

# The prosody of correction and contrast

Pepi Stavropoulou<sup>1</sup> & Mary Baltazani<sup>2</sup>

<sup>1</sup>University of Ioannina & <sup>2</sup>University of Oxford

## Abstract

In the extensive literature on the prosodic expression of Information Structure (IS) the notion of contrast is typically coarse grained and subsumed under relational dichotomies like the theme-rheme or topic-focus, or as an inherent feature of focus, evoking a set of alternatives. This paper has two goals. First, we advocate for a more nuanced conception of contrast. This distinguishes between the “alternatives” based meaning of contrast on one hand and correction on the other, which is a more discourse-oriented meaning that encodes the speaker’s assumptions about the hearer’s beliefs. Second, we present experimental evidence that among the pragmatic types of contrast examined, only correction receives distinct prosodic marking, which cuts across the traditional IS topic-focus division and is realized in the same way in focus and topic constituents.

Keywords: information status; contrast; prosody; topic; focus

To appear in Journal of Pragmatics  
Please do not cite in this form

## 1. Introduction

It is generally accepted that the interpretation of an utterance depends in great part on the context, or discourse it is uttered in (e.g., Pierrehumbert & Hirschberg, 1990; Moulin 1995; Selkirk 1995; Brehenya, Katsos & Williams 2006; Armstrong & Prieto, 2015; Brown, Salverda, Gunlogson, & Tanenhaus 2015; Baltazani, Gryllia & Arvaniti 2020). The structuring of an utterance into parts/constituents which contain information that is old or new in the discourse is referred to as its *information structure* (IS) or *information packaging* (Halliday 1967; Chafe 1974; Steedman, 2000; Büring 2007, 2009; Roberts 1996; Vallduví 1992; Vallduví and Engdahl 1996). Different information structure partitions of a string result in different pragmatic interpretations: the string with a particular partition can be felicitous in one context but infelicitous in another. Each of the information structure constituents has distinct prosodic realizations, i.e., is uttered with distinct and characteristic melodies. From the listener’s point of view, in the absence of context, the implicit knowledge of the relation between information structure and intonation can help the listener recover the context of the utterances—that is, understand what they presuppose or implicate—by decoding the different melodic realizations.

In the extensive literature on information structure there are many references to the notion of contrast often with diverging meaning and function (see Molnár 2002; Repp 2010, 2016 for an overview of the different aspects of contrast). In general, we can distinguish between two main meanings of contrast in the literature: In the first, contrastiveness arises from evoking a set of alternatives, which the focused constituent stands in contrast to (Jackendoff 1972; Vallduví & Vilkuna 1998; Steedman 2007). It's also been argued that for contrast to be linguistically marked through prosodic, syntactic or morphological means the set of alternatives must be limited and directly accessible (Rooth 1992; Kiss 1998; Calhoun 2009). In (2), for example the focused constituent contrasts with a salient, accessible and small set of alternative entities {Orwell, Huxley} contrary to (1), where an open set of alternative entities is evoked corresponding to all authors, not explicitly mentioned or contrasted in the context.

- (1) A: Who wrote “1984”?  
 B: [**Orwell**]<sub>Focus</sub> wrote “1984”.  
 (2) A: Was it Orwell or Huxley who wrote “1984”?  
 B: [**Orwell**]<sub>Focus</sub> wrote “1984”.

This notion of contrastiveness based on alternatives has also been linked to topics. Contrastive topics for example have been viewed as topics containing a focus constituent introducing alternatives (Steedman 2000; Krifka 2007) or topics denoting alternative questions under discussion, signaling some sort of deviation from the current topic (Büiring 2007; Roberts 1996). In example (4) from Büiring (2007), the contrastive topic “female pop stars” deviates from the established topic “pop stars”: it is neither a brand new topic nor an entirely old topic. As such it introduces new alternatives ({female pop stars, male pop stars}) or a new question under discussion (“What did the female pop stars wear”; Büiring 2007). Example (3), on the other hand, constitutes a simple, non-contrastive topic, a plain continuation of the already established topic (“pop stars”).

- (3) A: “What did the pop stars wear?”  
 B: “[The pop stars]<sub>Topic</sub> wore [**caftans**]<sub>Focus</sub>”  
 (4) A: “What did the pop stars wear?” (from Büiring 2007)  
 B: “[The **FEMALE** pop stars]<sub>CTopic</sub> wore [**caftans**]<sub>Focus</sub>”

On the other hand, several researchers have argued for the need to take a more discourse-oriented approach to defining contrast (Zimmerman 2008; Baumann & Kügler 2015; Repp 2016). In this line of thought, contrastiveness is primarily associated with correction and with less predictable discourse entities arising from the speaker's assumptions about hearers' belief states and expectations as well as the current discourse model. In example (5) below, the focused constituent “Politics” contrast to the hearer's belief that “John studies Linguistics”, and is thus the least expected or predictable continuation to the discourse. From an “information packaging” perspective (Vallduví 1992) the focused constituent comprises an instruction to the hearer not to merely add a new piece of information to his/her knowledge store but also delete an existing one.

- (5) A: John studies Linguistics

## B: (No) John studies **Politics**<sub>Focus</sub>

The prosodic expression of correction has been reported to differ from other levels of contrast, either categorically by being marked with a different pitch accent or in gradient ways by having longer pitch excursions and rendering tone bearing units longer and/or louder (e.g., see Frota 2014 for Portuguese; Gussenhoven 2008 for Basque; Greif 2010 for Mandarin Chinese; Sudhoff 2010 for German; Borràs-Comes et al. 2014 for Catalan). Along the same lines, Krifka (2007) suggests that only corrective - and additive - focus is truly contrastive, and that the size of the alternatives set has no impact on the realization of focus. The special marking of correction is attributed to the low degree of predictability that correction has in the discourse (Zimmerman 2008). Less predictable constituents are more likely to be emphasized, and expressed in a linguistically marked manner.

On the other hand, there are approaches that emphasize the need to take both dimensions of contrast into account when examining the grammatical manifestation of contrast in different languages—the alternatives based one, as well as the dimension of contrast that is rooted in discourse relations such as opposition or correction (e.g., Repp 2014). The fact that there is no clear or uniform conception of contrast among researchers is further revealed by and made worse through the use of terms such as ‘Contrastive Topic’ or ‘Corrective Focus’. Overall, it is still not clear whether contrast is an independent information-structural element or a feature of topic and focus with a different realization in each case, nor is there general consensus on the exact definition of contrast and the conditions that license it across different languages.

The main goal of this study is to examine the prosody of contrast in Greek and analyse the implications that the prosodic characteristics of contrast have for its role and function in the grammar. Our findings support the need for a clear distinction between the “set”-based, focus-related notion of contrast on one hand, and contrast as an independent information-structural component linked to the notions of belief, attention state, emphasis and predictability on the other. Viewed in this light, it lends support to the line of work arguing for an independent effect of discourse relations and information status on prosodic prominence (Zimmerman 2008; Baumann & Kügler 2015; Genzel et al. 2015; Repp 2014).

Specifically for Greek, no clear picture emerges about the prosody of contrast in previous analyses (Gryllia 2008; Georgakopoulos & Skopeteas 2010). Gryllia (2008) investigates the prosodic realization of contrastive topics and foci in initial and final sentence positions and reports differences in vowel duration and in pitch range between contrastive and non-contrastive focused constituents (note that this holds for some but not all the categories examined in that paper); alignment differences are not examined. Georgakopoulos and Skopeteas (2010), on the other hand, report higher scaling and later alignment for contrastive focus compared to the non-contrastive cases. In light of the above, the present investigation aims to clarify, through two production experiments, whether and how different types of contrast are prosodically distinguished in Greek. The results we present here advocate against a monolithic concept of ‘contrast’ and instead

support the necessity of distinguishing between different nuances of ‘contrast’ each of which has a distinct prosodic expression. Our findings also bring to light the effects that position in the utterance has on the prosody of topic and focus phrases. The first experiment tests the realisation of three levels of contrast in topic and focus phrases found in utterance initial position. The second experiment deals with three levels of contrast when focus phrases are found in final and non-final utterance position.

