Language and Speech 2015, Vol. 58(1) 84–113.

Manuscript: Please do not quote in this form

Drifting Without an Anchor: How Pitch Accents Withstand Vowel Loss

Mary Baltazani
University of Oxford, UK

Evia Kainada
University of Ioannina, Greece

Abstract
We offer an analysis of the influence exerted by segmental rules on the suprasegmental structure in the dialect of Ipiros Greek (IG). In particular we investigated how vowel deletion (VD) affects the phonetic realization of the L*+H pitch accent. Our data empirically establish that the H tone aligns much earlier when VD applies than when it does not. Furthermore, we show that there is a phonological contrast between the nuclear L+H* and the prenuclear L*+H which hinges on early versus late H alignment respectively. We demonstrate that the contrast between the L*+H and the L+H* pitch accents is not compromised by the earlier alignment caused by VD. In other words, intonational contrasts are not endangered by fine phonetic alignment variability within the same category.

1. Introduction

Intonational phonology, embedded within the Autosegmental-Metrical (AM) framework, is increasingly gaining ground as one of the most widely adopted theories for intonation analysis, providing us with major breakthroughs into the structure of intonation cross-linguistically. One of the tenets of this theory is that pitch accents are phonologically associated with metrically prominent syllables. Research on the precise phonetic alignment of pitch accents with the segmental string has revealed that this alignment is systematic in a large number of languages and dialects (e.g., Arvaniti, Ladd, & Mennen, 1998; Dilley, Ladd, & Schepman, 2005; Ishihara, 2003; Prieto, 2005; Prieto, van Santen, & Hirschberg, 1995; Silverman & Pierrehumbert, 1990, among others).

The interest for this line of research was further sparked by the finding in Arvaniti and Ladd (1995) and Arvaniti et al. (1998) that the low and high points in the rising pitch accent in Standard Modern Greek (henceforth SMG), which are reflexes of the L and H tone of the L*+H[1], are independently aligned with specific points of the segmental structure, contra previous assumptions that the distance between a starred tone and its leading or trailing tone is stable. More remarkably, Arvaniti et al. (1998) showed that these two points systematically occur outside the boundaries of the metrically strong syllable: the low tone typically aligns right before the onset of the stressed syllable, while the high tone appears at the onset of the first post-accentual vowel.

This finding gave rise to the ‘segmental anchoring hypothesis’ (SAH[2]), according to which the low and high tones of pitch movements independently anchor to specific segmental landmarks. As has been shown in a number of studies, while the alignment of these L and H tones is stable, their distance and the F0 slope between them are influenced by the segmental and prosodic context. For example, Ladd, Faulkner, Faulkner, and Schepman (1999) reported that tonal alignment in prenuclear rising accents in English is not affected by changes in speech rate. Dilley et al. (2005) showed that the L alignment in prenuclear L+H* pitch accents in English mirrors the syllabic affiliation of the consonant, suggesting stability in its alignment and that changes in the position of the L tone did not affect the position of the H, again suggesting that these two tones align independently of one another. Xu (1998) found that the peak of the lexical rising tone 2 in Standard Mandarin Chinese aligns consistently with the syllable edge across different syllable structures and speech rates. Arvaniti et al. (1998) argued that the H alignment of the L*+H of SMG is not affected by its distance from the word's right edge (see Baltazani, 2006, for corroborating quantitative data). Moreover, they showed that the H alignment is not affected by the segmental context, while its distance from the L is. Prieto and Torreira (2007), on the other hand, reported a different alignment for the H tone in Spanish depending on the segmental context, that is, whether the accented syllable is closed or open, attributing this finding to a secondary phonological association of each of the comprising tones to specific phonologically defined segmental landmarks.

Our understanding of segmental anchoring has more recently been enhanced by several studies on dialectal variability, which show that, while alignment is fairly stable within dialects, there are systematic cross-dialectal differences in the text-tune linking. For example, variation of pitch accents across British English dialects has been reported within the IViE online corpus on intonation (Fletcher, Grabe & Warren, 2004; Grabe, Post, Nolan & Farrar, 2000; Grabe & Post, 2002; Grabe, 2004 on 'truncation' vs. 'compression' in four varieties of British English; on the 'high rising tune' across four English varieties). Northern German varieties have been shown to align the tones of prenuclear pitch accents earlier than Southern varieties (Atterer & Ladd, 2004). Similarly, Arvaniti and Garding (2007) reported later alignment in Southern Californian than Minnesotan English rising accents, and Ladd, Schepman, White, Quarmby, and Stackhouse (2009) showed that both nuclear and prenuclear peaks are aligned earlier in RP in comparison to Scottish Standard English. Extensive research has also been conducted for several Spanish varieties with similar findings (for recent studies on Sp_ToBI see among others Beckman, Diaz Campos, McGory, & Morgan, 2002; Estebas & Prieto, 2008; Face & Prieto, 2007). For example, peaks in Lekeitio Spanish were found to align earlier than in Madrid Spanish and Vitoria Spanish (Elordieta & Calleja, 2005) and, in a different study, the L and H tones of the L+H* rising pitch accent in Dominican Spanish align closer to each other than in other Spanish varieties (Willis, 2010).

All these cross-dialectal studies demonstrate that, typically, variability in the fine phonetic alignment details of tones does not affect the intonational phonological contrasts existing across the dialects of a particular language. Despite the fuzziness in the literature on whether SAH should be given a phonological or a phonetic interpretation to explain differences like the ones described above, it is lately becoming increasingly clear that related findings involve detailed observations of phonetic regularities about the way pitch accents synchronize with segments. The fact that segmental anchoring phenomena occur within certain phonological domains like the syllable, for example, does not entail that the detailed – and very often gradient – instructions for interweaving segments with tones are phonological (see Ladd, 2006, 2008, p. 172ff, for a detailed discussion on the subject). Decisions on the phonetic versus phonological interpretation of empirical findings should be made after taking the whole system of the dialect into consideration so that dialect internal contrasts can be accounted for, and small differences should be attributed to phonetic implementation unless they result in a different pragmatic interpretation between dialects, to avoid the proliferation of phonological categories.

1.1. Our study

All studies mentioned above evince the need for careful and detailed analyses of alignment in order to understand in depth the extent to which variation can arise and shed light to the precise mechanism behind the coordination of the melodic and segmental dimensions of speech. In our investigation we probe segmental alignment from a new perspective. As an empirical test-bed we chose the dialect of Ipiros in North-Western Greece (henceforth IG), because it employs a rule of unstressed high vowel deletion (more later) which allows us to test what happens to H tone alignment in prenuclear L*+H pitch accents when its putative segmental anchor, that is, the high vowel, is deleted. In doing so, we were led to also analyse instances of a contrasting accent in our dataset, the nuclear L+H*, whose peak aligns earlier than the L*+H: despite the fact that an analysis of L+H* was not part of the original experimental design, enough instances of such productions arose to allow us to perform a comparison between L*+H and L+H* and test for a potential overlap between the nuclear accent and the pre-nuclear accent when VD applies (see section 1.1.2, *Hypotheses*, for the possible reasons for the emergence of L+H* occurrences in the corpus).

In the next two sections we first give a brief overview of the relevant sociolinguistic, segmental and intonational structure of SMG and IG and then lay out the experimental hypotheses and predictions.

1.1.1. Brief SMG and IG background.

It is useful to make a short digression at this point to provide some background information on SMG and IG. At the same time, we clarify some of the sociolinguistic, segmental and prosodic details that are relevant to our discussion.

Greek is spoken by approximately 11,000,000 speakers (2011 census). Approximately 350,000 inhabit the geographic area where Ipiros Greek, a Northern Greek (NG) dialect, is spoken (Figure 1). The exact number of Ipiros Greek speakers is impossible to determine due to lack of official data on the number of speakers for each dialect.

Starting with the sociolinguistic background, as pointed out by Archakis, Lambropoulou, and Papazachariou (2009), economic migration from rural to urban centres in Greece since the beginning of the 20th century has contributed to a rise in bi-dialectal speakers. Archakis et al. also argue convincingly that traditional dialectological approaches, which focus on geography and social groups as a means of explaining language variation are not the ideal tools to characterize bidialectal or bilingual individuals in modern societies. Instead they propose that speakers utilize different dialects for different socio-linguistic roles and consequently dialect choice is an index of the identity a speaker chooses to assume at any given moment and in any given context. In our experiment, speakers were called upon to take on the role of dialect informant and they fulfilled that role successfully: the frequency of VD and the vowel spaces of the productions used in the present paper have been separately analysed in Kainada and Baltazani in press, and showed that our participants' speech was indeed dialectal in that there was high percentage of VD and the vowels were positioned higher in the F1XF2 space in IG compared to SMG (for details see section 2.1, *Elicitation method*).

Figure 1. The map of Greece (white) with the geographical area of Ipiros (red).
http://www.jeepclub.be/images/2014greece/epirus-map.jpg

The status of IG across generations is poorly understood, as studies on this matter are lacking. Papazachariou and colleagues in a series of articles investigated the status of dialectal speech and especially the melody of polar questions among teenagers in Northern Greece, arguing for the creation of a new Koine in that geographic area (Papazachariou, 1998, 2004; Papazachariou & Archakis, 2001). This dialect, like all non-standard dialects of Greek, has low prestige.

Regarding the segmental aspect, SMG has a five-vowel system consisting of [i e ɐ o u], and so do all other dialects, albeit not in the same positions in the F1XF2 vowel space (for details on dialectal vowel spaces see Baltazani et al., 2014; Kainada & Baltazani, in press; Trudgill, 2009). The SMG consonantal inventory comprises voiceless and voiced obstruents [p b t d k g c ɟ f v θ ð s z x ɣ ç ʝ], nasals [n ɲ], liquids [l ʎ ɾ] and a glide [j] (see Arvaniti, 1999, for a detailed description of SMG; Baltazani & Nicolaidis, 2013 for the rhotic; Baltazani & Topintzi, 2013 for the glide [j]). The same consonantal inventory is attested in IG, according to impressionistic phonological sources (Kontosopoulos, 2000; Newton, 1972; Trudgill, 2003).

Our knowledge of the phonetic and phonological characteristics of Modern Greek dialects is still rather limited and informed by older, mostly impressionistic analyses (e.g., Chatzidakis, 1905; Kontosopoulos, 2000; Newton, 1972; Papadopoulos, 1927). Despite the repeated acknowledgement of phonological characteristics like VD in the literature, no systematic, quantitative verification exists yet of the phonological landscape as it appears today. Studies such as Newton (1972), though quite detailed, give us a snapshot of dialects now more than 40 years old and bound to be obsolete. Newer articles, for example Trudgill (2003), offer valuable and systematic analyses, which are nonetheless based on data from older studies. Recently some phonetic studies have appeared (see, e.g., Christou & Baltazani, 2010; Kainada & Baltazani, in press ; Lengeris & Kappa, in press; Loukina, 2008; Topintzi & Baltazani, 2012), but the field remains virtually unexplored.

Vowel deletion (VD) in Northern Greek dialects, among them IG, affects only unstressed high vowels (/i/, /u/) and can arise in a word like /ma.ˈlo.ni/ 'scolds', which in IG surfaces as [ma.ˈlon]. Topintzi and Baltazani (2012) show in an acoustic study of Kozani Greek, another Northern Greek dialect, that VD is optional, gradient and with variable output, including fully voiced vowels, completely or partly devoiced, as well as fully elided ones. Loukina (2008, p. 323), in an acoustic comparison across Athenian, Thessalian and Cypriot Greek, also reports that 'the difference between the dialects often lies not in the presence or absence of a certain feature, but rather in the extent or frequency of use of this feature, especially in quick casual speech'. Kainada and Baltazani (in press) corroborate the findings just mentioned, reporting that /i/ VD occurred in 34% of the unstressed /i/ tokens. Moreover Kainada and Baltazani quantitatively demonstrate that the vowel space of IG is more compressed than in SMG with all non-high vowels showing a substantial amount of raising in unstressed positions, leading to unstressed mid vowels approximating high vowels in terms of height (cf. Christou & Baltazani, 2010; Loukina, 2008).

