Tonal production and syllabification in Greek

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Abstract

This is a study of syllabification as a function of lexical stress and sentence focus tonal production in Greek. The results of a production experiment indicate that tonal turning points are associated with syllable onset constituents in both lexical stress and focus contexts and indicate thus syllable boundaries. On the other hand, several intervocalic consonant clusters favor vowel insertion whereas other ones disfavor it.

Introduction

This study examines syllabification of intervocalic consonants as a function of lexical stress and sentence focus tonal production in Greek. Syllabification usually refers to phonotactic distribution and syllable structure whereas empirical evidence is sporadic, at least with respect to acoustic correlates, being mainly restricted to duration patterns. However, syllabification may correlate with tonal production and a question thus concerns syllable boundaries and tonal correlations in lexical stress and focus production contexts.

Research on syllabification advocates several principles in various theoretical contexts, such as the “Maximum Onset” (MOP) and the “Sonority Sequencing” (SSP). MOP predicts syllabification of consonants on the right, if the outcome forms a legal word-edge onset cluster (Kahn 1976). SSP predicts syllabification of consonants in accordance with a sonority scale, i.e., in a fairly simple version, [V(owel) > S(emivowel), L(iquid) > N(asal) > O(bstruent)], which forms a mirror image onset rising and coda falling pattern in relation to nucleus syllable peak (Steriade 1982, Clemens 1990).

Syllable analysts oftentimes assume that syllable is an abstract phonological unit, which has not however any robust phonetic correlates (Koller 1966). In many languages, however, including Greek, tonal turning points and especially tonal onset rises correlate with syllable initial segments (e.g. Botinis 1989, Atterer & Ladd 2004). Thus, our main hypothesis in the present study is that tonal turning points correlate with syllable onset constituents and indicate thus syllabification in Greek.

Experimental methodology

In accordance with one production experiment, the speech material consists of 6 disyllabic oxytone words in the carrier sentence [ˈlen __ maˈzi] (“(they) say __ together”) in lexical stress and sentence focus contexts (Table 1). 4 female speakers with standard Athenian pronunciation, at their early twenties, produced the speech material 4 times each. The corpus counts thus to 192 tokens (6 words x 2 prosody conditions x 4 speakers x 4 productions). The recordings took place at Athens University Phonetics Studio and speech analysis was carried out with Praat (Boersma & Weenink 2013). Tonal normalization was carried out with the ProsodyPro Praat script (Xu 2013) and statistical processing with SPSS.

Table 1. Intervocalic consonant context and oxytone test words with respective glosses.

Cluster	Test word	Gloss
1. [mn]/[NN]	[amno]	lamb
2. [vɣ]/[FF]	[avɣo]	egg
3. [zv]/[SF]	[azvo]	badger
4. [ɣn]/[FN]	[aɣno]	pure
5. [vl]/[F/L]	[avlo]	flute
6. [lɣ]/[L/F]	[alɣo]	ache

Results

This section presents qualitative analysis examples, followed by quantitative analysis and generalization of results.

Qualitative analysis

Lexical stress context

In figure 1.1, the tonal turning point in the word “amˈno” correlates with the left edge of the second nasal, which implies heterosyllabification of the nasal-nasal cluster.

In figure 1.2, the tonal turning point in the word “avˈɣo” correlates with the left edge of the second consonant, implying heterosyllabification of the fricative-fricative cluster whereas a vowel insertion between consonants is evident (i.e. ^{v}), which also implies heterosyllabification.

In figure 1.3, the tonal turning point in the word “azˈvo” correlates with the left edge of the second consonant, implying heterosyllabification of the sibilant-fricative cluster whereas, in contrast to the fricative-fricative cluster in 1.2, no vowel insertion between the consonants is apparent.

In figure 1.4, the tonal turning point in the word “aɣˈno” correlates with the middle of the vowel on the right of the consonant cluster rather than any of the consonants whereas a vowel insertion between consonants is also apparent. Tonal displacement and vowel insertion also imply heterosyllabification of the fricative-nasal cluster.