In what follows, we first briefly outline key aspects of Modern Greek prosody that are related to this study. Next, we present the experimental setup and results for the two experiments conducted, followed by a discussion. We discuss key findings in the last section.

## 1.1 Greek intonation background

Here we give a brief overview of some aspects of the prosodic system of Greek that are relevant to the experimental results presented in this study. Specifically, we touch upon (a) the pitch accent types occurring in nuclear position in Athenian Greek declarative utterances, (b) the prosodic differences in the realisation of topics and foci reported in the literature, (c) prosodic and segmental cues to phrasing and (d) the effect of focus and phrasing on segments.

According to the analysis of the intonational system of Standard Modern Greek as spoken in Athens the prenuclear L\*+H pitch accent involves a L target that appears approximately 5 ms before the onset of the stressed syllable and a H peak that appears a few milliseconds into the first post-accentual vowel (Figures 2 and 3; Arvaniti et al. 1998; Arvaniti & Baltazani 2005). On the other hand, in L+H\*, which indicates narrow focus in nuclear position, the peak (Figure 3) typically aligns earlier, roughly in the middle of the accented vowel (Arvaniti, Ladd, & Mennen 2006). A H\* in declarative nucleus position, which signals broad focus (Baltazani 2003), lacks the initial dip associated with the L tone of the L+H\* (Arvaniti et al. 2006) and peaks earlier in the accented vowel, though quantitative data on this point are not yet available<sup>1</sup>. In the H\*+L accent, the fall starts early in the syllable, which means that in this pitch accent as well the H is earlier than in the L+H\*. Finally, the L\* is realized as a low plateau during the accentual syllable (Baltazani & Jun 1999; Baltazani 2002).

Topics typically form separate prosodic phrases with a L\* or L\*+H nuclear pitch accent and end in a high boundary (Baltazani & Jun 1999; Baltazani 2002, 2006), while focus is realised with a L+H\* pitch accent followed by deaccenting (Baltazani 2002, 2003, 2006; Arvaniti et al. 2006; Revithiadou 2004; Haidou 2012). Furthermore, while focus phrases can appear in various positions in the utterance (e.g., Tsimpli 1990; Alexiadou 1999; Baltazani & Jun 1999; Baltazani 2002; Haidou 2012), the distribution of topics is limited to the utterance initial position only (Baltazani & Jun 1999; Baltazani 2002).

---

<sup>1</sup> The work in Lohfink, Katsika & Arvaniti (2019) also examines the differences among these three pitch accents in Greek, but their analysis focuses on the differences in the shape of the f0 curves and does not offer quantitative alignment measurements, so comparisons cannot be made between that work and our results.

Several sandhi phenomena have been reported as phrasing boundary cues in Greek (Arvaniti & Baltazani 2005, Kainada 2007, 2010, 2012). Strong phrasal boundaries have been reported to block the sandhi phenomenon of /s/-voicing before a voiced obstruent or nasal in Greek (/mi'kres 'bales/ → [mi'krez 'bales] “small balls”; Nespor & Vogel 1986/2007: 215). More recent analyses show that /s/-voicing is a gradient phenomenon, whereby stronger boundaries do not categorically block it but are more likely to block it than weaker ones (Arvaniti & Pelekanou 2002; Baltazani 2006; Kainada 2007, 2010).

In either case, the percentage of /s/-voicing is used here as one of the indices of boundary strength, with a higher percentage of voicing taken to indicate a lower strength boundary. Finally, the cross-linguistic reports of pre-boundary lengthening as well as increase in duration and amplitude due to focus have also been documented to hold in Greek (Katsika 2012; Kainada 2007).

## 2. Experiment 1

### 2.1 Method

This experiment investigates three levels of contrast to determine whether a distinction is necessary between an ‘alternatives set’ notion of contrast on one hand (called OPENSET and CLOSEDSET from now on, depending on the size and accessibility of the set, cf. examples 1 and 2 in section 1) and correction on the other (cf. example 5 in section 1), which is seen here as a discourse-oriented notion linked to the belief attention state of the interlocutor (Vallduví 1992; Vallduví & Vilkuna 1998), as well as emphasis and predictability (Zimmerman 2008) due to the discourse context (CORRECTION).

Examples of stimuli used in this experiment for each of the three levels of contrast and two levels of information structure (topic, focus) are presented in Table 1. In the OPENSET level (1, 2 in Table 1), neither topic nor focus explicitly contrast with any entity in the dialogue context. The topic is the established question under discussion (cf. Roberts 1996) referring to old or evoked entities (cf. Prince 1981) and focus highlights the utterance constituent that carries new information. The constituent ‘The lieutenant’ in (1) is the established topic through the context question and in (2) it is focused as it corresponds to the wh-phrase of the context question.

In the CLOSEDSET level (3, 4 in Table 1), the focused constituent contrasts with a salient, accessible and small set of alternative entities {lieutenant, engineer} and topicalising ‘lieutenant’ is a slight departure from the established set ‘officers’, in the sense that the discussion continues neither with a new topic nor with the entire old topic but with a subset of it (Büring 2007).

Finally, in the CORRECTION level (5, 6 in Table 1), the speaker rectifies the interlocutor’s misunderstanding by deleting/replacing information in the interlocutor’s knowledge store (Vallduví 1992). Both in (5) and (6) a correction is made whereby ‘lieutenant’ replaces ‘engineer’ in the interlocutor’s knowledge store. The move of topicalising ‘lieutenant’

constitutes a complete change of the topic under discussion: in (6) the speaker establishes that the discussion refers to the lieutenant, not the engineer, and in addition provides the new information requested by the wh-word in the phrase ‘the evacuation of the ship’. The sets involved in (5) and (6) respectively are  $\{\lambda x.\text{order}(\text{engineer}, x), \lambda x.\text{order}(\text{captain}, x), \dots\}$  for the alternative topics and  $\{\text{order}(\text{captain}, \text{evacuation}), \text{order}(\text{captain}, \text{notification}), \dots\}$  for the alternative focus entities.