Concerning prosody, Greek is a dynamic stress language across all its dialects (Arvaniti, 1991, 2000; Joseph & Philippaki-Warburton, 1987, among others). Syllables can be open or closed, but there are no weight differences between them. There is typically one lexical stress per word, whose position is not predictable, apart from the fact that it can only appear in the last three[3] syllables (Arvaniti, 2000; Arvaniti & Baltazani, 2005; Joseph & Philippaki-Warburton, 1987; Setatos, 1974).

The intonational system of SMG (GRToBI) has been analysed in Arvaniti and Baltazani (2005).[4] Several aspects of Greek intonation are tackled in GRToBI; specifically with respect to the pitch accent at hand, the prenuclear L*+H pitch accent involves an L target that appears approximately 5 ms before the onset of the stressed syllable and an H that appears a few milliseconds into the first post-accentual vowel (Figures 2 and 3). Therefore, at least two syllables are required for the pitch accent to be fully realized (Arvaniti et al., 1998; Arvaniti & Baltazani, 2005). One of the main characteristics of peak alignment in SMG, advocating the stability of tonal alignment, is that it is influenced by its distance from the beginning of the stressed syllable but not by the duration of the first post-accentual vowel

(Arvaniti et al., 1998). Furthermore, it has been shown that the phonetic environment does not affect the tonal scaling of the L and H tones of this rising accent (Arvaniti & Ladd, 1995; Arvaniti et al., 1998). In contrast to L*+H, the SMG tonal inventory also contains an L+H* pitch accent (Figure 3). The latter typically occurs in nuclear position, and its H tone aligns earlier, roughly in the middle of the accented vowel (Arvaniti, Ladd, & Mennen, 2006). Analogous categorical distinctions between pitch accents with similar F0 movements but differences in alignment details have been reported in other languages; for example, empirical evidence from both production and perception studies in European Portuguese suggests there is a categorical distinction between two falling pitch accents, H+L* and H*+L (Frota, 2002, 2012). The alignment of the L tone has not been reported to differ between pitch accents. Finally, SMG is claimed to be a language that favours target undershoot over complete truncation (Arvaniti & Baltazani, 2005), but more research on this area is still needed.

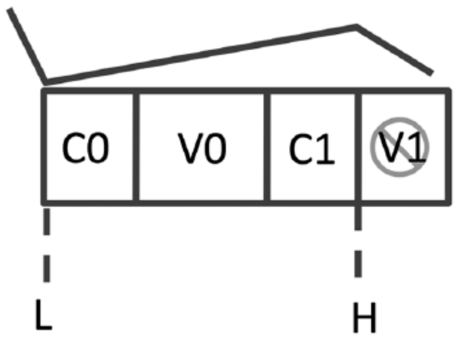

Figure 2. Schematic representation of Hypothesis 1. The L accent is found at the onset of the stressed syllable, and the H at the right edge of C1 when V1 is deleted. C0V0 = stressed syllable, C1V1 = the following unstressed one.

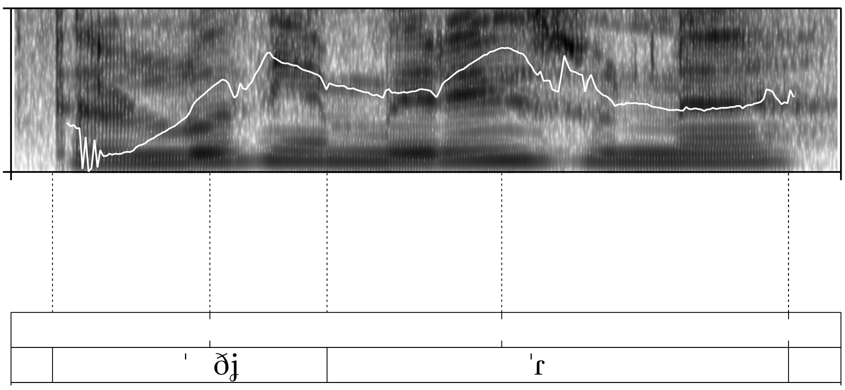

Figure 3. Example of the L*+H and L+H* realization in SMG in the sentence *ta luˈluðja miˈɾizune* ‘The flowers smell’.

So far, with the exception of SMG, no comprehensive analysis of the prosodic and intonational system for any dialect of Greek exists. Apart from a few studies involving a single melody or phenomenon (e.g., Giakoumelou & Papazachariou, 2013, on Corfu polar questions; Papazachariou, 1998, 2004, on Northern Greek), no other intonational studies exist, to our knowledge. In previous work (Kainada & Baltazani, 2013) we observed that under normal conditions the L*+H pitch accent in IG aligns similarly to SMG, but no details of the acoustic realization of the pitch accent were offered in that paper. Based on that observation, we predict that IG will have the L*+H pitch accent, with alignment and slope findings similar to SMG and in support of the SAH.

The overall goal of the paper, therefore, is to shed light on the interplay between the segmental and suprasegmental aspects of language by taking advantage of the very interesting traits of IG, that is, the behaviour of the anchor-less H target when its segmental anchor point gets deleted due to VD. The results will also enrich our understanding of cross-dialectal intonational variation.

1.1.2. Hypotheses.

Based on findings on SMG, we predict that the alignment of L*+H will also be stable in IG, regardless of VD. Moreover, it is expected that there will be no effect of VD on the L tone of L*+H but there will be a small, phonetic effect of VD on H alignment, because (a) the docking site of the H tone is no longer present and (b) it has been shown for SMG that pressure from an upcoming word boundary or pitch accent can result in earlier H alignment (Arvaniti et al., 1998; see Baltazani, 2006, for evidence that word boundaries do not affect H alignment). It should be stressed here that these alignment differences, although systematic, are quite small (approx. 15 ms in Arvaniti et al., 1998) and are viewed as phonetic (allophonic or, more precisely, ‘allotonic’) regularities since they do not result in categorical pitch accent distinctions.

Such reports motivate our study: when comparatively small duration differences can affect H alignment, it will be interesting to see whether the stability predicted by the segmental anchoring hypothesis persists in more drastic reductions in the segmental material such as VD in IG. According to our past qualitative observations (Kainada & Baltazani, 2013), the H in L*+H appears near the start of the post-accentual vowel, V1. We predict that the anchor point will remain relatively stable even after VD because impressionistically we detect no changes. Therefore we anticipate that deletion of the vowel target will only push the H slightly leftwards to the end of the post-accentual consonant, C1, so that it remains as close as possible to the missing vowel onset. Finally, because, as already mentioned, in SMG tonal scaling is not affected at all by changes in the segmental material, we expect the same to hold for IG.

1. *Hypotheses regarding L*+H and L*+H with VD*
1a. There will be no scaling differences between L*+H and L*+H with VD (L*+Hdel)
1b. The L tone in L*+Hdel will appear near the stressed syllable onset, like in L*+H; the H will appear near the right edge of C1, in the vicinity of (the deleted) V1 (Figure 2).

Our experiment was designed to test the effects of VD on L*+H for three reasons: (a) VD applies to unstressed vowels; (b) the H tone of L*+H aligns with an unstressed vowel; and (c) the L*+H pitch accent is virtually ubiquitous in Greek as the typical prenuclear pitch accent, so it is easy to elicit a large number of tokens. The competing L+H* nuclear accent is unsuitable for our purposes as the H aligns with the stressed syllable, which cannot be deleted. However, during the recordings, speakers frequently produced tokens with a target word in focus, that is, with an L+H* nuclear pitch accent (13.1% of total instances). This happened because occasionally speakers would drift from casual speech to speech that resembled a particular narrative style employed by IG speakers, and would place focus in unexpected places (see section 2.3.1 *Items available for analyses*). These productions resulted in the collection of enough L+H* tokens to permit a direct comparison between the prenuclear L*+H and the nuclear L+H* accents. Even though this comparison was not originally part of the experimental design, we decided to perform the analyses in the interest of obtaining a more complete picture and a wider context of the melodic categories in IG against which to interpret the behaviour of the L*+H pitch accent. The comparison results, however, should be viewed with caution and await confirmation from a further experiment that will encompass both types of pitch accents from the outset.

Although we anticipated a slightly earlier alignment for the H in L*+Hdel in hypothesis 1b, we nevertheless expect an alignment difference between L+H* and L*+Hdel, because (i) we can impressionistically differentiate between the two pitch accents despite V1 deletion (the L*+H/L*+Hdel is used for unfocused prenuclear material and the L+H* for nuclear) and (ii) the L+H* peak has been found in SMG to align with the middle of the stressed vowel.

2. *Ancillary hypotheses on L*+H vs. L+H**
2a. IG will have a L+H* nuclear pitch accent, with a distinct H alignment from L*+H
2b. IG will have a L+H* nuclear pitch accent, with a distinct H alignment from L*+Hdel
2c. No differences are expected in the alignment of L across conditions since L has been reported to be stable in alignment.

To anticipate our results, we demonstrate that a segmental phenomenon, VD, influences the alignment of the H, which is resolved through compression of the pitch accent and early alignment of the H. Despite this readjustment, the contrast between the melodic categories L*+H and L+H* in IG is not compromised. Just like in SMG, the two pitch accents have distinct functions: L*+H is predominantly used as a prenuclear pitch accent, while L+H* as a nuclear one. This finding in turn indicates that any differences in the realization of the L*+H after high vowel deletion are better viewed as phonetic. Finally, we report evidence that the IG L*+H pitch accent is implemented with subtle but consistent differences in alignment compared to the SMG L*+H.

2. Method

2.1. Elicitation method

The experimental data are the result of field study. In designing the methodology for fieldwork on dialectal variation, fieldworkers aspire to combine two desiderata in their methodology: (a) ecological validity (Brunswik, 1956), that is, speech which approximates natural communication in register with dialectal authenticity, and (b) avoidance of influences from the dominant linguistic norm of a more prestigious standard variety. According to the Speech Accommodation Theory (e.g., Bebee & Giles, 1984; Giles, Coupland, & Coupland, 1991), individuals might de-accentuate ethnolinguistic characteristics and converge toward the dominant culture when they desire social approval from members of the dominant culture, since standard accents connote high socioeconomic status and intellectual competence. This is exactly the situation informants are found in when they face a fieldworker who is viewed as a dominant figure in a powerful position (i.e., 'the observer's paradox'; Labov, 1972, p. 209). The fieldworker's task is to employ a method of data gathering which counteracts the aforementioned tendencies.

The fact that IG speakers are very often bi-dialectal (cf. section 1.1.1 *Brief SMG and IG background*) and exposed every day to SMG, the dominant variety of which is high in prestige, makes it essential and also challenging to design a proper experimental setting that will elicit dialectal productions from the participants (cf. Archakis et al., 2009). No written version of IG exists, therefore asking the participants to read a set of written sentences was bound to trigger their convergence to the dominant SMG and therefore not an option for the present experiment. A further objective was to elicit frequent samples of the investigated linguistic events to form a balanced experimental design to allow for quantitative analyses. While this issue is commonly stated as a problem in prosodic and dialectal research (Post & Nolan, 2012; Prieto, 2012), the question of how methodologies can be combined to work best in controlled experiments has not been systematically tested yet.