In figure 1.5, the tonal turning point in the word “avˈlo” correlates with the middle of the vowel rather than any of the cluster consonants, much like the fricative-nasal cluster in 1.4, implying heterosyllabification of the fricative-liquid cluster whereas a vowel insertion between consonants is also apparent.

In figure 1.5, the tonal turning point in the word “alˈɣo” correlates with the left edge of second consonant, implying heterosyllabification of the liquid-fricative cluster, whereas a vowel insertion between consonants is evident.

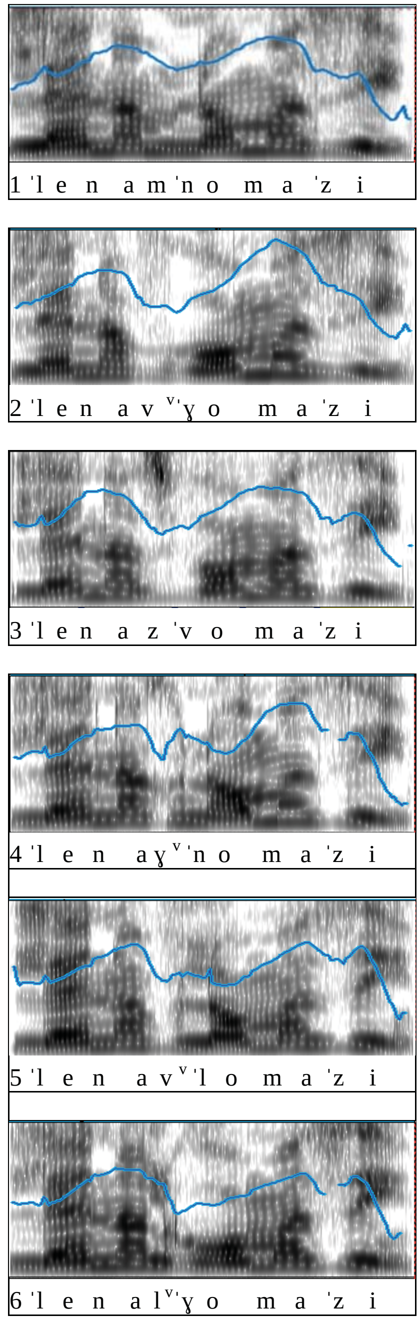

Figure 1. A female speaker’s examples of tonal representations as a function of syllable structure variability (cont. next page).

Focus context

In figure 1.7, the tonal turning point in the word “amˈno” in focus correlates with the left edge of the second nasal of the cluster. In figure 1.8, the tonal turning point in the word “avˈɣo” in focus correlates with the middle of the second fricative of the cluster. In figure 1.9, the tonal turning point in the word “azˈvo” in focus correlates with the left edge of the second consonant of the cluster. In figure 1.10, apart from microtonal perturbations, hardly any turning point in the word “aɣˈno” in focus is apparent. In figure 1.11, the tonal turning point in the word “avˈlo” in focus correlates with the left edge of the second consonant of the cluster. In figure 1.12, the tonal turning point in the word “alˈɣo” in focus correlates with the second consonant of the cluster whereas a vowel insertion is also evident.

Summary of qualitative analysis

The qualitative analysis above indicates the following regularities. First, a tonal turning point takes place between examined intervocalic cluster consonants, which indicates heterosyllabification of respective consonants.

Second, a vowel insertion between consonants is favoured in several cluster contexts (e.g. “avˈɣo”, “aɣˈno”) reinforcing thus respective heterosyllabifications but disfavored in other ones (e.g. “amˈno”, “azˈvo”).

Third, the turning point correlates with the onset of the syllable constituent, except for the words “aɣˈno” and “avˈlo” in out of focus context. Specifically, the latter words appear with both vowel insertions and right tonal rise displacement to about the middle of the nucleus vowel whereas no such a displacement takes place in focus context.

Thus, in general, it seems that tautosyllabification of intervocalic consonants is disfavored in Greek. On the other hand, focus production is an optimal context for tonal turning points and syllabification correlations.