**Table 1.** Examples of the stimuli in experiment 1. A = context, B = target utterance.

	Condition		Example
1.	OPENSET	Topic	<p>A: <i>ti ði'etakse o ipo'pliarxos</i> what order-3SG the-NOM lieutenant-NOM “What did the lieutenant order?”</p> <p>B: <i>o ipo'pliarxos ði'etakse tin e'cenosi tu 'pliu</i> the-NOM lieutenant-NOM order-3SG the-ACC evacuation-ACC the-GEN ship-GEN “[The <b>lieutenant</b>]<sub>Topic</sub> ordered the evacuation of the ship.”</p>
2.		Focus	<p>A: <i>pços ði'etakse tin e'cenosi tu 'pliu</i> who order-3SG the-ACC evacuation-ACC the-GEN ship-GEN “Who ordered the evacuation of the ship?”</p> <p>B: <i>o ipo'pliarxos ði'etakse tin e'cenosi tu 'pliu</i> the-NOM lieutenant-NOM order-3SG the-ACC evacuation-ACC the-GEN ship-GEN “[The <b>lieutenant</b>]<sub>Focus</sub> ordered the evacuation of the ship.”</p>
3.	CLOSEDSET	Topic	<p>A: <i>Ti ði'etaksan i 'ðio aksiomati'ci</i> what order-3PL the-NOM two -NOM officers-NOM <i>o mixani'kos ði'etakse to sinajer'mo</i> the-NOM engineer-NOM order-3SG the-ACC distress singal-ACC “What did the two officers order? The engineer ordered the distress signal.”</p> <p>B: <i>o ipo'pliarxos ði'etakse tin e'cenosi tu 'pliu</i> the-NOM lieutenant-NOM order-3SG the-ACC evacuation-ACC the-GEN ship-GEN [The <b>lieutenant</b>]<sub>Topic</sub> ordered [the evacuation of the <b>ship</b>]<sub>Focus</sub></p>
4.		Focus	<p>A: <i>pços ði'etakse tin e'cenosi tu 'pliu</i> who order-3SG the-ACC evacuation-ACC the-GEN ship-GEN <i>o ipo'pliarxos i o mixani'kos</i> the-NOM lieutenant-NOM or the-NOM engineer-NOM “Who ordered the evacuation of the ship? The lieutenant or the engineer?”</p> <p>B: <i>o ipo'pliarxos ði'etakse tin e'cenosi tu 'pliu</i> the-NOM lieutenant-NOM order-3SG the-ACC evacuation-ACC the-GEN ship-GEN “[The <b>lieutenant</b>]<sub>Focus</sub> ordered the evacuation of the ship.”</p>
5.	CORRECTION	Topic	<p>A: <i>ti ði'etakse o mixani'kos</i> what order-3SG the-NOM engineer-NOM “What did the engineer order?”</p> <p>B: <i>o ipo'pliarxos ði'etakse tin e'cenosi tu 'pliu</i> the-NOM lieutenant-NOM order-3SG the-ACC evacuation-ACC the-GEN ship-GEN “[The <b>lieutenant</b>]<sub>Topic</sub> ordered [the evacuation of the <b>ship</b>]<sub>Focus</sub>”</p>
6.		Focus	<p>A: <i>o mixani'kos ði'etakse tin e'cenosi tu 'pliu</i> the-NOM engineer-NOM order-3SG the-ACC evacuation-ACC the-GEN ship-GEN “The engineer ordered the evacuation of the ship.”</p> <p>B: <i>o ipo'pliarxos ði'etakse tin e'cenosi tu 'pliu</i> the-NOM lieutenant-NOM order-3SG the-ACC evacuation-ACC the-GEN ship-GEN “[The <b>lieutenant</b>]<sub>Focus</sub> ordered the evacuation of the ship.”</p>

### 2.1.1 Speakers, stimuli and procedure

Target utterances and matching appropriate contexts were designed to trigger the desired pragmatic interpretation of three levels of contrast (OPENSET; CLOSEDSET; CORRECTION)

within two IS constituents (topic, focus). These were placed in utterance initial position because utterance final topics are not allowed in Greek (Baltazani 2002).

Eight native speakers of Athenian Greek (6 female, 2 male) participated in the experiment, aged 19 – 36 (M=28.5, SD=8.3), with university education and no reported hearing or visual problems. Four matrix sentences were created for the first experiment (6 – 9). Each matrix sentence was paired with six different contexts to facilitate a different pragmatic interpretation. The resulting corpus comprised 192 produced utterances (4 matrix sentences X 6 contexts X 8 speakers). Note that given the number of observations, some marginally non-significant results may become significant and vice versa if tested with a larger sample. The utterances were recorded in a quiet room with an Olympus Linear PCM Recorder LS-10 and digitized at 16-bit and 44.1 kHz sampling rate.

- (6) ***o ipo'pliarxos*** *ði'etakse tin e'cenosi tu 'pliu*  
the-NOM lieutenant-NOM order-3SG the-ACC evacuation-ACC the-GEN ship-GEN  
“The lieutenant ordered the evacuation of the ship.”
- (7) ***o ma'nolis*** *nosi'levete sto iatri'ko*  
the-NOM Manolis-NOM is.hospitalized-3SG at.the-ACC Iatriko-ACC  
“Manolis is hospitalized at Iatriko.”
- (8) ***o kaje'larios*** *'milise ja ana'pofefkti xreoko'pia*  
the chancellor-NOM speak-3SG of inevitable-ACC bankruptcy-ACC  
“The chancellor spoke of inevitable bankruptcy.”
- (9) ***o jeo'loyos*** *mele'tuse apoksira'menes 'limnes*  
the-NOM geologist-NOM study-3SG dried-ACC lakes-ACC  
“The geologist studied dried lakes.”

The target phrase (shown in bold) constituted one prosodic word with 4-6 syllables, mostly containing sonorant consonants to avoid micro-prosodic effects. Additionally, the target word ended in /s/ and was followed by a voiced obstruent or nasal to allow for /s/-voicing analysis as one of the indices used in this experiment to determine boundary strength. Moreover, the target prosodic word had medial stress to avoid tonal crowding and also to allow the canonical realisation of pitch accents by locating them away from word boundaries.

Finally, the target utterances had a Subject-Verb-Object word order, as this has been shown to be the most common order for indicative transitive constructions in text corpora (Horrocks 1983; Laskaratou 1998; for a different view see Philippaki-Warbuton 1982). Variations in word order in Greek have been linked with different functions of Information Structure (Keller & Alexopoulou 2001) and therefore SVO was chosen to avoid possible confounds of word order influences on the experimental utterances.

Participants were asked to read aloud context – target utterance pairs (stimuli) presented to them one by one on a computer screen. Despite the fact that reading both the context and the target utterance limits naturalness, it was chosen over a task where the experimenter reads the context question and the participant responds, to ensure that participants pay full attention to the context question and thus maximize the probability of producing their response with the appropriate melody. Participants were given additional instructions for the CORRECTION condition (9) to aid their understanding of the

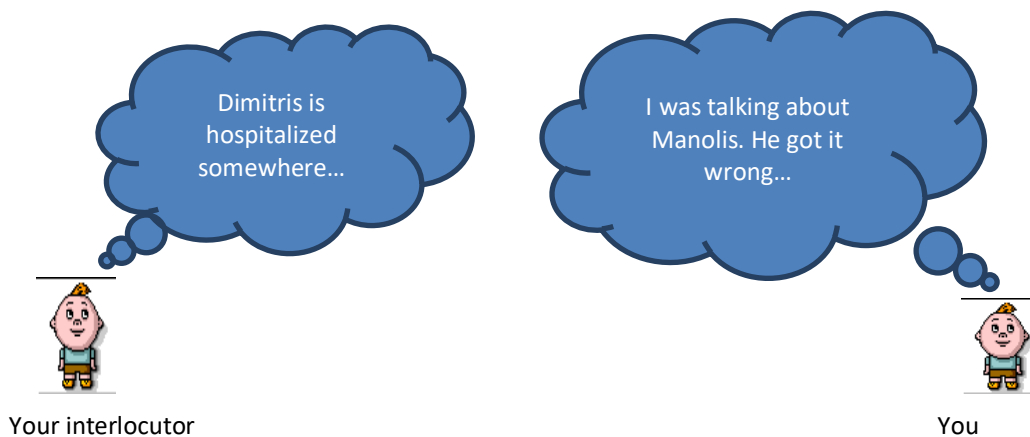
pragmatic context. This description was accompanied by figures of the interlocutors with relevant "thinking bubbles" (Figure 1) so that the participants can quickly identify the dialog situation and produce the utterance with the appropriate prosody.