In a separate experiment, preceding the current one (henceforth 'pretest'), we compared different experimental protocols to determine the best way of obtaining ecologically valid and linguistically meaningful results (for details see Kainada & Baltazani, 2013). For the current study we employed the protocol that yielded the best results during the pretest: The experiment was performed using an intermediary who was a native speaker of IG. The subjects heard a question about a picture (Figure 4) and were asked to answer in a full sentence using information from the picture. The questions were recorded using a speaker of IG and were presented aurally to the subjects to avoid influences from SMG.

The pretest showed that speakers, especially older ones, frequently had difficulties remembering the names of characters in the pictures. One of the protocols examined in the pretest showed that including the characters' names in the pictures used as stimuli (see Figure 4) made the task easier without influencing their pronunciation, so names of characters were

Figure 4. Example of a visual experimental stimulus. For 6/20 of the stimuli the name of the character – but crucially never a target word – would appear at the top (here Γιάννης 'Yannis'). See text for details.

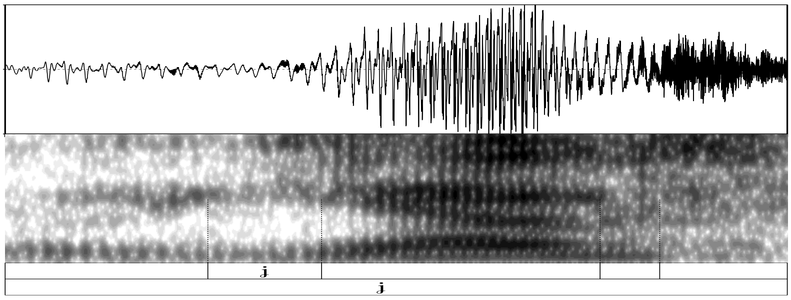

Figure 5. The name *Γιάννης* 'Yannis' as pronounced by one of the speakers. The final [i] is deleted (see text for details).

included in six of the 20 stimuli. Results reported elsewhere (Kainada & Baltazani, in press examining the quality of 3,272 vocalic tokens from the same corpus used in the present paper) suggest there was no priming effect of SMG on IG despite the inclusion of these names: Kainada and Baltazani report that all vocalic processes characteristic of this dialect (Kontosopoulos, 2000; Loukina, 2008; Newton, 1972; Topintzi & Baltazani, 2012; Trudgill, 2003) – that is, unstressed high vowel deletion, vowel raising and vowel diphthongization – were robustly attested in the corpus and moreover, they replicate results of previous studies showing a shorter distance between mid and high vowels than between mid and low ones (cf. Baltazani et al., 2014; Christou & Baltazani, 2010; Loukina, 2008), as well as a more compressed and raised vowel space in comparison to SMG, also reported in Baltazani et al.

Finally, Figure 4 shows one of the stimuli with the name 'Γιάννης' [ˈjanis] (which is not a target word) written in. This was produced as [jans], with VD, despite the fact that the name appears written in SMG on the picture (see Figure 5 for a representative example of its production). It should be stressed that as an extra precaution, target words never appeared written in the pictures, and speakers responded to pre-recorded questions produced by a native speaker of their dialect.

2.2. Participants and recordings

Recordings were obtained on location to avoid the adverse influence of laboratory environment on the speakers. Eight native NG speakers were recorded (four females, four males, 65–70 years old with the exception of one female being 47 years old, but having highly dialectal speech; seeing as it was difficult to recruit participants in the villages altogether, we decided to include her in the analysis). A training session preceded the experiment to familiarize participants with the expectations. No participant had difficulty understanding the experimental task. None of the speakers reported hearing, visual or reading deficits and we screened for speech and cognitive ones. Recordings took place at the participants' homes, or at a caf. the locals frequent (in a separate, as much as possible quiet room). Recordings were made directly on a laptop using Audacity, v.2.0.4 as the recording software, set at 44,100 sampling rate, and a Blue Yeti USB microphone set at cardioid direction.

Table 1. Example of sentences designed to induce L*+H pitch accents in vocalic deletion (top) and non-deletion contexts (bottom). Final syllables of target words are shown in bold.

Condition	Stimulus and expected response
L*+Hdel	Q: me pçon ðʝa'leʝi to ɾu'bini i e'leni? '*Who is Eleni choosing the ruby with*?' R: i e'leni ðʝa'le**ʝi** to ɾu'bi**ni** me to 'ʝani '*Eleni is choosing the ruby with John*'
L*+H	Q: me pçon ðʝa'leɣun ta ɾu'biɲa ta ko'ɾitsça? '*Who are the girls choosing the rubies with?*' R: ta ko'ɾitsça ðʝa'le**ɣun** ta ɾu'bi**ɲa** me to ma'noli '*The girls are choosing the rubies with Manolis*'

2.3. Materials

To ensure a large number of high vowel deletion and L*+H pitch accent tokens, we specifically asked participants to answer with a full declarative sentence using the words that were contained in the question they heard (examples in Table 1).[5] All participants understood the directions easily and all utterances conformed to the instructions. The order of the target answers is typically Subject-Verb-Object, which has been shown to be the most unmarked order for Greek speakers (Keller & Alexopoulou, 2001).

In past work we measured how often pre-nuclear pitch accents occurred (without measuring their phonetic realization) to test the efficiency of the experimental protocol (Kainada & Baltazani, 2013). The results of that study suggested that the L*+H is used as a prenuclear pitch accent in IG, similarly to SMG. To ensure that the target words carried an L*+H pitch accent we placed them in the prenuclear field, that is, away from focus. This was accomplished by drawing focus to some other constituent in the sentence. For example, the question accompanying the picture in Figure 4, 'What is Yannis cutting the onion with?', elicits a response like 'Yannis is cutting the onion with the knife' [o '**ʝ**anis **'**kovi to kre**'**miði me to ma**'**çeri] (target words in bold; focused constituent in italics), directed focus away from the target words and onto the prepositional phrase 'with the knife'. Although the target words are also in the questions, therefore discourse-given, they were not de-accented since they were in the prenuclear field, which cannot be de-accented in Greek.

We created 20 sentences, each with two words inducing deletion of the post-accentual vowel (L*+Hdel condition), matched with 20 sentences not involving deletion (L*+H condition), resulting in a corpus of 640 instances of L*+H tokens (20 sentences × 2 words × 2 conditions (L*+H and L*+Hdel) × 8 speakers; see Appendix 1 for all materials). No fillers were used as this would lengthen the experiment and tire the participants. The test words formed near-minimal pairs across the two conditions, for example, *ɾuˈbini – ɾuˈbiɲa* 'ruby-rubies' (Table 1). Only the first word in each pair was suitable to induce deletion of the post-accentual vowel (final /i/). The post-accentual consonant was a sonorant [n, l, r] or a voiced obstruent [v, ð, z, ʝ] (20 sonorants, 20 obstruents). As word-final syllables have been reported to be the most likely sites for unstressed high vowel deletion (Topintzi & Baltazani, 2012), all target words carried penultimate stress, and ended in –i for the L*+Hdel condition to maximize the possibility of /i/ deletion. Close proximity of pitch accents has been shown to create tonal crowding in SMG which results in compression, that is, altering of the alignment of tones; especially for the L*+H, two unaccented syllables need to intervene between pitch accents to avoid tonal crowding (Arvaniti et al., 1998). We thus constructed sentences with at least three syllables between stresses even after the potential deletion.

Participants were instructed to avoid pauses, hesitations, continuation rises or list intonation, all of which exclude the possibility of eliciting the pitch accent under investigation. This was accomplished by having the intermediary, a dialectal speaker who acted as the experimenter, produce counter-example utterances with, for example, list intonation during the training session. However, in the interest of eliciting dialectally sound data and in order not to tire the participants, we instructed the intermediary to avoid frequent interruptions. Naturally this resulted in a number of tokens unsuitable for analysis (see section 2.3.1 *Items available for analyses* below).

Even though the experimental procedure was carefully designed, we knew from the pretest that participants sometimes would not produce pre-nuclear L*+H pitch accents, but would use nuclear L+H* in all words in the sentence (see section 2.3.1 below for a possible explanation). We did not intervene during the recording to rectify this, since we did not want the participants to feel pressured in their productions. Instead, we decided to add any emerging L+H* pitch accents to our analysis aiming to understand the IG system better.

It is important to point out that our participants understood the experimental instructions and produced a large number of sentences with the anticipated contour. Our claim that the current experiment has elicited dialectal speech is based on quantitative measures of the participants' output like the following. In work presented elsewhere, (a) vowel formants analysis of the same speakers' output (Kainada & Baltazani, in press) showed a vocalic space that replicates past findings on IG (see section 2.1 *Elicitation method* earlier) and (b) intonational analysis on the frequency of specific intonational patterns across different experimental protocols has shown that this protocol produced the highest percentage of the target L*+H pitch accents (Kainada & Baltazani, 2013).

2.3.1. Items available for analyses.

Several tokens had to be excluded for various reasons, resulting in a final corpus of 158 instances of L*+H, 78 instances of L*+Hdel and 84 instances of L+H* (hence our decision to include this accent in the analysis), with a small number of minimal pairs among them (50% of the initial anticipated corpus is, thus, analysed). Among the reasons for excluding tokens were the following. First, vocalic deletion did not always take place, nor was its phonetic manifestation always categorical[6] (235 items excluded, 36.7%). Often there was a residual vowel and sometimes the full vowel was present. For the purposes of our experiment, we only analysed total deletion renditions that did not have any residual vowel in their spectrographic analysis. Second, as mentioned earlier, speakers often used L+H* renditions (placing the focus on the experimental item). The reason for this behaviour is that speakers sometimes entered a particular 'narrative' mode frequently used in IG when the role of a narrator telling a story is adopted (cf. Archakis et al., 2009) and many words are emphasized (i.e., carry a nuclear pitch accent). This would last for a few sentences, and then speakers would fall back to their normal productions. The distinctive melody of the two pitch accents enabled us to distinguish impressionistically between the two, and perform a reliable classification. The data were transcribed by both authors and crosschecked for mismatches. Very little disagreement arose in the transcription. Finally, two more reasons to discard tokens were (a) phrase boundaries placed after each word (26 tokens, 4%), and (b) changes in word order which placed a target word in the post-focal, de-accented field (38 tokens, 5.9%). The remaining missing tokens were discarded due to disfluencies, hesitations and other similar factors (21 tokens, 3.4%).

Since the number of minimal pairs was drastically reduced, in the interest of statistical reliability we decided to include all target words in our analysis even if they were not part of a minimal pair. In addition, we included all appropriate non-target word tokens carrying L*+H, L*+Hdel and L+H*. This resulted in an unbalanced corpus, but rich enough to provide a clear picture of the two rising pitch accents in the dialect (Appendix 2 shows a breakdown of C1 consonant by pitch accent). Moreover, we also identified and analysed a set of 15 minimal pairs with words carrying L*+H and L*+Hdel from the whole dataset uttered by the same speakers in the same position in the utterance as a means of cross-checking results from the larger dataset.