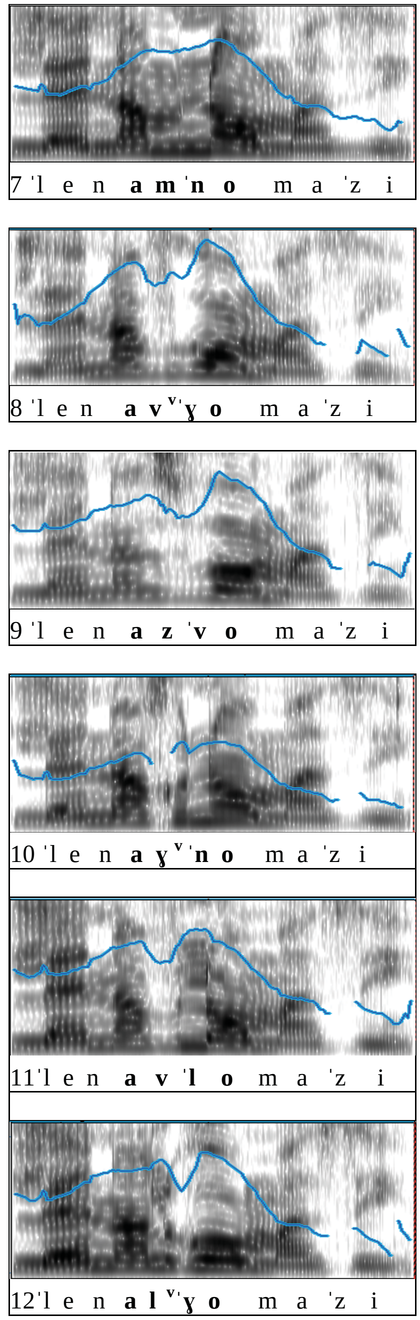

Figure 1. A female speaker’s examples of tonal representations as a function of syllable structure variability (see text).

Quantitative analysis

Table 2 shows vowel insertion as a function of different consonant clusters in stress, i.e. out of focus, and focus contexts. In general, some clusters disfavor vowel insertion, i.e. nasal-nasal (NN), sibilant-fricative (SF), and fricative-liquid (FL), and some other favor it, i.e. fricative-fricative (FF), fricative-nasal (FN), and liquid-fricative (LF).

Table 2. Vowel insertion (no/yes) as a function of consonant cluster (cluster) and prosody context variability (stress/focus).

Cluster	Stress		Focus		Total	
	No	Yes	No	Yes	No	Yes
[NN]	16	0	16	0	32	0
[FF]	3	13	0	16	3	29
[SF]	16	0	12	4	28	4
[FN]	0	16	0	16	0	32
[FL]	15	1	13	3	28	4
[LF]	4	12	7	9	11	21
Total	54	42	48	48	102	90

Kruskal-Wallis nonparametric test showed significant differences among consonant clusters in “stress” context ($H(5) = 66.5$, $p < 0.0001$), with a mean rank of 68.0 for NN, 30.22 for FF, 68 for SF, 21.5 for FN, 65 for FL and 33.1 for LF. Pairwise comparisons showed significant differences in 9 pairs out of 15, i.e. FN/FL, FN/NN, FN/SF, FF/FL, FF/NN, FF/SF, LF/SF ($p < 0.0001$) and LF/NN, LF/FL ($p < 0.005$).

There were also significant differences of consonant clusters in “focus” context ($H(5) = 60.8$, $p < 0.0001$), with a mean rank of 74 for NN, 24.5 for FF, 61.6 for SF, 24.50 for FN, 64.7 for FL and 46.1 for LF. Pairwise comparisons showed that 7 out of 15 pairs differed significantly, i.e. FN/NN, FN/SF, FN/FL, FF/NN, FF/SF, FF/FL ($p < 0.0001$) and LF/NN ($p < 0.05$).

Mann-Whitney nonparametric test, on the other hand, did not show any significant difference between “stress” and “focus” contexts except for the SF cluster ($U=96.0$, $p<0.05$, two-tailed), indicating that focus production hardly has any effect on vowel insertion.

Figure 2 shows quantitative results of four key words (additional results will be presented at the conference). In general accordance with the qualitative analysis (see figure 1), the tonal turning point in all four figures correlates with the second consonant of the clusters, which indicates heterosyllabification of all clusters, whether a vowel is inserted or not. Thus, the tonal turning point correlates as a rule with the onset consonant, but hardly with its left edge as earlier studies have shown.