(9) Example of instructions for one of the conditions:

*Θέμα της συνομιλίας είναι το ατύχημα που είχε ένας φίλος με αυτοκίνητο. Ο συνομιλητής σου έχει καταλάβει λάθος και νομίζει ότι το ατύχημα το έπαθε ο Δημήτρης και τώρα νοσηλεύεται κάπου, ενώ αυτός που έπαθε το ατύχημα ήταν ο Μανώλης. Θέλει λοιπόν να μάθει πού νοσηλεύεται ο Δημήτρης. Πρέπει να τον διορθώσεις και ταυτόχρονα να απαντήσεις πού νοσηλεύεται ο Μανώλης.*

*The conversation is about a car accident that one of your friends had. Your interlocutor has misunderstood and is under the impression that Dimitris had an accident and is now hospitalized, while in fact it was Manolis who had the accident. Your interlocutor wants to know where Dimitris is hospitalized. You need to correct this misconception and at the same time answer where Manolis is hospitalized.*

The stimuli were presented in a randomized order and 68 fillers were used from two other experiments (including the second experiment presented in Section 3) to eliminate priming effects.



**Figure 1.** Example of drawing accompanying context description.

### 2.1.2 Measurements and hypotheses

The experimental utterances were acoustically analysed by measuring the scaling and alignment of a number of tonal targets (cf. Arvaniti and Ladd 2009) manually annotated in *Praat* (Boersma & Weenink 2011):

- (a) Accentual Low (AL): the local  $f_0$  minimum near the onset of the target word's stressed vowel after which the pitch rise unambiguously began.
- (b) Accentual High (AH): the local  $f_0$  maximum in the vicinity of the target word's stressed vowel.



- (c)  $f_0$  excursion: the difference in Hz between the L and H tones of rising pitch accents
- (d) Boundary High (BH) and Boundary Low (BL): The actual  $f_0$  values of boundary tones were not measured. The type of edge tones was annotated instead.

In addition to the above measurements, which aimed at measuring scaling differences between the pitch accents in the experimental conditions, we also calculated the temporal alignment of the AH and AL with respect to the onset of the stressed syllable in the target word, which is the main criterion used to distinguish between the two rising pitch accents in Athenian Greek (Arvaniti, Ladd & Mennen 1998, 2000). The alignment values were normalized for syllable duration, and expressed as the distance of the H/L target from the beginning of the syllable divided by the total syllable duration. The H tone in the L+H\* accent, according to the literature (Arvaniti & Baltazani 2005), was expected to align within the accented syllable, that is, to have a mean value below 1, and the H in the L\*+H to align in the post-accentual syllable with a mean value over 1. Boundary strength was also annotated (3 strongest to 0 weakest, Arvaniti & Baltazani 2005).

A number of segmental measurements were also made including (a) the duration (in ms) and (b) the intensity (in dB) of the stressed syllable aimed to uncover differences caused by the information structure and contrast levels; (c) the duration of the segmental stretch from the end of the stressed syllable to the end of the target word, where a topic phrase boundary was expected to appear; (d) the percentage of [s]-voicing measured as the ratio of the duration of the voiced portion of [s] over the duration of the whole [s] segment, with a higher percentage of voicing taken to indicate a lower strength boundary. The voiced portion of [s] was automatically extracted in *Praat*.

These are the hypotheses:

H1: Information Structure will mainly affect phrasing. Based on previous reports, topics are expected to form a separate phrase from the rest of the utterance, while focus constituents are not (Baltazani & Jun 1999; Baltazani 2002; Revithiadou 2005).

H2: Contrast levels will mainly affect pitch accent choice.

H2A: Based on cross-linguistic reports, CORRECTION will be prosodically distinguished from OPENSET and CLOSEDSET (cf. Gussenhoven 2008; Greif 2010) across Information Structure levels.

H2B: CORRECTION will have a uniform pitch accent realisation across Information Structure levels, meaning that the same pitch accent, L+H\*, will be used for both topics and foci. L+H\* has been primarily associated with instances of narrow focus in Greek (Arvaniti & Baltazani, 2005) and has also been associated with "emphasis" constructions in other languages as well (Frota 2014 for Portuguese; Steube 2001 for German; Prieto 2014 for Catalan).

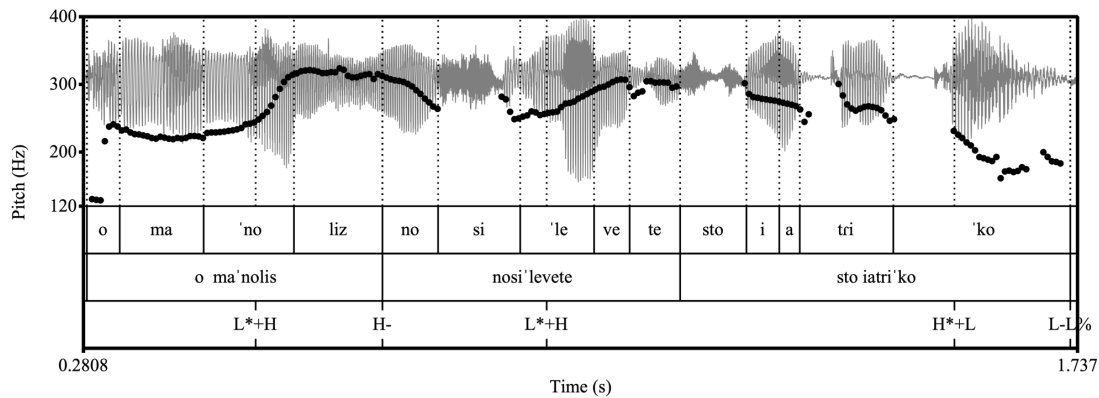
H3: In addition to the tonal categorical differences predicted in H1 and H2, IS and contrast levels will have gradient effects: (a) tonal ones (in alignment and scaling); and (b) segmental ones in the degree of /s/-voicing and pre-boundary lengthening (phrasing effect of IS), as well as amplitude and duration of the accented syllable (accentuation effect of Contrast).

#### 2.1.4 Statistical analysis

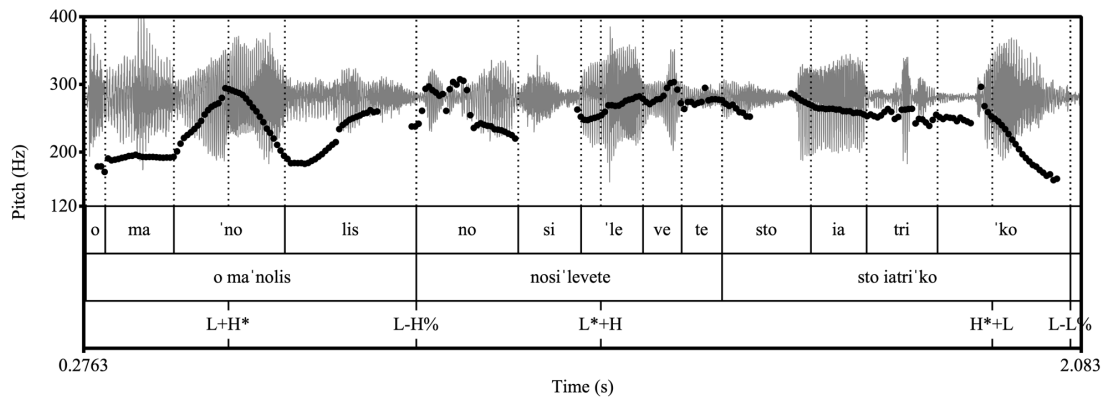
A series of linear mixed-effects models were fitted to the data using IBM SPSS Statistics package 20. Specifically, we set Contrast Level and Information Constituent as the fixed factors and Speaker and Lexicalization as random factors. Random slopes were included for the effects of Contrast Level and Information Constituent. No model reduction was applied to random factors. The dependent variable each time was one of: syllable duration, mean syllable intensity, H tone scaling, H tone alignment, L tone scaling,  $f_0$  excursion, pitch accent, pre-boundary lengthening and [s]-voicing. For assessing the statistical significance of each fixed factor, we ran likelihood ratio tests on model fit (Bolker et al. 2009). The analysis started with a maximal model containing all fixed factors and interaction effects and the complexity of the model was reduced stepwise excluding Contrast Level and Information Constituent. Each time a factor was removed, the likelihood of the reduced model (-2 log likelihood) was compared to the likelihood of the more complex one using  $\chi^2$  tests. For factors with more than two levels, Bonferroni-adjusted post hoc pairwise tests were run for assessing the contribution of each level once the significance of the factor was verified. In addition, targeted ANOVAs were used for assessing the correlation between annotated accent types and gradient accent characteristics such as tone alignment.