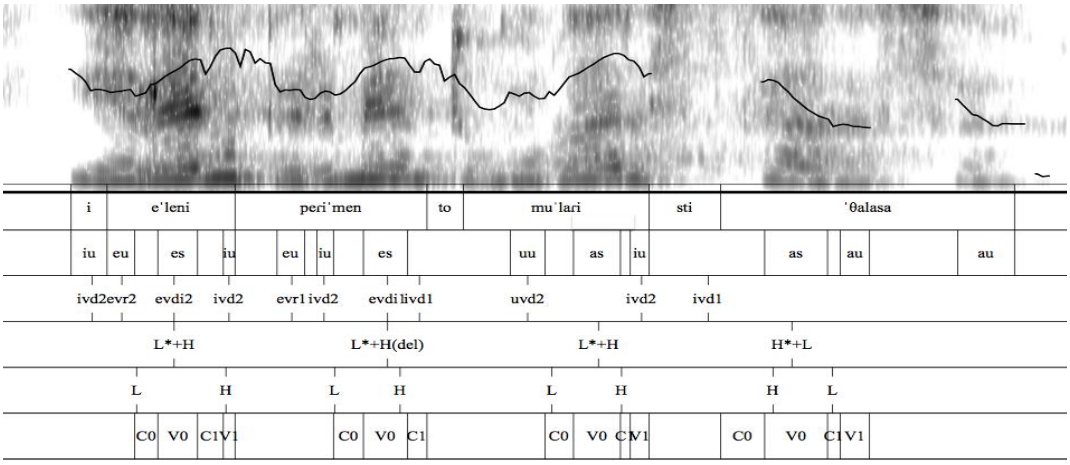

Figure 6. Segmentation example for L*+H and L*+Hdel. Tier 2 marks vowels (stressed/unstressed) and Tier 3 the application of vocalic phenomena, Tiers 4–6 show intonational phenomena and segmentation.

2.4. Measurements and segmentation

The test words were manually segmented and labelled by both authors using simultaneous inspections of waveforms and wide-band spectrograms. The segmentation followed the standard criteria outlined by Peterson and Lehiste (1960) and the segmentation guidelines proposed by Turk, Nakai, and Sugahara (2006). F0 was extracted using the pitch tracking facility of PRAAT (Boersma, 2001). In line with Arvaniti et al. (1998), we labelled as L the ‘elbow’ at the beginning of the rise, that is, the lowest point immediately before F0 turned unequivocally into a rise. In cases where there were two possible candidates, we marked as L the one closest to the rise[7]. The maximum F0 value at the peak of the rise was labelled as H. In cases of H plateaux, the first F0 point at the beginning of the plateau was measured. All instances of L*+H, L*+Hdel and L+H* were identified in all sentences. The duration and F0 measurements were automatically obtained through a PRAAT script, and pitch doublings or halvings were manually identified and corrected. The following measurements were performed (Figure 6) and statistical analyses were mixed effects models as presented in section 2.5 *Statistical analyses*[8] (C0V0 = stressed syllable, C1V1 = the following unstressed one).

Duration of all segments and distance between them:

- C0, V0 = consonant and vowel of stressed syllable
- C1, V1 = consonant and vowel of post-accentual syllable

Alignment of tones:

- LtoC0 = Distance (ms) between L and C0 onset
- HtoV0 = Distance (ms and proportional expressed as the x% of the vowel’s duration) between H and V0 onset (in the case of L+H*)

- HtoV1 = Distance (ms and proportional) between H and V1 onset (in the case of L*+H and L+H*)
- HtoC1 = Distance (ms and proportional) between H and C1 onset (mainly for the case of L*+Hdel, since the first post-accentual vowel gets deleted, but also used for L*+H and L+H* for completeness)

Scaling:

- Scaling of H and L in L*+H, L*+Hdel and L+H* (measured both in raw Hertz values and logarithmically transformed)
- Rise time (LtoH) = distance (ms) between L and H
- F0 excursion = distance (Hz) between L and H
- Slope = F0 excursion/rise time

2.5. Statistical analyses

Statistical analysis of the data was performed using mixed-effects models (see, e.g., Baayen, Davidson, & Bates, 2008) to test the effect of pitch accent type and speaker on the realization of the scaling and alignment of the L and H targets. Four separate models were used, one for each outcome variable (LtoC0 alignment, HtoC1 alignment, L scaling log-transformed, H scaling log-transformed), with *Pitch Accent Type* as the independent variable with three levels (L*+H, L*+Hdel and L+H*) and *Speaker* as a random intercept. More complicated models using Gender and Consonant (C1) as random slopes did not provide a good fit for the data (the use of the basic model was each time confirmed by simpler regression models, not reported since they all confirmed the results of the mixed-effects models). Each of the mixed-effects models that reached significance was subsequently tested using Kruskal-Wallis analyses, examining the influence of pitch accent type on each of the dependent variable. One-way ANOVAs with Bonferroni post-hoc analyses then tested the relationship between the three levels of pitch accent. In addition to the general analysis using mixed-effects models, specific questions were tested with ANOVAs and correlation analyses; these are explained in each section as they arise.

3. Results

3.1. L*+H alignment in IG and SMG

Confirming our prediction, the realization of L*+H was similar in the two Greek varieties. The L and H tones of the L*+H in IG aligned with the same segmental landmarks reported for SMG (Arvaniti et al., 1998), that is, the L near the onset of the stressed syllable, and the H at the beginning of the first post-accentual vowel. The L was found 15 ms before the onset of the stressed syllable (SD = 24 ms), and the H 5 ms into the first post-accentual vowel (SD = 26 ms), or else at 9.2% of V1 duration.

Figure 7 illustrates the alignment of each tonal target with respect to the segmental tier in SMG (left) and IG (right). C0V0 stands for the stressed syllable segments and C1V1 for the post-accentual ones. The whole pitch accent in IG is realized a little earlier than in SMG. Small alignment differences were found for H depending on whether C1 is a sonorant or obstruent (obstruent = 2 ms, SD = 29 ms, sonorant = 7 ms, SD = 24 ms – not statistically significant).

There is also evidence indicating that the H tone in IG appears at a stable distance from the beginning of the stressed syllable (C0), unaffected by the duration of the V1 vowel itself (cf. Arvaniti et al., 1998). This was confirmed through two Pearson's correlation analyses: (i) there was a correlation of the interval duration C0toH with the interval C0toV1 ($R^2 = 0.678$, $p < .001$, $df = 126$, $n = 128$, *sd*C0toH = 0.051, *sd*C0toV1 = 0.048; Figure 8); this suggests that the H appears at a specific distance from C0 and that the duration of the intervening segments affects the distance of the H from the onset of C0; (ii) in contrast, no correlation was found between the interval duration HtoV1 and the duration of the first post-accentual vowel (V1) (R^2 = 0.026, *df* = 131, *n* = 133, *sd*HtoV1 = 0.026, *sd*V1dur = 0.023; Figure 9), suggesting no effect of V1 on H alignment.

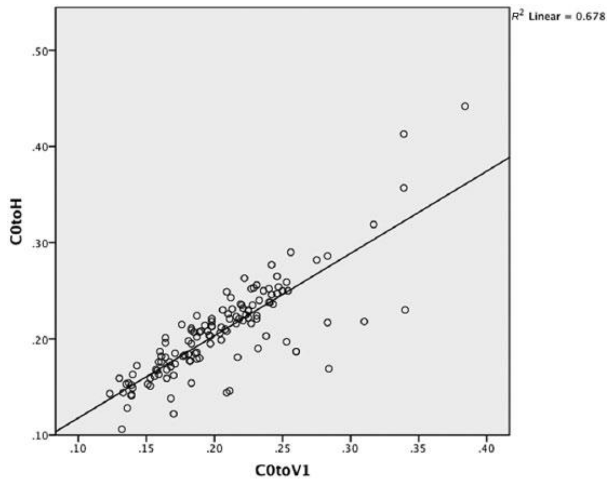

Figure 8. The interval C0toH as a function of the combined duration of the accented syllable and the post-accentual syllable.

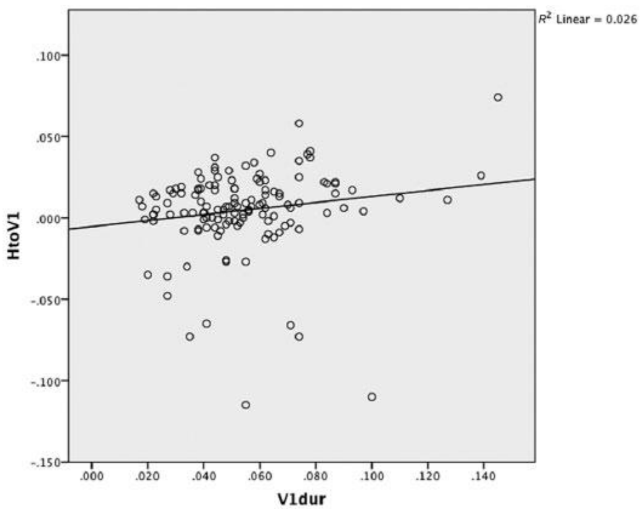

Figure 9. The interval HtoV1 as a function of the duration of the first post-accentual vowel.

Knowing the precise alignment details of IG's L*+H pitch accent, and having established that the anchor point for H in this dialect is the beginning of V1, as in SMG, we now turn to a more detailed comparison among the three pitch accent types in IG, that is L*+H, L*+Hdel and L+H*.

In what follows we present (i) two mixed-effects models analyses testing the effect of pitch accent type on the scaling of the L and H targets (section 3.2 *Scaling across the three pitch accent types*), (ii) two mixed-effects models analyses testing the effect of pitch accent type on the alignment of the L and H targets (section 3.3 *Alignment across the three pitch accent types*), and direct comparisons between each accent type testing the Hypotheses set out in section 1.1.2 *Hypotheses* (sections 3.4 *L*+H vs. L*+Hdel* and 3.5 *L*+H and L*+Hdel vs. L+H**).

3.2. Scaling across the three pitch accent types

Two mixed-effects models showed a significant influence of pitch accent type on the L tone scaling, t 294.292 = 3.539, p < .001, but no effect on the H scaling, t 304.515 = –0.757, p = .450. Kruskal-Wallis confirmed that the scaling of the L target was significantly influenced by pitch accent type, $\chi^2(2) = 33.421$, $p < .001$, with a mean rank L*+H = 158.73, L*+Hdel = 189.24 and L+H* = 109.62, while post-hoc Bonferroni adjusted ANOVAs revealed no scaling difference for L between L*+H and L*+Hdel, and that the L of the nuclear L+H* was scaled significantly lower than the other two (logarithmically transformed values of L and H, L*+H L = 5.258, SD = 0.203, H = 5.631, SD = 0.218, L*+Hdel L = 5.277, SD = 0.242, H = 5.661, SD = 0.149, L+H* L=5.07, H=5.6). Table 2 presents the summary of regression coefficients for each of the four models.

Table 2. Summary of regression coefficients for each model.

	Intercept	Slope
LtoC0	0.011	0.003
HtoC1	0.062	-0.028
L scaling	5.028	0.029
H scaling	5.443	-0.008

Hypothesis 1a, according to which scaling of the L and H is not expected to differ across L*+H and L*+Hdel, was confirmed (lack of effect replicated in minimal pairs analysis on raw Hz values).[9] This suggests no undershooting of the tonal targets caused by deletion.

3.3. Alignment across the three pitch accent types

Two mixed-effects models showed a significant effect of pitch accent type on the alignment of the H tone, t 301.532 = –9.651, p < .001, but no effect on the alignment of the L, t 299.291 = 1.460, p =.145. A Kruskal-Wallis test confirmed that the H alignment was significantly affected by pitch accent type, $\chi^2(2\ ) = 199.014$, $p < .001$, with a mean rank L*+H=219.72, L*+Hdel=135.88 and L+H* = 52.38. Post-hoc Bonferroni adjusted ANOVAs revealed that all three pitch accents were significantly different from one another in terms of H alignment.[10]

3.4. L*+H versus L*+Hdel

Hypothesis 1b, which predicted no change in L alignment and a small leftward movement to the end of C1 in H alignment, was partially refuted. As expected, the LtoC0 distance was not significantly different between the two accent types (Figure 10, LtoC0 in L*+H = −15 ms, SD = 24ms; in L*+Hdel = −10 ms, SD = 24 ms, confirmed by post-hoc results presented in 3.3 above). On the other hand, contrary to our predictions, there was a significant difference in H alignment (as seen in section 3.3 *Alignment across the three pitch accent types*). The H tone was found at the beginning of C1 and not at its end, that is, the L*+Hdel pitch accent was *more compressed* than we initially expected (H alignment in L*+H = 5 ms into V1, SD = 34 ms, and 53 ms past the onset of C1, SD = 34 ms, or else 9.2% into V1; in L*+Hdel = 10 ms into C1, SD = 26 ms, or else 18.9% into C1). Figure 10 shows a comparison between L*+H and L*+Hdel in terms of alignment. This finding persisted when C1 was an obstruent.