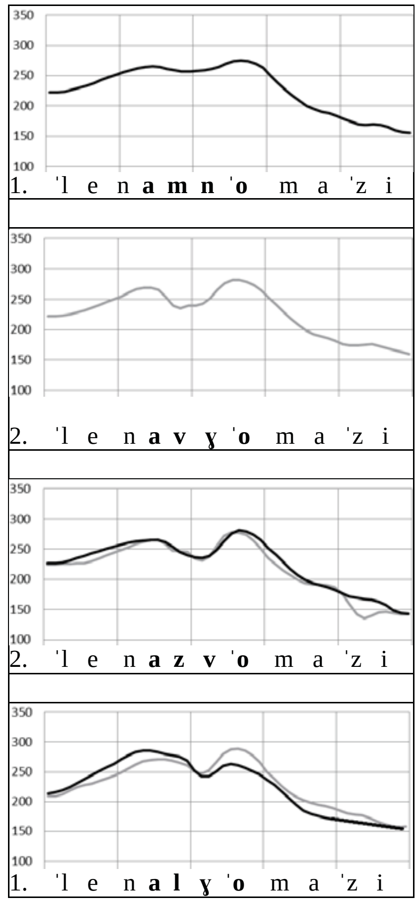

Figure 2. Average tonal contours of five female speakers and four repetitions of the key words in focus (bold letters) as a function of syllable structure variability (dark lines indicate no vowel insertion and light lines indicate vowel insertion).

Discussion

The basic hypothesis of the present study is that tonal turning points in Greek indicate syllable boundaries. Early research on Greek prosody (e.g. Botinis 1989) showed that tonal rises in lexical stress and sentence focus contexts initiate at the very beginning of the syllable, i.e. the left edge of the onset consonant. However, we assume that this is an optimal context with reference to tonal turning points and syllabification correlates, i.e. a CV phonotactic syllable context, with minimum interaction from immediate prosody context. The results of this study corroborate in principle earlier results with reference to correlation of tonal turning points and onset syllable consonants. Considerable variability is nevertheless evident within the domain of the onset consonant, even tonal turning point displacements to the right as a function of syllable context variability and especially vowel insertions.

Our results do not support either MOP or SSP predictions. The fricative-fricative as well as sibilant-fricative clusters in [avˈɣo] and [azˈvo], respectively, are as a rule heterosyllabified, despite the tautosyllabification on the right that MOP predicts. However, a vowel is as a rule inserted in the fricative-fricative cluster but not in the sibilant-fricative one. Vowel insertion as a function of consonant cluster variability may depend on word-edge coda legality, as [s] is a legal coda but not [v]. Likewise, the fricative-nasal cluster in the word [aɣˈno] is as a rule heterosyllabified, as evidenced also by vowel insertion, despite the right tautosyllabification that both MOP and SSP predict. Thus, it seems that Greek speakers disprefer complex consonant onsets, which results in heterosyllabification of intervocalic consonant clusters as well as vowel insertions between consonants. Thus, syllabification in Greek results in a variety of syllable consonant codas, which do not whatsoever constitute legal word-edge coda phonotactics.

In accordance with a study on Swedish, similar to the present one, the results indicate that tonal rises in sentence focus contexts initiate at the left edge of onset syllable consonants and correlate thus with syllable boundaries (Botinis, Ambrazaitis & Frid, this volume). Furthermore, much like in Greek, several consonant clusters favor vowel insertion whereas other ones disfavor it. Vowel insertion in Swedish is most unexpected as it concerns a fairly closed syllable structure language and any syllabification of intervocalic consonants does not in principle violate coda legality phonotactics. Thus, both Greek and Swedish seem to disfavor complex onsets and codas and show consequently fairly similar tendencies of vowel insertions between consonants. On the other hand, languages with different prosodic systems and syllable structures in particular, such as Greek and Swedish, may use similar strategies to mark syllable boundaries.