## 2.2 Results

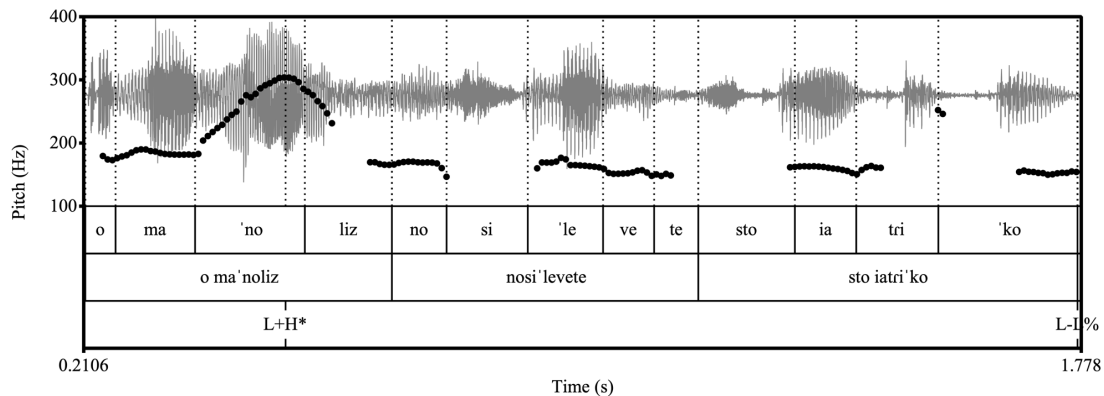
As predicted by H1 and confirming previous reports (Baltazani & Jun 1999; Baltazani 2002; Revithiadou 2005), the two IS categories, topic and focus, differed in phrasing. Topics typically formed a separate phrase (Table 2), while foci did not, as illustrated in Figures 2-4. In Figure 2 the target word *o manólis*, produced in a context facilitating its interpretation as an OPENSET topic, has a L\*+H pitch accent aligned with the stressed syllable *-no-* and ends in a H- phrase accent which causes the pitch to remain high during the final syllable *-lis-*, forming a high plateau. Figure 3 shows the same word produced in a context facilitating a CORRECTION topic; there is a more complex rise-fall-rise pitch movement at the end of the phrase, which we have analysed as a combination of the L+H\* pitch accent with a L-H% rising boundary. In comparison foci were not separated from the rest of the phrase but were followed by de-accented material, as shown in Figure 4, which contains phrase-initial focus realized with a L+H\* pitch accent aligned with the stressed syllable *-no-* and followed by a low plateau throughout the rest of the utterance.



**Figure 2.** The OPENSET topic [ma'nolis] in the utterance “Manolis is hospitalized in Iatriko”.



**Figure 3.** The CORRECTION topic [ma'nolis] in the utterance “Manolis is hospitalized in Iatriko”. Note the complex fall rise movement of the contour before the boundary corresponding to an L-H% boundary tone (Arvaniti & Baltazani 2005), in contrast to the simple high phrase tone in Figure 2. In general, the complexity of the F0 movement (indicating the existence of two targets), the scaling of the high tone, and the perceived boundary strength (Ostendorf et al. 1995; Wightman et al. 1992; Nespor & Vogel 2007; Pierrehumbert 1980; Beckman & Pierrehumbert 1986) were the main criteria for annotating phrase versus boundary tones.



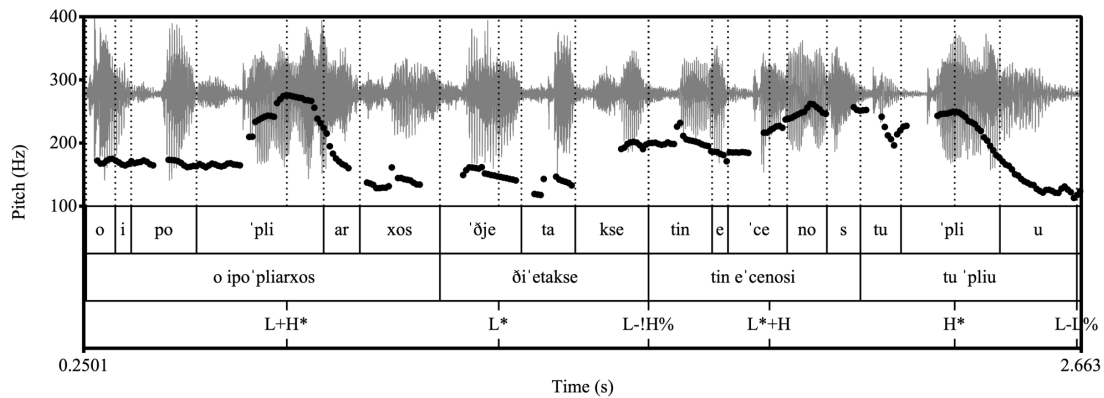
**Figure 4.** The CORRECTION focus [ma'nolis] in the utterance “Manolis is hospitalized in Iatriko”.

Interestingly, the results further revealed that phrasing was realized differently across the contrast levels in *topic* constituents, where the presence and type of edge tones varied as

shown in Table 2. Notably, about one third of OPENSET and a quarter of CLOSEDSET topics were not demarcated by a boundary, while CORRECTION topics were almost always separated from the rest of the utterance by some type of boundary, which occurred either right after the verb (Figure 5) or at the end of the target word (Figure 3). Furthermore, speakers produced CORRECTION topics with a wider variety of edge tones, which were overall stronger in comparison to OPENSET and CLOSEDSET topics shown in Figures 2-4.

**Table 2.** Distribution of edge tones at the end of the target word (topic phrases). Downstepped tones (marked with !) scaled relatively lower. Phrase (L-, H-) and boundary tones (H%, L%) were distinguished based on the following main criteria: the complexity of the F0 movement (indicating the existing of two targets), the scaling of the tone, and the perceived boundary strength. Please refer to Arvaniti & Baltazani (2005) for a complete description of the GRTobI annotation schema.