The refutation of our hypothesis 1b gave rise to two further analyses to explore the behaviour of the H peak. We first ran a by-speaker analysis on the H alignment (which we defined as the HtoV1 interval for L*+H and the HtoC1 interval for L*+Hdel) to determine the alignment point for H in the VD and non-VD condition across speakers. Second, we compared the rise time (time interval between the L and H tones) and the slope between the L*+H and the L*+Hdel conditions to quantify the pitch accent compression that was clearly visible in the deletion environments.

It turned out that in the non-deletion condition all speakers align the H tone around the same point (Figure 11, left, no statistical differences across speakers). In contrast, significant cross speaker variation was found for the location of the anchor point in the deletion condition (right panel, $F(5, 62) = 4.317$, $p = .002$). It is clear that different speakers cope differently with V1 deletion, suggesting that the repair strategies are phonetic and not categorical in nature.

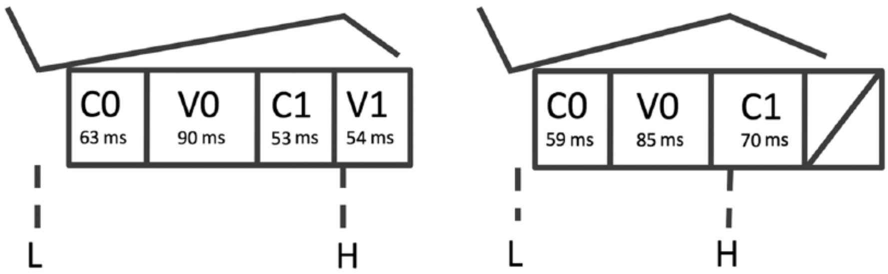

Figure 10. Comparison of tonal target alignment in L*+H (left) versus L*+Hdel (right) in IG. C0V0 = stressed syllable, C1V1 = the following unstressed one. Numbers show average segment durations.

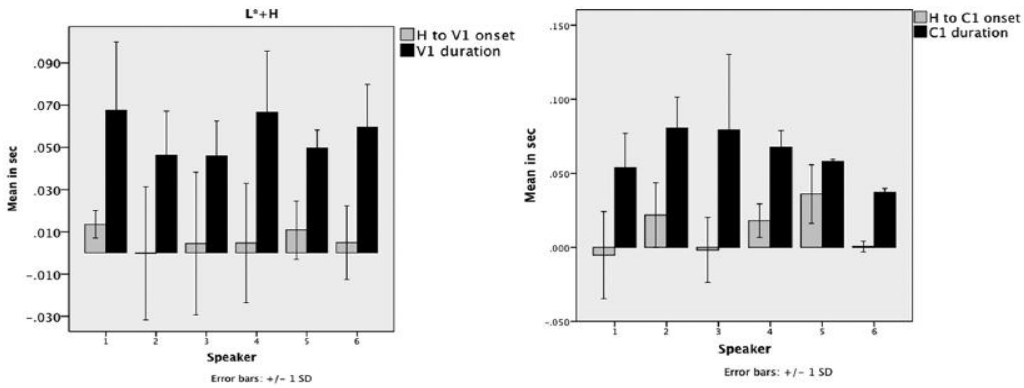

Figure 11. By speaker analysis of H alignment in L*+H (left) and L*+Hdel (right). Duration of the respective segment within which the tone is located is given.

To quantify the L*+Hdel compression, we measured the temporal interval between L and H (rise time), the F0 difference between L and H (F0 excursion), and calculated the slope (F0 excursion/rise time; see also, among others, Frota, 2000; Welby, 2006 and references therein). Table 3 presents means for each of the five speakers that had enough tokens of each condition to permit statistical analyses (i.e., more than 25 tokens per category–speakers 5, 7 and 8 are excluded because they had few L*+Hdel instances).

Table 3. Mean rise time, F0 excursion and slope for each speaker; standard deviations in parentheses.

Speaker	Rise time		F0 excursion		Slope (Hz/ms)	
	L*+H	L*+Hdel	L*+H	L*+Hdel	L*+H	L*+Hdel
1	$195_{(31)}$	$143_{(31)}$**	$105_{(25)}$	$85_{(24)}$	$.56_{(.15)}$	$.61_{(.18)}$
2	$170_{(28)}$	$144_{(33)}$ **	$59_{(21)}$	$44_{(15)}$ *	$.35_{(.11)}$	$.32_{(.10)}$
3	$184_{(43)}$	$138_{(36)}$**	$118_{(36)}$	$94_{(31)}$**	$.63_{(.17)}$	$.67_{(.22)}$
4	$197_{(39)}$	$147_{(16)}$**	$114_{(22)}$	$100_{(27)}$	$.50_{(.13)}$	$.69_{(.20)}$
6	$215_{(36)}$	$135_{(28)}$**	$97_{(23)}$	$82_{(14)}$	$.45_{(.09)}$	$.55_{(.03)}$

** = p < .001, * = p < .05.

The temporal distance between L and H in the L*+Hdel condition was always significantly shorter than in L*+H t (198) = 9.009, $p < .001$, as expected, given that V1 is deleted (the result was replicated when analysing the available minimal pairs; rise time L*+H = 184 ms, SD = 45 ms, L*+Hdel = 132 ms, SD = 35 ms, paired samples t-tests t (13) = 3.107, p = .008. The F0 rise between L and H across L*+H and L*+Hdel was not significantly different for three out of five speakers, which was also expected given that no difference in the scaling of the L and H tones was found in the two pitch accent types. Figure 12 shows the pitch accent slope broken down by speaker in pairs of lines: the long line shows L*+H and the short one L*+Hdel. The slope in the deletion condition is steeper (though it did not reach significance) than in the non-deletion one across speakers (a paired-samples comparison of slope between L*+H and L*+Hdel in our set of 15 minimal pairs reached significance, L*+H = 0.43, SD = 0.18, L*+Hdel = 0.62, SD = 0.26, t (10) = –2.569, p = 0.028, suggesting that the slope might be significantly different, but the effect is masked due to variability in the dataset).

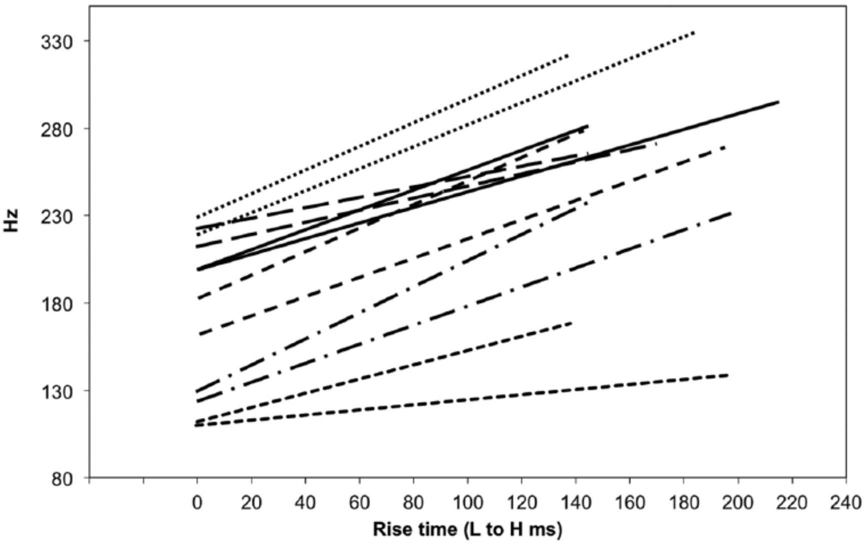

Figure 12. Slope of L*+H and L*+Hdel productions by speaker. Each set of lines depicts one speaker: the shorter line is L*+Hdel and the longer one L*+H.

3.5. L*+H and L*+Hdel versus L+H*

While, as already mentioned, the investigation of L+H* was not initially planned in our experiment, enough instances were produced (84 tokens) to allow its analysis. Recall that the H in L*+Hdel was found near the onset of C1. Given that in SMG the H in L+H* is located in the second half of V0, we wanted to determine whether the L+H* and L*+Hdel have distinct H alignment patterns.

Hypothesis 2a was confirmed; the mixed-effects model showed a significant effect of pitch accent type on H alignment, which proved to be significant across all three pitch accents. As shown in Figure 13 panels (a) versus (c), the H of L*+H was found at the onset of the first post-accentual vowel, while the H in L+H* was found much earlier, 56 ms after the beginning of the stressed vowel V0, or else at 60% of the vowel’s duration (SD = 29 ms). In other words, the IG intonational inventory contains two distinct rising phonological categories just like SMG.

Hypothesis 2b, which predicted different H alignment across L+H* and L*+Hdel, was also confirmed (see mixed-models analysis in section 3.3 Alignment across the three pitch accent types for statistical support). The H tone aligned earlier in L+H* (HtoC1 = −32 ms, SD = 27 ms) than in L*+Hdel (HtoC1 = 10 ms, SD = 26 ms; Figure 13, panels (b) vs. (c)). As for the L tone, hypothesis 2c was confirmed by the mixed-effects model, which revealed no statistical significance; however, follow-up non parametric tests revealed a difference in alignment: the L aligned later in L+H* (LtoC0 = 10 ms, SD = 33 ms) than in

L*+Hdel (LtoC0 = −15 ms, SD = 24 ms). This finding should be treated with caution given the results of the mixed-effects model.

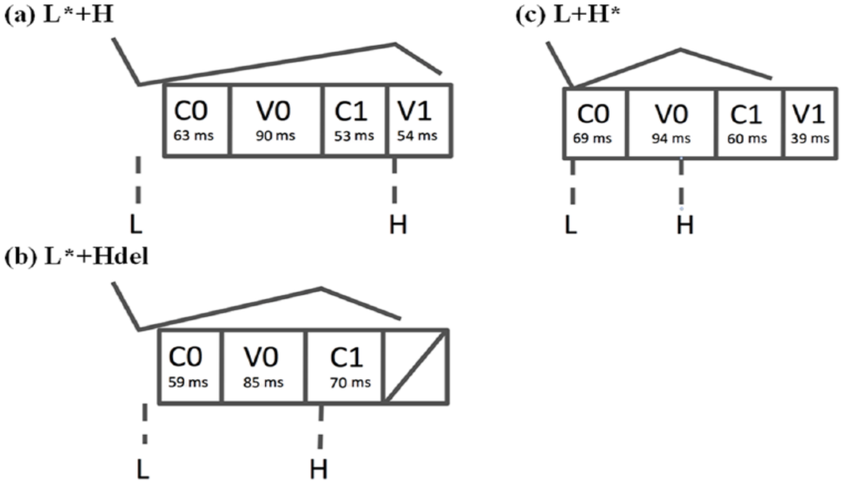

Figure 13. Comparison of tonal target alignment in L*+H (panel a) versus L+H* (panel c) in IG, and L*+Hdel (panel b) versus L+H* (panel c). C0V0 represent the stressed syllable followed by an unstressed one, C1V1. The numbers show average segment durations.

