] is both significantly higher in *1-syllable* words, and much more fronted in *3-syllable*–as opposed to *2-syllable*–words. The front mid vowel [e] is significantly higher in *1-syllable* words than in *2-*, *3-*, and *5-syllable* words, while [o] is much more fronted in *1-syllable* words as opposed to *2-syllable* words. Finally, [u] is only affected on F1, as in *1-syllable* words it is significantly higher than in *2-* and *3-syllable* words. Generally, it seems that *1-syllable* words is the category with the strongest effect on vowel quality. Something else emerging from the data, is that [e] and [a] tend to be more centralized in *5-syllable* wordscompared to shorter carrier-words. Vowel areasuggests that the shorter the carrier-word, the more peripheral the vowels, featuring a strong linear correlation ($R^2$=.85) and verifying Baltazani (2007) for SMG.

### *3.3 Pre-/post-tonic position*

The position of vowels in relation to the stressed syllable is a statistically significant factor of variation, according to the multivariate analysis (Pillai's Trace=.033, F(18, 13104)=7.98, p<.001, partial $\eta^2$=.011). For a better understanding of the variable, the level *no stress* is also used.

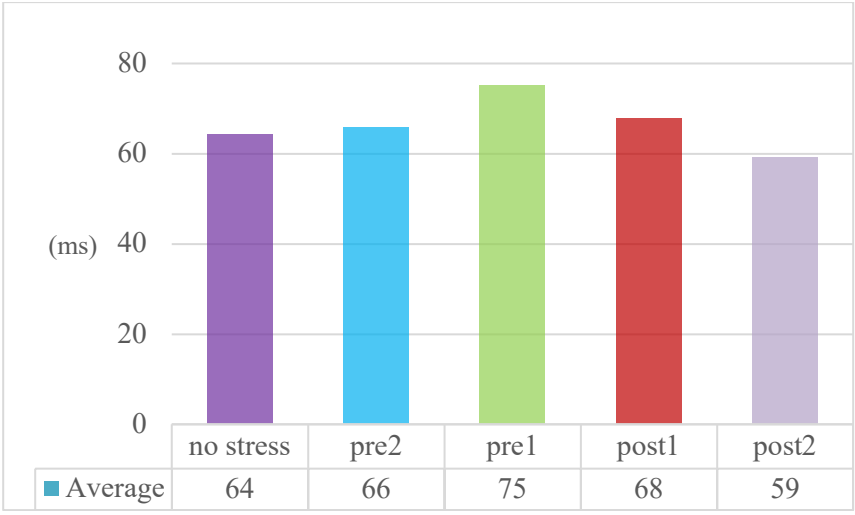


**Figure 5 | Mean vowel duration by pre-/post-tonic position**

Vowels are generally longer pre-tonically than post-tonically. This tendency, however, is not accompanied by a distance effect. Thus, vowels in the second pre-tonic position are not longer than vowels in the first pre-tonic position (actually, they are 9ms shorter). In addition, there is no evidence for word-final lengthening taking place, as *post2* vowels are 9ms shorter than *post1* vowels. With these four variable levels forming an ordinal scale, the determination coefficient was found to be rather low ($R^2$=.3), with the slope of the correlation descending. This suggests a weak tendency of vowels to become shorter as their position shifts from two syllables left of the stressed syllable to

two syllables right of it, that is, in a rightward direction in the carrier-word (disregarding the stressed syllable).

What is more, vowel duration in words bearing no stress was found almost the same as the average post-tonic (64ms vs. 63.5ms), indicating that lexical stress clearly strengthens prosodically pre-tonic vowels. As for how much, the percentage difference between average pre-tonic and post-tonic vowel duration is 10%. Also, given that stressed vowels cross-dialectally have an average duration of 102ms, it seems that pre-tonic vowel lengthening covers almost 18% of the distance between post-tonic and stressed vowels.