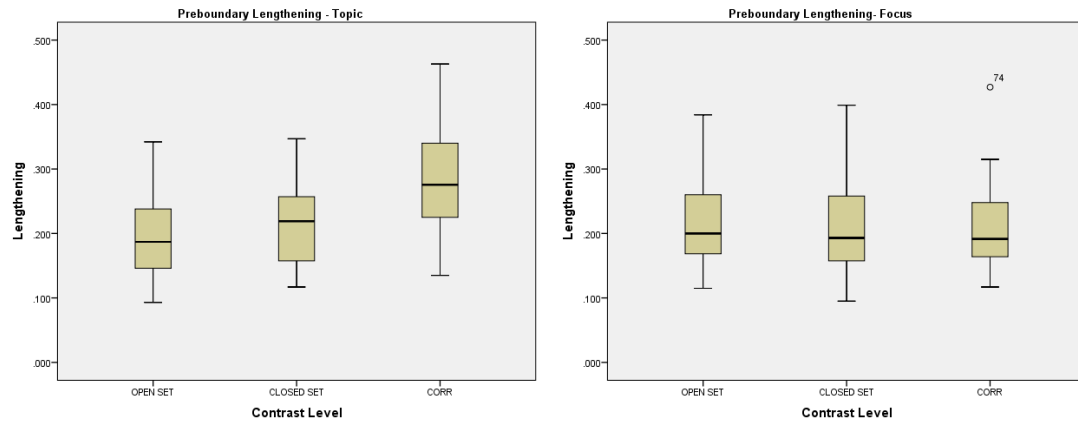
Edge tones	OPENSET		CLOSEDSET		CORRECTION	
	count	%	count	%	count	%
H-	20	63%	16	50%	5	16%
H-(!)H%	1	3%	7	22%	1	3%
L-	0	0%	0	0%	6	19%
L-(!)H%	0	0%	1	3%	10	31%
L-L%	0	0%	0	0%	6	19%
No boundary	11	34%	8	25%	4	13%



**Figure 5.** CORRECTION topic [ipo'pliarxos] with a boundary tone at the right edge of the verb [ði'etakse] "ordered".

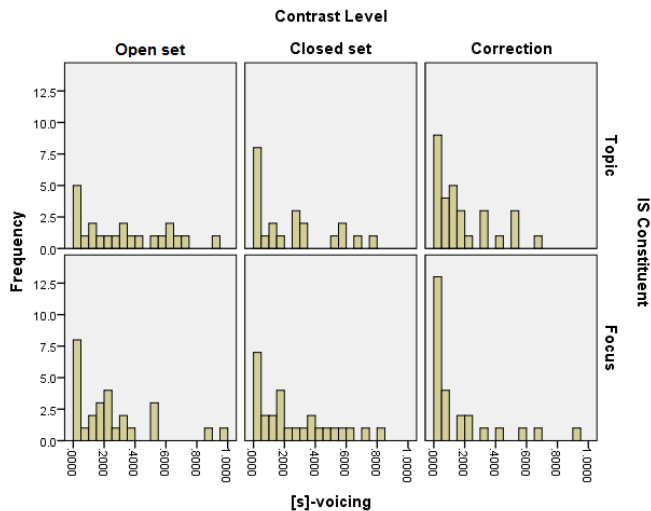
The difference in boundary strength between CORRECTION topics and the other levels is further corroborated by segmental differences, supporting H3. Significant effects of contrast level ( $\chi^2(4) = 30.239$ ,  $p < 0.001$ ) and information category ( $\chi^2(3) = 9.609$ ,  $p = 0.02$ ) on pre-boundary lengthening were found, as well as an interaction effect between contrast level and information structure category ( $\chi^2(2) = 38.701$ ,  $p < 0.001$ ). As shown in Figure 6, pre-boundary lengthening was longer in CORRECTION topics ( $\mu = 281$  ms) compared to OPENSET ( $\mu = 194$  ms) and CLOSEDSET ( $\mu = 216$  ms) topics and all foci as well. Within focus constituents in particular, there were no significant differences in pre-

boundary lengthening across different contrast levels (mean values: 212 ms, 208 ms and 210 ms for OPENSET, CLOSEDSET and CORRECTION respectively).



**Figure 6.** Preboundary lengthening for all contrast levels in topic and focus phrases.

Additionally, our analysis revealed a significant effect of contrast level on /s/-voicing ( $\chi^2(4) = 10.297, p = 0.036$ ), but no interaction effect ( $\chi^2(2) = 5.807, p = 0.055$ ). A lower voicing ratio ( $\mu = 0.23$ ) in CORRECTION topics compared to OPENSET ( $\mu = 0.54$ ) and CLOSEDSET ( $\mu = 0.47$ ) indicated that /s/-voicing was blocked more frequently in CORRECTION topics. These differences are also illustrated in Figures 2-4: the final syllable /lis/ in Figures 2 and 4 is realized as [liz] with an extremely shortened vowel and a voiced /s/, while in Figure 3 it is realized as [lis] due to the stronger boundary. Mean voicing ratio in foci was 0.36, 0.37 and 0.32 for OPENSET, CLOSEDSET and CORRECTION respectively. Pairwise tests showed that only CORRECTION topic differed in both lengthening and /s/-voicing from the other conditions.



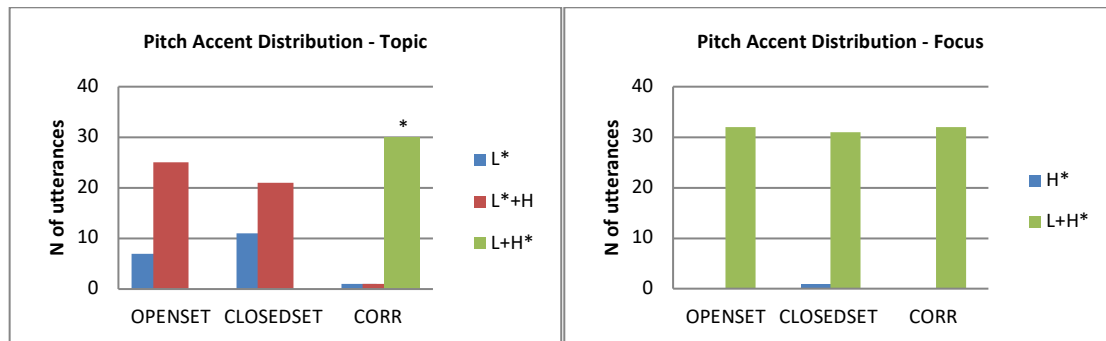
**Figure 7.** Voicing ratio for all contrast levels in topic and focus phrases.

H2 was partially confirmed. The pitch accent in CORRECTION was uniformly realised in

topic and focus alike as L+H\* supporting H2B (cf. Figures 3, 4). However, H2A was borne out only for topics, which had a different realisation in each of the three contrast levels, but not for foci, where all contrast levels carried a L+H\* pitch accent in all but one case (there was one instance of an H\* accent under CLOSEDSET focus where the H tone lacked the preceding dip in pitch and was instead preceded by a high plateau). Table 3 and figure 8 show the distribution of pitch accents across topic and focus phrases.