4. Discussion and conclusion

This study examined the effect of a segmental phenomenon, high Vowel Deletion (VD), on intonational structure. The specific variety of Ipiros Greek studied here is ideal for extending our understanding of the fine phonetic intricacies involved in the realization of pitch accents: we investigated how the H tonal target of L*+H copes when its anchor point is lost under VD. In the process, we investigated two rising pitch accents of IG, L*+H and L+H*.

Overall, it is shown that IG has a prenuclear L*+H pitch accent, which differs in fine phonetic details from its SMG counterpart; both the L and the H align earlier in IG. Within the IG system, it is shown that the prenuclear pitch accents L*+H and L*+Hdel differ only in terms of the alignment of the H target, a finding which we discuss in the following paragraphs. The nuclear L+H* of IG, on the other hand, is scaled lower than its prenuclear counterpart (at least for the High target), and its peak appears close to the midpoint of the stressed vowel, like in SMG. Interestingly, the L tone appears after the onset of the stressed consonant, an alignment which is different from that reported for SMG.

The proposal put forth here is that timing pressures on a pitch accent in Greek which result from insufficient segmental material for its realization lead to compression strategies instead of truncation: both component tones of the L*+Hdel were realized without change in scaling, confirming hypothesis 1a, which is clear evidence against truncation (for cross-dialectal differences in using compression vs. truncation see, e.g., Grabe & Post, 2002). Instead, a significant difference was found in the alignment of the peak, which occurred earlier in deletion environments. This behaviour was tested through words that in IG delete the typical H docking site. Surprisingly, the prediction of hypothesis 1b that the H would align as close as possible to the site of the deleted vowel (V1), that is, the end of the preceding consonant (C1), was not borne out. What we found instead was that the H aligned near the beginning of C1.[11]

Before elaborating on this unexpected result, it should be stressed that we interpret our findings as clearly phonetic, conditioned by V1 deletion, for two reasons. First, probing the H alignment across speakers in the two experimental conditions revealed that the location of the H was significantly different across speakers under VD, but constant in the non-deletion condition. This finding strongly indicates that the amount of displacement of the H point under deletion pressure is phonetic and not categorical in nature. The second piece of evidence regards the phonological contrast between two rising pitch accents in IG, L*+H and L+H*, the former used in prenuclear and the latter in nuclear positions. The alignment pattern of the H tone in L+H* is significantly distinct from both L*+H and L*+Hdel, as predicted by hypotheses 2a and 2b respectively.[12] Tentatively we propose that the same is true for the alignment of the L tone, contra hypothesis 2c, although more research is required. These findings suggest that the L+H* belongs to a different phonological category from the other two, while L*+H and L*+Hdel are in a sense ‘allo-tones’ of the same phonological entity, the L*+H pitch accent.

These findings also bear on the issue of whether intonational transcription should be phonetically completely transparent. Such a transcription would necessarily (a) distinguish between L*+Hdel and L+H* because of their different phonological function and also their different phonetic details (the peak of the former aligns with the stressed syllable edge while that of the latter aligns with the middle of the stressed vowel) and (b) also distinguish L*+Hdel and L*+H because of their different phonetic alignment details (the peak of the latter aligns with the post-stress vowel onset). Such phonetic transparency is not necessary for Greek because the peak alignment of L*+Hdel is predictable – in languages where surface tones are not predictable from underlying tones, for example Korean, two separate tiers, a phonetic and a phonological one, have been proposed to address the problem (Jun, 2005; also see Beckman, Hirschberg, & Shattuck-Hufnagel 2005; Frota (submitted) for relevant discussions on the issue).

The question still remains as to why the H tone in L*+Hdel aligns so far from the point where the H in L*+H does. Although this phenomenon should be investigated further to be better understood, we see two possible contributing factors: compression due to V1 deletion, combined with pressure from the upcoming word boundary. Compression occurs when the segmental material over which the realization of tones normally extends is not sufficient, that is, when the time domain span is shortened (e.g., Arvaniti et al., 1998; Arvaniti, 2000; Grabe, 1998; Grabe et al., 2000; Prieto, 2005). This shortening has been shown to be the effect of either pressure from upcoming tones and/or boundaries or of shrinkage of the segmental material (deletion, shortening of long vowels, absence of sonorants, etc.). In the case of our experimental material[13] the V deletion and the right word boundary both contribute to the compression, which we believe is the reason behind the large displacement of the H in L*+Hdel[14] (cf. Arvaniti et al., 1998, about SMG, where in some cases the position of the accent correlated with displacement of the H to the left). Evidence for the effect of the word boundary on H alignment is found also in the non-deletion condition. Recall that the H tone in the L*+H tone of IG aligns earlier than in SMG and this is probably an artifact of the target words’ make-up, which were paroxytones. We expect that the anchor point for the H tone in IG proparoxytone words will not be very different from that in SMG (although we cannot exclude the possibility of cross-dialectal differences), but evidence for this will have to come from a future experiment.

We can offer two more pieces of evidence for the effect of word boundaries, coming from our present experiment, the alignment of H in L+H* and further analysis of the H anchor point in L*+Hdel. First, the H tone in L+H* occurred earlier in IG, 60% into the stressed vowel compared to 66% in SMG, a difference which we also attribute to the upcoming word boundary. Second, we explored the H location in L*+Hdel through two additional correlation analyses: (i) there was a significant correlation between the intervals C0toH and C0toC1 (Figure 14; $R^2 = 0.730$, $df = 66$, n = 68, $p < .001$, *sd*C0toH = 0.046, *sd*C0toC1end = 0.053). Predictably, this result resembles what we found for the H in L*+H. The alignment point for the H tone is stable, therefore the duration of the intervening segments affects its distance from the onset of C0. (ii) Notably, there was also a significant, though weaker correlation between the interval HtoC1 and the duration of the post-accentual consonant C1 (Figure 15; $R^2 = 0.309$, $df = 66$, $n = 68$, $p < .001$, *sd*HtoC1 = 0.026, *sd*C1dur = 0.032). In other words, H appears later as C1 duration increases, an effect that we ascribe to the right word boundary, since a longer C1 means that the word boundary is further away from the H and thus allows the H in the deletion condition to approximate the position of the

H in the non-deletion condition.

An alternative interpretation for the shift of H from the onset of V1 to the onset of C1 would be to invoke a secondary phonological association with prosodic (syllabic) edges (e.g., Prieto, D'Imperio, & Gili Fivela, 2005). When the H cannot align with the edge of the syllable nucleus (i.e., V1) due to VD, C1 becomes syllabic and the H completely shifts its alignment to the onset of the now nucleic C1. This analysis is not supported by large inter-speaker variability in the alignment patterns under VD, nor by the correlation between C1 duration and H alignment. Moreover, such an analysis would lead to a circular argument whereby in order to explain the H alignment C1 is deemed syllabic, and at the same time the syllabicity of C1 is dependent on the finding that the H shifts its alignment.

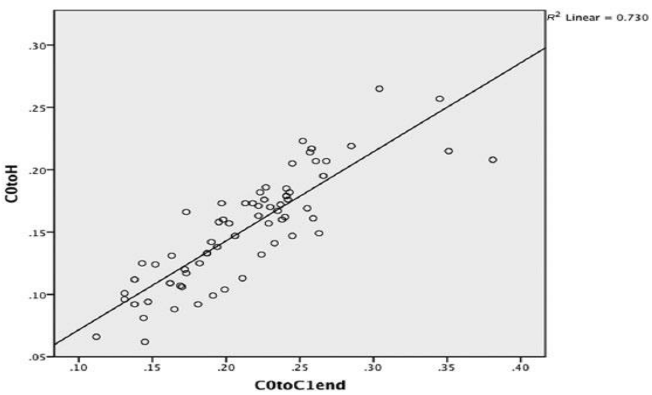

Figure 14. The interval C0toH as a function of the combined duration of the accented syllable and the post-accentual consonant.

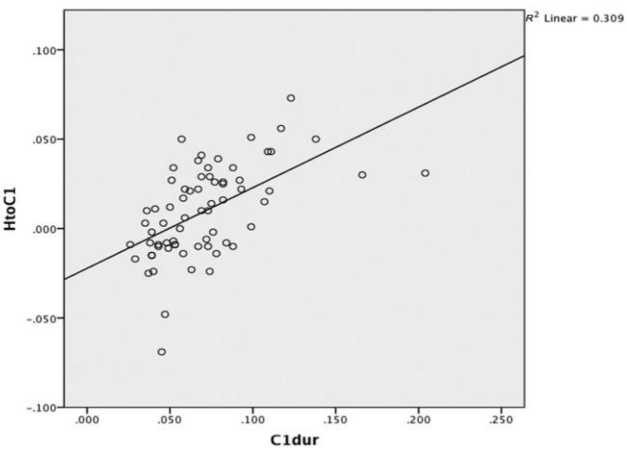

Figure 15. The interval HtoC1 as a function of the post-accentual consonant's duration.

In conclusion, the data examined in this paper has provided valuable insights into the influence that segmental phenomena like vowel deletion exert on the realization of pitch accents. Additionally we have provided evidence for cross-dialectal differences in the fine phonetic alignment of tonal targets, and – importantly – we discussed contributing conditions to compression, a phenomenon that, like other tonal crowding phenomena, has not received much quantitative analysis. It was shown that, in cases where a L*+H pitch accent is deprived of its vocalic anchor point, Ipiros Greek resolves the pressure by compressing the pitch accent. These findings add to our understanding of segmental anchoring as a phonetic rule, which undergoes phonetically defined adjustments when necessary. Our future research will further probe issues such as the influence of distance from an upcoming word boundary on the H alignment, the steepness of the slope following the H, the precise alignment of the L targets in each respective category, as well as the perceptual distinction among L*+H, L*+Hdel and L+H*.

Acknowledgements
We would like to thank Giannis Themelis and Theofano Christou for their help with material recordings, as well as the editors of the Special Issue and three anonymous reviewers for their helpful comments and corrections. We would like to thank Theo Marinis for allowing the use of pictures from his NWO research programme 'Cross-linguistic study of the production and processing of grammatical morphemes in L2 children compared to children with Specific Language Impairment' with Susan Edwards. We are greatly indebted to all participants from our field recording.

Funding
This research was funded by a National Strategic Reference Framework fund (THALIS project 'Vocalect', project number 379396).