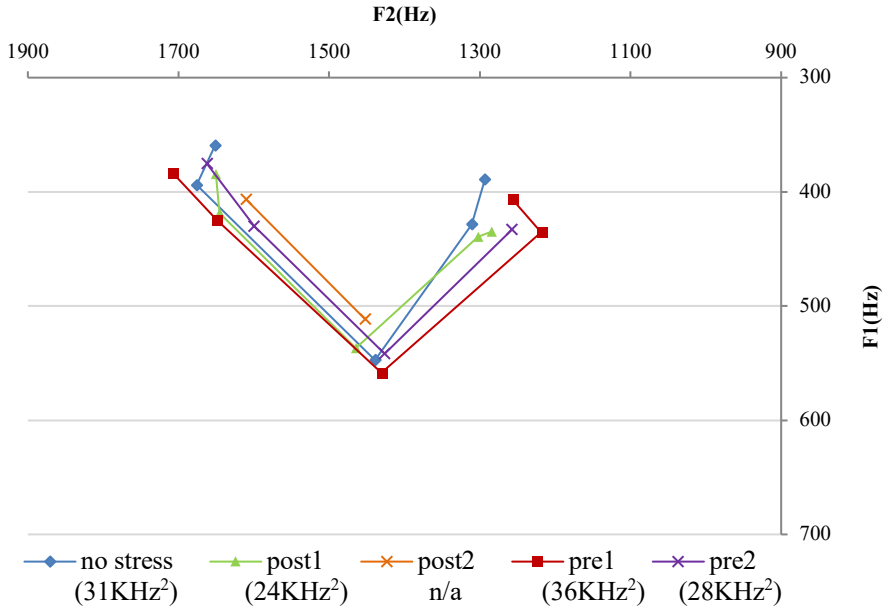


**Figure 6 | Vowel quality (and vowel area) by pre-/post-tonic position**

The variability in vowel quality associated with *pre-/post-tonic position* generates a different picture than the ones found in the previous sections (i.e., variables), in that F2 is not significantly affected. Another finding, is that all significant variation is associated with the *no stress* category, with [i], [e], and [u] generally found significantly raised in this type of words. Unfortunately, there are not enough data for [i], [o], and [u] in the *post2* position, as well as for [u] in the *pre2* position.The area measurements are quite informative, however. Although there is no result for the *post2* category, judging from the positions of [e] and [a] in figure 6, it is reasonable to predict that this shape would be the smallest. The overall order of the values suggests three things: first, pre-tonic vowels are clearly more peripheral than post-tonic ones; second, a distance effect is present only post-tonically; third, vowels in *no stress* words form a rather large vowel shape, suggesting more peripheral vowels. With vowels in *no stress* words not affected by stress, their similar behaviour to the pre-tonic vowels, indicates that stress has a stronger carry-over effect, which makes vowels prosodically weaker, something verifying Baltazani (2007) for SMG.

### *3.4 Position in carrier-word*

The last variable refers to the relative position of vowels in the carrier-word, and is associated with significant variation (multivariate analysis: Pillai's Trace=.016, F(9, 13113)=8.04, p<.001, partial $\eta^2$=.005).

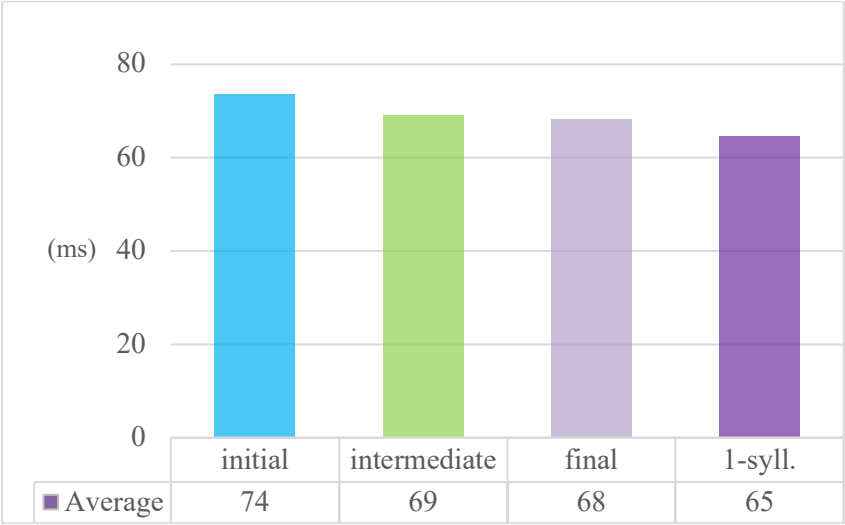


**Figure 7 | Mean vowel duration by relative position in word**

Vowels are clearly longer (p<.05) word-initially. Moreover, there is a strong correlation between vowel position and vowel length ($R^2$=.87; excluding 1-syllable words), with a descending trend line, showing that vowels become shorter from left to right in a carrier-word. As for vowels in 1-syllable words, they are the shortest, replicating the findings already presented in the *carrier-word length* section.