In addition to syllabification as a function of tonal turning points, the results of the present study (and especially in combination with the results in Swedish, Botinis et al., this volume) have several major implications. Tonal turning points are defined as a result of tonal targets, which are associated with the segmental string (Bruce 1977). Autosegmental-metrical theory (AM theory) and especially Pierrehumbert and collaborators (e.g. Pierrehumbert 1980, Pierrehumbert & Beckman 1986), adopting in principle Bruce's analysis of Swedish, suggest several "pitch accents" for the description of different languages, such as L*+H, H*+L, etc. Thus, in lexical stress context in Greek, e.g. the stressed syllable (*) is assumed to associate with a L*+H pitch accent in accordance with AM theory premises. In practice, this means that the L tonal target may vary across the entire domain of the stressed syllable whereas the H tonal target may just be on the right with hardly any further specification, i.e. a "trailing tone".

A similar shortcoming of AM theory is the lexical accent II representation in Swedish. Assuming a H*+L pitch accent, the H tonal target is within the domain of the stressed syllable, i.e. a starred tone, whereas the L tonal target is unspecified. In principle, the L tonal target may be anywhere on the right of the H tone, even outside the stressed syllable itself. We have however provided evidence that both H and L targets of the HL tonal fall of accent II in Swedish is confined within the stressed syllable and in particular within the nucleus vowel (Botinis et al., this volume). Thus, in accordance with AM premises, any H*+L or H+L*, or even H*+L* or [HL]* sequence is as good as any other. On the other hand, the starred tone, i.e. the H* tone, is assumed to be somehow stronger and in some way more important than the unstarred one, i.e. the L tone. It seems that, with specific reference to Swedish, no reason can be found why either of the two H and L tonal targets should be starred or why either of the tonal target might be more important than the other.

In accordance with our approach, our general hypothesis is that tonal targets "seek" for specific syllable constituent associations. Thus, in Greek, the L tonal target associates with the onset syllable constituent. This is however an optimal association as tonal displacements may take place as a result of various context pressures. On the other hand, in onsetless syllable contexts, e.g. /aˈoristos/ (aorist) the L target presumably associates with the nucleus vowel of the stressed syllable, which may be an alternative association. We may thus assume L target association with onset syllable constituent, otherwise with nucleus vowel. Another aspect of our approach is the "domain" of tonal target associations. In Swedish the domain of the accent II HL tonal fall is intrasyllabic whereas the domain of the LH tonal rise in Greek is intersyllabic. Thus, a major issue is the temporal window between tonal targets versus the syllable constituent association.

References

Atterer, M. & Ladd, D.R. (2004). On the phonetics and phonology of ‘‘segmental anchoring’’ of F0: evidence from German. Journal of Phonetics 32, 177-197.

Beckman, M.E. & Pierrehumbert, J.B. (1986). Intonational structure in Japanese and English. Phonology 3, 255-309.

Boersma, P. & Weenink, D. (2013). Praat: Doing phonetics by computer (http://www.praat.org).

Botinis, A. (1989). Stress and Prosodic Structure in Greek. Lund: Lund University Press.

Botinis, A., Ambrazaitis, G. & Frid, J. (2014). Syllable structure and tonal representation: revisiting focal Accent II in Swedish. Proc. FONETIK 2014 (this volume), Stockholm, Sweden.

Bruce, G. (1977). Swedish Word Accents in Sentence Perspective. Lund: Gleerup.

Clements, G.N. 1990. The role of the sonority cycle in core syllabification. In Kingston, J. & Beckman, M.E. (eds.), Papers in Laboratory Phonology I: Between the Grammar and Physics of Speech, 283-333. Cambridge University Press.

Kahn, D. (1976). Syllable-based Generalizations in English Phonology. Ph.D. thesis, MIT.

Kohler, K.J. 1966. Is the syllable a phonological universal? Journal of linguistics 2, 207-208.

Pierrehumbert, J.B. 1980. The Phonology and Phonetics of English Intonation. PhD thesis, MIT.

Steriade, D. (1982). Greek prosodies and the nature of syllabification. Ph.D. thesis, MIT.

Xu, Y. (2013). ProsodyPro. Proc. of tools and resources for the analysis of speech prosody, 7-10. Aix-en-Provence, France.