Notes

1. This pitch accent was not consistently labelled "L*+H" until Arvaniti and Baltazani (2005).
2. Although Arvaniti et al. (1998) were the first to report this finding of independent and stable alignment of tones, the term 'segmental anchoring' was coined in Ladd et al. (1999).
3. In some dialects, especially northern ones, stress can appear in the last four syllables (Kontosopoulos, 1994; Newton, 1972, among many others).
4. Note that GRToBI analyses the prosodic and intonation structure only of SMG and no other Greek dialect.
5. Although a full declarative sentence is not the most natural answer to the questions, participants did not have difficulty complying with our request.
6. Although we were aware of the optionality of vowel deletion from previous research (Topintzi & Baltazani, 2012), we could not predict the circumstances that would ensure full deletion since almost nothing is known about it so far. For a first attempt at a quantitative description of the vocalic phenomena of IG see Kainada and Baltazani, in press.
7. The alignment of the L, as has been noted in a number of studies in the past, was not easy to identify and measure, so when the turning point was not clearly identifiable we measured instead from the beginning of C0 (cf. Arvaniti et al., 1998).
8. The lack of a full set of minimal pairs unfortunately prevented us from using any repeated-measures tests – with the exception of the small set of L*+H–L*+Hdel minimal pairs.
9. Because logarithmic values are not readily interpretable, here we also report on the raw Hz values: L*+H L = 213Hz, H = 288Hz, L*+Hdel L = 288Hz, H = 296Hz, L+H* L = 163Hz, H = 223Hz.
10. Kruskal-Wallis tests also showed a significant difference for L across pitch accents, $\chi^2(2) = 37.062$, $p < .001$, with a mean rank L*+H = 129.89, L*+Hdel = 138.57 and L+H* = 200.45) which, according to post-hoc analyses, was due to a significant difference between L+H* and the prenuclear pitch accents. Such a difference has not been reported before and merits further investigation.
11. An anonymous reviewer pointed out that compensatory lengthening of C1 in the VD condition could be viewed as the C1 representing two phonological segments, C1 and V1, thus affecting the interpretation of our data. Indeed C1 was significantly longer in the VD condition (C1 duration L*+H = 54ms, SD = 26ms, L*+Hdel = 70ms, SD = 32ms, $t(200) = –4.180$, $p < .001$. However, it is not immediately clear that (a) this could be termed compensatory lengthening (CP), since the term is usually attributed to lengthening of a vowel due to the loss of a following segment (Hayes, 1989; Kavitskaya, 2002) and to the fact that the view of consonant lengthening as CP is controversial; (b) in the few cases where CP has been ascribed to consonants (see, e.g., discussion on Trique in Topintzi, 2010), the lengthening is phonologized, that is, the lengthened C is viewed as a geminate, something for which we have no evidence for in IG.
12. As an anonymous reviewer noted, these results also replicate previous cross-linguistic findings of alignment differences between prenuclear and nuclear accents (cf. Deh., 2010; D'Imperio et al., 2007 and references therein).
13. A question raised by a reviewer is what would happen if C1 was a voiceless obstruent. We avoided voiceless obstruents for the obvious reason that F0 cannot be detected for such sounds. The question of whether in this case the L*+H and L+H* would still be distinguished in terms of H alignment is nonetheless valid, extremely interesting and open.
14. One reviewer also suggested that the steepness of the F0 fall following the L*+Hdel is also important in separating intonational categories (Niebuhr & Zellers, 2012), in the sense that a steeper fall would force earlier H alignment and vice versa. This remains to be verified in the future.

References

Archakis, A., Lambropoulou, S., & Papazachariou, D. (2009). 'As for the dialect, I will now tell you how we spoke at home': On the performance of dialectal talk. *Journal of Greek Linguistics*, 9, 5–33.

Arvaniti, A. (1991). *The phonetics of Modern Greek rhythm and its phonological implications*. Doctoral dissertation, Cambridge University.

Arvaniti, A. (1999). Illustrations of the IPA: Modern Greek. *Journal of the International Phonetic Association*, 19, 167–172.

Arvaniti, A. (2000). The phonetics of stress in Greek. *Journal of Greek Linguistics*, 1, 9–39.

Arvaniti, A., & Baltazani, M. (2005). Intonational analysis and prosodic annotation of Greek spoken corpora. In S.-A. Jun (Ed.), *Prosodic typology: The phonology of intonation and phrasing* (pp. 84–117). New York, NY: Oxford University Press.

Arvaniti, A., & Garding, G. (2007). Dialectal variation in the rising accents of American English. In J. Cole & J. H. Hualde (Eds.), *Papers in laboratory phonology*, 9 (pp. 547–576). Berlin, New York: Mouton de Gruyter.

Arvaniti, A., & Ladd, D. R. (1995). Tonal alignment and the representation of accentual targets. *13th International Congress of Phonetic Sciences* (ICPhS), 220–223.

Arvaniti, A., Ladd, D.R., & Mennen, I. (1998). Stability of tonal alignment: The case of Greek prenuclear accents. *Journal of Phonetics*, 26, 3–25.

Arvaniti, A., Ladd, D.R., & Mennen, I. (2006). Tonal association and tonal alignment: Evidence from Greek polar questions and contrastive statements. *Language and Speech*, 49, 421–450.

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.

Baayen, R. H., Davidson, D. J., & Bates, D.M. (2008). Mixed-effects modeling with crossed random effects for subjects and items. *Journal of Memory and Language*, 59(4), 390–412.

Baltazani, M. (2006). Effects of stress on intonational structure in Greek. Paper presented at Speech Prosody 2006, Dresden, Germany, 2–5 May 2006.

Baltazani, M., E. Kainada, K. Nikolaidis, A. Sfakianaki, A. Lengeris, E. Tsiartsoni, … M. Giakoumelou. (2014). Cross-dialectal vowel spaces in Greek. *Presentation at the 14th Conference on Laboratory Phonology*, Tokyo, Japan, 25–27 July 2014.

Baltazani, M., & Nicolaidis, K. (2013).The many faces of r. In L. Speafico & A. Vietti (Eds.), *Rhotics: New data and perspectives* (pp. 125–144). Bozen, Italy: BU Press.

Baltazani, M., & Topintzi, N. (2013). On some phonetic and phonological properties of the Greek glide. In Z. Gavriilidou, A. Efthymiou, E. Thomadaki & P. Kambakis-Vougiouklis (Eds.), *Proceedings of the 10th International Conference on Greek Linguistics* (pp. 153–166).

Beckman, M., D.az Campos, M., McGory, J. T., & Morgan, T. A. (2002). Intonation across Spanish, in the Tones and Break Indices framework. *Probus*, 14, 9–36.

Beckman, M., Hirschberg, J., & Shattuck-Hufnagel, S. (2005). The original ToBI system and the evolution of the ToBI framework. In S.-A. Jun (Ed.), *Prosodic typology: The phonology of intonation and phrasing* (pp. 9–54). New York, NY: Oxford University Press.

Beebe, L. M., & Giles, H. (1984). Speech accommodation theories: A discussion in terms of second language acquisition. *International Journal of the Sociology of Language*, 46, 5–32.

Boersma, P. (2001). Praat, a system for doing phonetics by computer. *Glot International*, 59/10, 341–345.

Brunswik, E. (1956). *Perception and the representative design of psychological experiments* (2nd ed.). Berkeley, CA: University of California Press.

Chatzidakis, G. (1905). *Medieval and Modern Greek A'* [Μεσαιωνικά και Νέα Ελληνικά Α']. Athens, Greece: P.D. Sakellarios.

Christou, T., & Baltazani, M. (2010). The phonetic realisation of stressed vowels in the dialect of Kato Pedina in Ioannina. In M. Janse, B. D. Joseph, P. Pavlou, A. Ralli & S. Armosti (Eds.), *Studies in Modern Greek dialects and linguistic theory* (pp. 15–26). Nicosia, Cyprus: Kykkos Cultural Research Centre.

Deh., N. (2010). The timing of nuclear and prenuclear Icelandic pitch accents. *Proceedings of the 5th International Conference of Speech Prosody*, 1–4.

Dilley, L. C., Ladd, D. R., & Schepman, A. (2005). Alignment of L and H in bitonal pitch accents: Testing two hypotheses, *Journal of Phonetics*, 33, 115–119.

D'Imperio, M., Bertrand, R., Di Cristo, A., & Portes, C. (2007). Investigating phrasing levels in French: Is there a difference between nuclear and prenuclear accents? In J. Camacho, V. Deprez, N. Flores & L. Sanchez (Eds.), *Selected papers from the 36th Linguistic Symposium on Romance Languages* (pp. 97–110). New Brunswick: John Benjamins.

Elordieta, G., & Calleja, N. (2005). Microvariation in accentual alignment in Basque Spanish. *Language and Speech*, 48, 397–439.

Estebas, E., & Prieto, P. (2008). La notaci.n pros.dica en espa.ol. Una revisi.n del Sp_ToBI. *Estudios de Fonética Experimental XVII*, 263–283.

Face, T., & Prieto, P. (2007). Rising accents in Castilian Spanish: A revision of Sp-ToBI. *Journal of Portuguese Linguistics*, 6(1) (special issue on Prosody of Iberian Languages, ed. by G. Elordieta & M. Vigario), 117–146.

Fletcher, J., Grabe, E., & Warren, P. (2004). Intonational variation in four dialects of English: The high rising tune. In S.-A. Jun (Ed.), *Prosodic typology: The phonology of intonation and phrasing* (pp. 390–409). New York, NY: Oxford University Press.

Frota, S. (2000). *Prosody and focus in European Portuguese*. New York: Garland.

Frota, S. (2002). Tonal association and target alignment in European Portuguese nuclear falls. In C. Gussenhoven & N. Warner (Eds.), *Laboratory phonology* 7 (pp. 387–418). Berlin, Germany/New York, NY: Mouton de Gruyter.

Frota, S. (2012). A focus intonational morpheme in European Portuguese: Production and perception. In G. Elordieta & P. Prieto (Eds.), *Prosody and Meaning* (pp. 163–196). Berlin, Germany/New York, NY: Mouton de Gruyter.

Frota, S. (submitted). Surface and structure: Transcribing intonation within and across language. *Laboratory Phonology*.

Giakoumelou, M., & Papazachariou, D. (2013). Asking questions in Corfu: An intonational analysis. *Proceedings of the 5th MGDLT*, 89–100. Gent, Belgium.

Giles, H., Coupland, J., & Coupland, N. (1991). Accommodation theory: Communication, context, and consequence. In H. Giles, J. Coupland & N. Coupland, *Contexts of accommodation*. New York, NY: Cambridge University Press.

Grabe, E. (1998). *Comparative intonational phonology: English and German*. PhD Thesis, Max Plank Institute for Psycholinguistics, Nijmegen.

Grabe, E. (2004). Intonational variation in urban dialects of English spoken in the British Isles. In P. Gilles & J. Peters (Eds.), *Regional variation in intonation* (pp. 9–31). Tuebingen, the Netherlands: Linguistische Arbeiten.

Grabe, E., & Post, B. (2002). Intonational variation in English. In B. Bel & I. Marlin (Eds.), *Proceedings of the 2002 Speech Prosody Conference* (pp. 343–346). Aix-en-Provence, France: Laboratoire Parole et Langage.

Grabe, E., Post, B., Nolan, F., & Farrar, K. (2000). Pitch accent realisation in four varieties of British English. *Journal of Phonetics*, 28, 161–185.

Hayes, B. (1989). Compensatory lengthening in moraic phonology. *Linguistic Inquiry*, 20, 253–306.

Ishihara, T. (2003). A phonological effect on tonal alignment in Tokyo Japanese. *Proceedings of the 15th ICPhS*. Barcelona, 615–618.

Joseph, B. D., & Philippaki-Warburton, I. (1987). *Modern Greek*. London, UK: Croom Helm.

Jun, S.-A. (2005). Korean intonational phonology and prosodic transcription. In S.-A. Jun (Ed.), *Prosodic typology: The phonology of intonation and phrasing* (pp. 201–229). New York, NY: Oxford University Press.