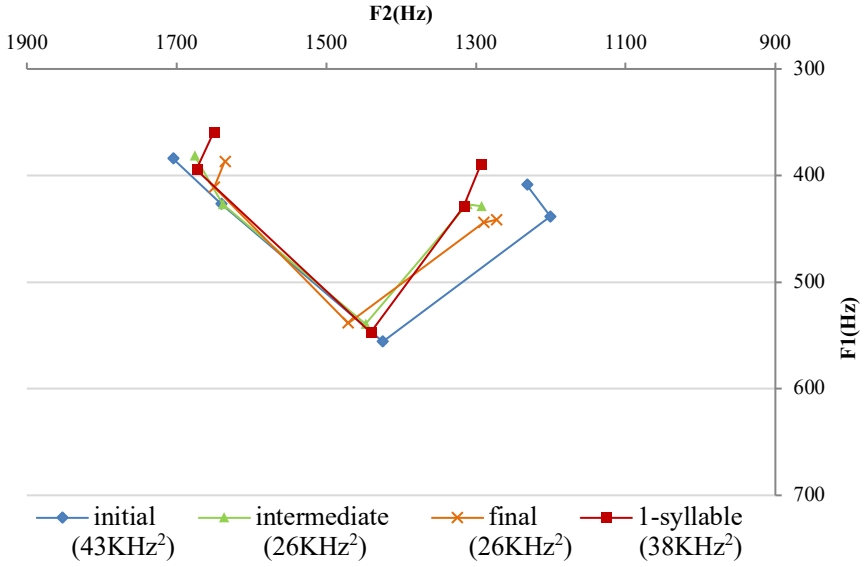


**Figure 8 | Vowel quality (and vowel area) by relative position in word**

Vowel position seems to interact with *vowel category*. Thus, word-initial [a] is significantly lower than its intermediate and final counterparts, and further back on F2 than its word-final counterpart. As for [i], it is higher in *1-syllable* words than in any other condition. The mid vowel [e] is also stable on F2, but it takes significantly different positions on F1 in the pairs of *initial vs. final*, *initial vs. intermediate*, *intermediate vs. final*, *intermediate vs. 1-syllable*, and *final vs. 1-syllable*. The other mid vowel ([o]) is unexpectedly less affected on F1 (it is lower word-finally rather than word-medially), and more affected on F2, where it is found much further back word-initially than in the other conditions. Finally, [u] is significantly higher word-initially than word-finally, and higher in *1-syllable* words rather than in an intermediate or the final position of longer words. The tendency for more peripheral word-initial vowels is confirmed by vowel area measurements. What is more, there is a medium to strong linear correlation between vowel position (initial → intermediate → final) and vowel area ($R^2$=.76), suggesting that vowels tend to become reduced rightwards in a carrier-word. Lastly, vowel area in *1-syllable* words is closer to that of the initial position, showing that these two categories are associated with prosodically stronger vowels.

## 4 Conclusion

A basic outcome of the analysis is that some of the most influential prosodic factors of phonetic variation do not interact with language variety. That is, despite the grave differences between southern and northern, or within northern Greek dialects, the various prosodic arrangements operate at an independent level. In this context, phonetic variability has been examined solely as a correlate of the prosodic configuration of vowels. The factors chosen, represent some of the most influential ones cross-linguistically. The results seem to align to an extent with the findings in the relevant literature. Hence, the *final lengthening effect* is present in the environment of final boundaries, while boundary-initial vowels are relatively shorter but not establishing a corresponding *initial shortening* effect. What is more, the strength of the boundary does not seem to be important for the realization of duration. As for vowel quality, initial boundaries are associated with more peripheral vowels, while both initial and final boundaries are associated with mid-vowel raising when compared to an environment without boundaries. Lastly, there is strong evidence that boundary type is important for initial boundaries, as *ip-initial* boundaries are associated with prosodically much more prominent vowels than *IP-initial* boundaries.

Regarding carrier-word length, vowel duration does not follow a pattern of compression in longer words (contra other studies). Instead, vowels in 1-syllable words are found to be the shortest, and vowels in 5-syllable words the longest cross-dialectally. To a certain extent, there is evidence of vowel "overshoot" (as opposed to "undershoot"), as vowel duration generally increases in longer words. Unlike vowel duration, vowel quality is in line with the findings in the relevant literature. In that sense, vowels are more peripheral in shorter carrier-words, with vowel space shrinking in longer words, featuring a quite strong correlation ($R^2$=.85). Moreover, [i], [u], and [e] are significantly raised in 1-syllable words, an indication that contrasts between vowel categories are enhanced in shorter words.

Regarding the effect of stress, vowel duration is significantly longer pre-tonically, whereas vowel duration in words without lexical stress (usually monosyllabic functional words) resembles the post-tonic syllables. This shows that word stress has a rather anticipatory lengthening effect on vowels. However, the distance from the stressed syllable does not have an additive effect. Vowel quality is also affected, though only on the vertical positioning of vowels. Generally, post-tonic vowels show a tendency for centralization, suggesting a predominantly carry-over effect. Furthermore, a distance effect cannot be generalized, as it is present only post-tonically. To conclude, post-tonic vowels are found reduced, confirming earlier studies.

Finally, word-initial vowels are found prosodically stronger, confirming studies on other varieties and languages. Thus, the dialectal vowels are longer and more peripheral word-initially, while word-final vowels do not differ significantly from vowels in intermediate positions. With the relevant linear correlations being rather strong, it seems that, knowing the position of a vowel token in a word, we can predict with a rather high degree of confidence how long or peripheral it might be. Another finding is that vowels in 1-syllable words show some unique properties compared to vowels in longer words, resembling word-final vowels in terms of duration, but word-initial ones in terms of quality.

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