**Table 3.** Counts and percentages of pitch accent types in topics and foci.

	Pitch accents	OPENSET		CLOSEDSET		CORRECTION	
		count	%	count	%	count	%
TOPIC	L*	7	22%	11	34%	1	3%
	L*+H	25	78%	21	66%	1	3%
	L+H*	0	0%	0	0%	30	94%
FOCUS	H*	0	0%	1	3%	0	0%
	L+H*	32	100%	31	97%	32	100%



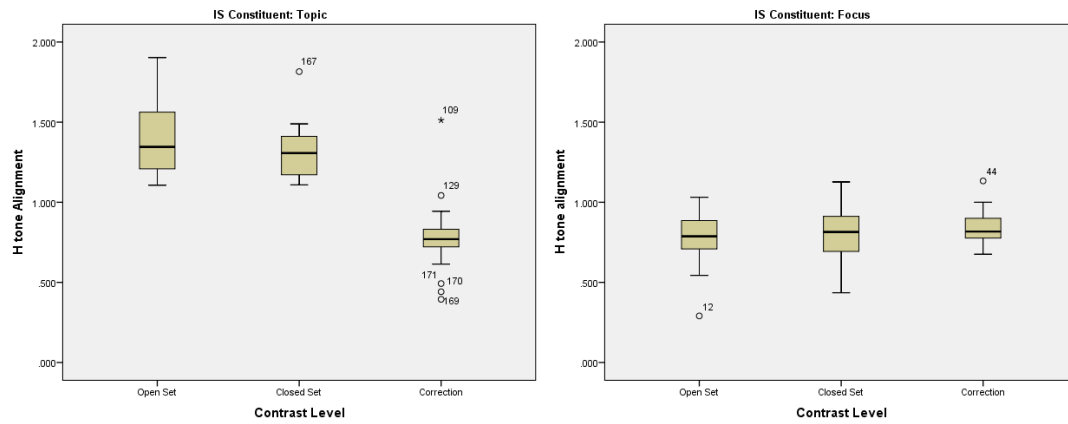
**Figure 8.** Pitch accent distribution as a function of contrast level.

Likelihood ratio tests showed a main effect of both information category ( $\chi^2(3) = 80.445$ ,  $p < 0.001$ ) and contrast ( $\chi^2(4) = 45.238$ ,  $p < 0.001$ ) on alignment, as well as a significant interaction effect between the two factors ( $\chi^2(2) = 121.838$ ,  $p < 0.001$ ; Figure 9). The result is expected, given the inherent differences in the alignment of the different pitch accents associated with topics. Concretely for *topics*, the accentual peak in CORRECTION was located within the stressed vowel ( $\mu = 0.78^2$ ), unlike OPENSET ( $\mu = 1.4$ ) and CLOSEDSET ( $\mu = 1.32$ ) where the peak occurred in the post-accentual syllable. In other words, phonologically there were typically two distinct pitch accents, each associated with a different H alignment pattern: Early alignment in CORRECTION topics, a L+H\*

<sup>2</sup> Recall that in the normalized alignment measurement when the mean value is below 1 the H aligns within the accented vowel (i.e., there is a L+H\* pitch accent) and when it is above 1 it aligns after the accentual vowel (i.e., there is a L\*+H pitch accent).

accent (Figures 3 and 5) and late alignment typically<sup>3</sup> in the other two levels, a L\*+H (Figure 2).

On the other hand, contra hypothesis H2A, in all *focus* constituents the alignment of the accentual peak occurred within the stressed vowel (0.78, 0.81 and 0.84 for OPENSET, CLOSEDSET and CORRECTION respectively), that is, all contrast levels in foci carried a L+H\* pitch accent. We return to this result in 2.3.



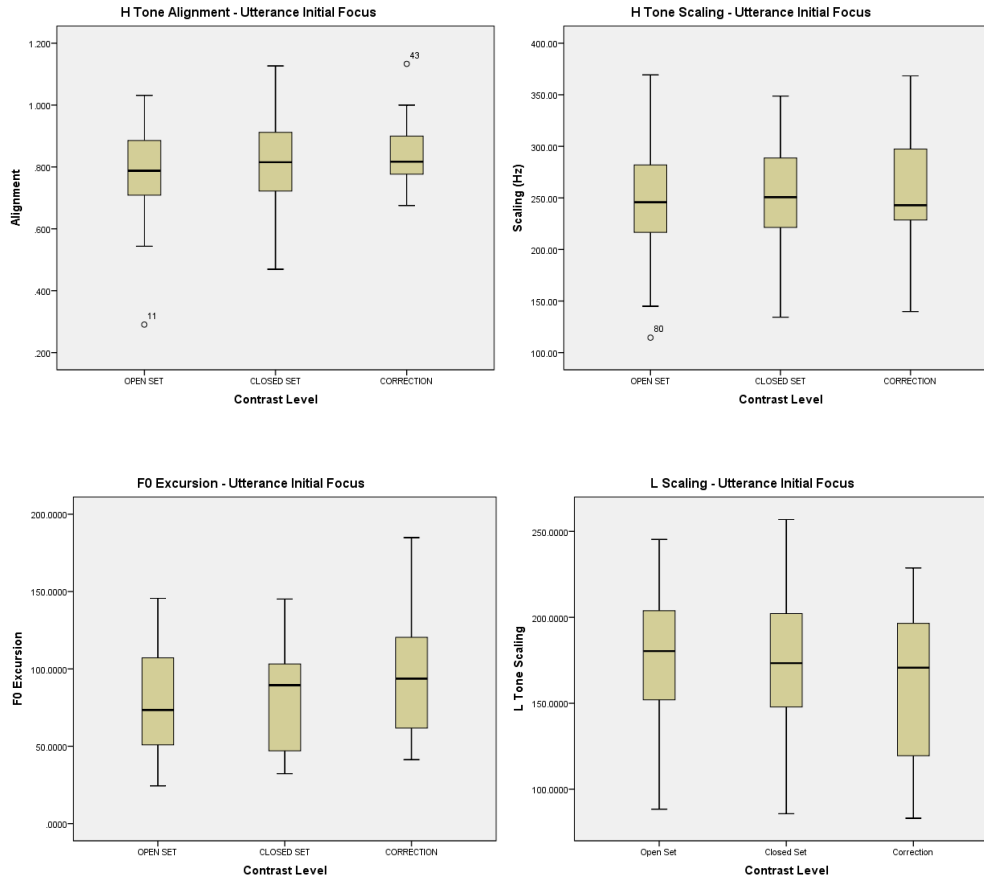
**Figure 9.** Alignment of accentual peak for all contrast conditions in topic and focus phrases.

Summing up, CORRECTION topics and all three contrast levels in focus were realized with the same L+H\* pitch accent. This allowed us to further measure the fine gradient phonetic realisation details of this accent and thus compare the effect of contrast level and the effect of information structure on the realisation of L+H\*. The remaining pitch accent categories (H\*, L\*+H, L\*) were not included in this analysis because their alignment properties are contrastively different (Arvaniti et al. 1998; Arvaniti & Baltazani 2005; Arvaniti et al. 2006; Baltazani & Jun 1999; Baltazani 2002) and therefore do not lend themselves for a comparison of gradient differences. We concentrated on the L+H\* accent, running an analysis of H tone scaling, alignment, and F0 excursion from the L to the H tones in a) the three contrast levels within focus and b) CORRECTION across focus and topic conditions.

For focus, the results did show some gradient effects of contrast on the realisation of L+H\*, as predicted by H3. Specifically, CORRECTION focus was realized with a longer  $f_0$  excursion ( $\chi^2(4) = 8.129$ ,  $p = 0.087$ ) between the L tone and the peak (11-14 Hz) compared to the other two levels (OPENSET,  $\mu = 78.7$  Hz; CLOSEDSET,  $\mu = 82.8$  Hz; CORRECTION  $\mu = 92.61$  Hz). The L tone in CORRECTION also scaled lower compared to the other levels (OPENSET,  $\mu = 168$  Hz; CLOSEDSET,  $\mu = 170$  Hz; CORRECTION focus,  $\mu = 161$  Hz;  $\chi^2(4) = 6.502$ ,  $p = 0.1647$ ), but the effects did not reach significance. Similarly, no effect of contrast was found on the scaling of the H peak ( $\chi^2(4) = 3.174$ ,  $p = 0.529$ ; OPENSET,  $\mu = 249$  Hz; CLOSEDSET,  $\mu = 253$  Hz; CORRECTION  $\mu = 254$  Hz). Last, the H peak aligned slightly later in CORRECTION (OPENSET,  $\mu = 0.78$ ; CLOSEDSET,  $\mu = 0.81$ ;

<sup>3</sup> Less frequently, OPENSET and CLOSEDSET were produced with a L\* accent (22% and 34% respectively).