Kainada, E., & Baltazani, M. (2013). Evaluating methods for eliciting dialectal speech. In M. Janse, B. Joseph, A. Ralli & M. Bagriacik (Eds.), *Proceedings of the 5th Modern Greek*

Dialects and Linguistic Theory Conference, (pp. 101–123).
Kainada, E., & Baltazani, M. (In press). The vocalic system of the dialect of Ipiros. In *Proceedings of the 11th ICGL*, Rhodes, Greece.
Kavitskaya, D. (2002). *Compensatory lengthening: Phonetics, phonology, diachrony*. London, UK: Routledge.
Keller, F., & Alexopoulou, T. (2001). Phonology competes with syntax: Experimental evidence for the interaction of word order and accent placement in the realization of information structure. *Cognition*, 79, 301–372.
Kontosopoulos, N. (2000). *Dialekti kai Idiomata tis Neas Ellinikis* [Dialects and idioms of Modern Greek]. Athens, Greece: Ekdoseis Grigoris.
Labov, W. (1972). *Sociolinguistic patterns*. Philadelphia, PN: University of Pennsylvania Press.
Ladd, D. R. (2006). Segmental anchoring of pitch movements: Autosegmental phonology or gestural coordination? *Rivista di Linguistica*, 18, 19–38.
Ladd, D. R. (2008). *Intonational phonology*. Cambridge, UK: Cambridge University Press, 2nd edition.
Ladd, D. R., Faulkner, D., Faulkner, H., & Schepman, A. (1999). Constant "segmental anchoring" of F0 movements under changes in speech rate. *JASA*, 106, 1543–1554.
Ladd, D. R., Schepman, A., White, L., Quarmby, L.M., & Stackhouse, R. (2009). Structural and dialectal effects on pitch peak alignment in two varieties of British English. *Journal of Phonetics*, 37, 145–161.
Lengeris, A., & Kappa, I. (In press). Extreme palatalization and (af)frication of velar consonants in the (western) Cretan dialect. In *Proceedings of the 21st International Symposium on Theoretical and Applied Linguistics*, Thessaloniki, Greece.
Loukina, A. (2008). *Regional phonetic variation in Modern Greek*. PhD Thesis, University of Oxford.
Newton, B. (1972). *The generative interpretation of dialect: A study of Modern Greek phonology*. Cambridge, UK: Cambridge University Press.
Niebuhr, O., & Zellers, M. (2012). Late pitch accents in hat and dip intonation patterns. In O. Niebuhr (Ed.), *Understanding prosody – the role of function, context, and communication* (pp. 159–186). Berlin, Germany/New York, NY: de Gruyter.
Papadopoulos, A. (1927). *Grammar of Modern Greek northern idioms* [Γραμματική των Βορείων Ιδιωμάτων της Νέας Ελληνικής]. Athens, Greece: P.D. Sakellarios.
Papazachariou, D. (1998). *Language variation and the social construction of Iidentity: The sociolinguistic role of intonation among adolescents in Northern Greece*. PhD Thesis, University of Essex, U.K.
Papazachariou, D. (2004). Greek intonation variables in polar questions. In P. Gilles & J. Peters (Eds.), *Graphematische Systemanalyse als Grundlage der historischen Prosodieforschung* (pp. 191–217). Tubingen, Germany: Max Nieneyer Verlag.
Papazachariou, D., & Archakis, A. (2001). The dialectal role and discourse function of six semantic-intonation variables in Northern Greece. In A. Ralli, B. Joseph & M. Janse (Eds.), *First International Conference on Modern Greek Dialects and Linguistic Theory* (pp. 223–236). Patras, Greece: Patras University Press.
Peterson, G., & Lehiste, I. (1960). Duration of syllable nuclei in English. *JASA*, 32(6), 693–703.
Post, B., & Nolan, F. (2012). Data analysis for prosodic analysis of continuous speech and dialectal variation. In A. C. Cohn, C. Fougeron & M. Huffman (Eds.), *The Oxford handbook of laboratory phonology* (pp. 538–547). Oxford, UK: Oxford University Press.
Prieto, P. (2005). Stability effects in tonal clash contexts in Catalan. *Journal of Phonetics*, 33(2), 215–242.
Prieto, P. (2012). Experimental methods and paradigms for prosodic analysis. In A. C. Cohn, C. Fougeron & M. K. Huffman (Eds.), *Handbook of laboratory phonology* (pp. 527–547). Oxford, UK: Oxford University Press.
Prieto, P., D'Imperio, M., & Gili Fivela, B. (2005). Pitch accent alignment in Romance:

Primary and secondary associations with metrical structure. *Language and Speech* (special issue on Variation in Intonation, P. Warren (Ed.)), 48(4), 359–396.
Prieto, P., & Torreira, F. (2007). The segmental anchoring hypothesis revisited: Syllable structure and speech rate effects on peak timing in Spanish. *Journal of Phonetics,* 35(4), 473–500.
Prieto, P., van Santen, J., & Hirschberg, J. (1995). Tonal alignment patterns in Spanish. *Journal of Phonetics*, 23, 429–451.
Setatos, M. (1974). *Phonology of standard Modern Greek* [in Greek]. Athens, Greece: Papazisis.
Silverman, K., & Pierrehumbert, J. 1990. The timing of prenuclear high accents in English. In J. Kingston & M. Beckman (Eds.), *Papers in laboratory phonology* I (pp. 71–106).
Topintzi, N. (2010). *Onsets: Suprasegmental and prosodic behaviour*. New York, NY: Cambridge University Press.
Topintzi, N., & Baltazani, M. (2012). The acoustics of high-vowel loss in a Northern Greek dialect and typological implications. In P. Hoole, L. Bombien, M. Pouplier, C. Mooshammer & B. Kühnert (Eds.), *Consonant clusters and structural complexity* (pp. 373–402). Berlin, Germany/Boston, MA: Mouton de Gruyter.
Trudgill, P. (2003). Modern Greek dialects: A preliminary classification. *Journal of Greek Linguistics*, 4, 45–64.
Trudgill, P. (2009). Greek dialect vowel systems, vowel dispersion theory, and sociolinguistic typology. *Journal of Greek Linguistics*, 9, 165–182.
Turk, A., Nakai, S., & Sugahara, M. (2006). Acoustic segment durations in prosodic research: A practical guide. In S. Sudhoff, D. Lenertov, R. Meyer, S. Pappert, P. Augurzky, I. Mleinek, N. Richter & J. Schlie.er (Eds.), *Methods in empirical prosody research* (pp. 1–26). Berlin, Germany/ New York, NY: Walter de Gruyter.
Welby, P. (2006). French intonational structure: Evidence from tonal alignment. *Journal of Phonetics*, 34, 343–371.
Willis, E. W. (2010). Dominican Spanish intonation. In P. Prieto & P. Roseano (Eds.), *Transcription of intonation of the Spanish language* (pp. 123–153). München, Germany: Lincom Europa.
Xu, Y. (1998). Consistency of tone-syllable alignment across different syllable structures and speaking rates. *Phonetica*, 55, 179–203.

Appendix 1

Anticipated answers meant to induce (a) L*+Hdel instances and (b) L*+H in minimal pairs (target words in bold).

(a) L+Hdel*

1. Η Μαρία **λερώνει** το **σεντόνι** με καφέ.

Maria soils the sheet with coffee.

2. Το **χελιδόνι σκαρφαλώνει** στη φωλιά.

The swallow climbs into the nest.

3. Ο Μάριος **ζυγίζει** το **δαχτυλίδι** της Ελένης.

Marios weighs Eleni's ring.

4. Η Ελένη **ζυμώνει** το **κουλούρι** με τον Γιάννη.

Eleni kneads the bun with Yannis.

5. Ο Γιάννης **καθαρίζει** το **κρεμμύδι** με το μαχαίρι.

Yannis peels the onion with the knife.

6. Ο Γιάννης **βρωμίζει** το **πηγάδι** με σκουπίδια.

Yannis soils the well with trash.

7. Η ζέμπρα **παλεύει** με το **λιοντάρι** στη ζούγκλα.
The zebra fights the lion in the jungle.
8. Η γιαγιά **μαλώνει** το **εγγόνι** στην κουζίνα.
Grandma scolds her grandchild in the kitchen.
9. Ο παπάς **λιβανίζει** το **καρβέλι** με το λιβάνι.
The priest incenses the bread with incenses.
10. Η Ελένη **διαλέγει** το **ρουμπίνι** με το Μανώλη.
Eleni picks the rubby with Manolis.
11. Η Ρένα **φυτεύει** το **γεράνι** στις γλάστρες.
Rena plants a geranium in the pots.
12. Η Μελίνα **σφυρίζει** το **τραγούδι** με την Κατερίνα.
Melina whistles the song with Katerina.
13. Η Ελένη **περιμένει** το **μουλάρι** στην παραλία.
Eleni awaits the mule at the beach.
14. Το λιοντάρι **δαγκώνει** το **ελάφι** στο πόδι.
The lion bites the deer in the leg.
15. Ο καπετάνιος **βαραίνει** το **καράβι** με αυτοκίνητα.
The captain piles the ship with cars.
16. Ο Γιάννης **τηγανίζει** το **κυνήγι** στο τηγάνι.
Yannis fries the game in the pan.
17. Η Μαρία **διπλώνει** το **λουλούδι** με χαρτί.
Maria folds the flower with paper.
18. Το **πετιμέζι** της Μαρίας **κοστίζει** 10 ευρώ.
Maria's molasses cost 10 euro.
19. Ο Γιάννης **γεμίζει** το **αχλάδι** με σοκολάτα.
Yannis fills the pear with chocolate.
20. Ο Γιάννης **πληρώνει** για το **ψαλίδι** 10 ευρώ.
Yannis pays 20 euro for the scissors.

(b) L+H*

1. Τα κορίτσια **λερώνουν** τα **σεντόνια** με καφέ.
The girls soil the sheets with coffee.
2. Τα **χελιδόνια σκαρφαλώνουν** στη φωλιά.
The swallows climb into the nest.
3. Τα αγόρια **ζυγίζουν** τα **δαχτυλίδια** της Ελένης.
The boys weigh Eleni's rings.
4. Τα αγόρια **ζυμώνουν** τα **κουλούρια** με την Ελένη.
The boys knead the buns with Eleni.
5. Τα αγόρια **καθαρίζουν** τα **κρεμμύδια** με το μαχαίρι.
The boys peel the onions with the knife.
6. Οι άντρες **βρωμίζουν** τα **πηγάδια** με σκουπίδια.
The men soil the well with trash.
7. Τα λιοντάρια **παλεύουν** με τις **ζέβρες** στο χορτάρι.
The lions fight with the zebras on the grass.
8. Οι γιαγιάδες **μαλώνουν** τα **εγγόνια** στην κουζίνα.
The grandmothers scold their grandchildren in the kitchen.
9. Οι παπάδες **λιβανίζουν** τα **καρβέλια** με το λιβάνι.
The priests incense the bread with incense.

10. Τα κορίτσια **διαλέγουν** τα **ρουμπίνια** με το Μανώλη.
The girls pick the rubies with Manolis.
11. Τα κορίτσια φυτεύουν τα γεράνια στις γλάστρες.
The girls plant geraniums in the pots.
12. Τα κορίτσια σφυρίζουν τα τραγούδια με τον Γιάννη.
The girls whistle songs with Yannis.
13. Τα παιδιά περιμένουν τα μουλάρια στην παραλία.
The chilren await the mules at the beach.
14. Τα λιοντάρια **δαγκώνουν** τα **ελάφια** στο πόδι.
The lions bite the deers in the leg.
15. Οι καπετάνιοι **βαραίνουν** τα **καράβια** με αυτοκίνητα.
The captains pile the ships with cars.
16. Τα αγόρια **τηγανίζουν** τα **κυνήγια** στο τηγάνι.
The boys fry the game in the pan.
17. Τα κορίτσια **διπλώνουν** τα **λουλούδια** με χαρτί.
The gilrs fold the flowers with paper.
18. Τα **πετιμέζια** της Μαρίας **κοστίζουν** 20 ευρώ.
Maria's molasses cost 20 euro.
19. Τα αγόρια **γεμίζουν** τα **αχλάδια** με σοκολάτα.
The boys fill the pears with chocolate.
20. Τα αγόρια **πληρώνουν** για τα **ψαλίδια** 20 ευρώ.
The boys pay 20 euro for the scissors.

Appendix 2.

Number of times each consonant appears as C1 in each pitch accent type.

Consonant	**L*+H**	**L+H***	**L*+Hdel**
n	47	34	49
r	12	4	2
l	3	1	1
z	17	26	13
j	45	7	1
δ	18	4	6
v	11	4	2
γ	2	2	2
s	3	2	0
f	0	2	0