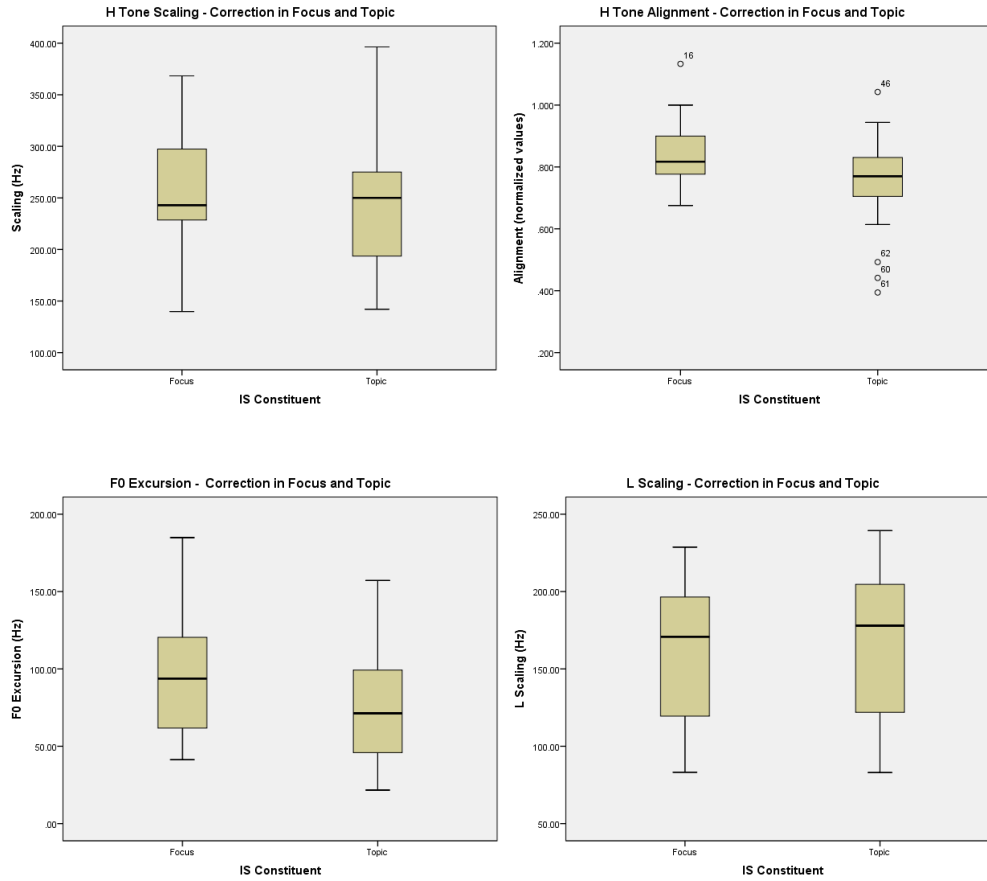
CORRECTION  $\mu = 0.84$ ) but the effect was not significant ( $\chi^2(4) = 4.234, p = 0.3755$ ). Figure 10 summarizes the results.



**Figure 10.** Counterclockwise from bottom left:  $f_0$  excursion, L tone scaling, H tone scaling and H tone alignment values for the contrast levels in focus phrases.

This further examination of L+H\* also revealed gradient differences in its tonal realisation as an effect of information structure. Figure 11 (counterclockwise from bottom left) shows that there was a significant effect of information structure on the  $f_0$  excursion of the L+H\* which was larger in CORRECTION foci ( $\mu = 93$  Hz) compared to CORRECTION topics ( $\mu = 76$  Hz;  $\chi^2(3) = 10.554, p = 0.014$ ). There was also an IS effect on L tone scaling, which was higher in topics (169 Hz versus 161 Hz;  $\chi^2(3) = 10.888, p = 0.0049$ ). And an IS effect at the 0.5 level on H tone scaling ( $\chi^2(3) = 10.983, p = 0.012$ ). The H tone scaled at 245 in topics and 254 Hz in foci. Finally, there was an IS effect on H tone alignment which was later in focus (0.84 versus 0.78;  $\chi^2(3) = 20.125, p < 0.001$ ).





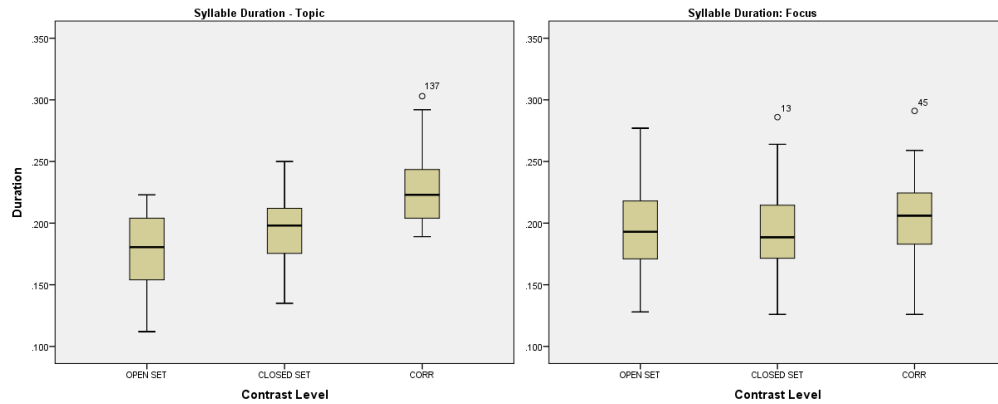
**Figure 11.** Counterclockwise from bottom left:  $f_0$  excursion, L tone scaling, H tone alignment and H tone scaling values for the CORRECTION condition in topic and focus phrases.

However, on further examination, these differences in  $F_0$  excursion and H tone alignment seem to be primarily dependent on the phrase boundary aligned with the edge of the contrasted phrase rather than a feature of the pitch accent itself. Recall that corrective topic was most of the times realized with a complex boundary tone (L-H%) contrary to the focus phrase that was typically not associated with a strong boundary. Thus, the earlier alignment in the case of topic could be interpreted as a result of leftward shifting of the H tone under pressure from the boundary tone. As for the difference in  $F_0$  excursion, this seems to be due to the fact that the low tone was scaled higher in the case of topic, and the H tone scaled lower. This allowed the speaker to reach the high tone target despite the earlier alignment of the topic phrase. Adding boundary strength to the linear models lead to better fit for both  $F_0$  excursion and alignment, rendering the effect of IS non-significant ( $\chi^2(3) = 3.494$ ,  $p = 0.3215$  and  $\chi^2(3) = 5.974$ ,  $p = 0.1129$  on excursion and alignment respectively) and revealing a main effect of boundary strength ( $\chi^2(2) = 8.689$ ,  $p < 0.013$  and  $\chi^2(2) = 11.483$ ,  $p = 0.003$  for excursion and alignment respectively).

The gradient segmental differences predicted by H3 were also verified for duration (Fig. 12) and intensity (Fig. 13). CORRECTION topic syllable was longer ( $\mu = 227\text{ms}$ ) than in

OPENSET topic ( $\mu = 178\text{ms}$ ), CLOSEDSET topic ( $\mu = 195\text{ms}$ ) and all foci. The CORRECTION focus syllable ( $\mu = 205\text{ms}$ ) was longer than in OPENSET ( $\mu = 193\text{ms}$ ) and CLOSEDSET focus ( $\mu = 192\text{ms}$ ).

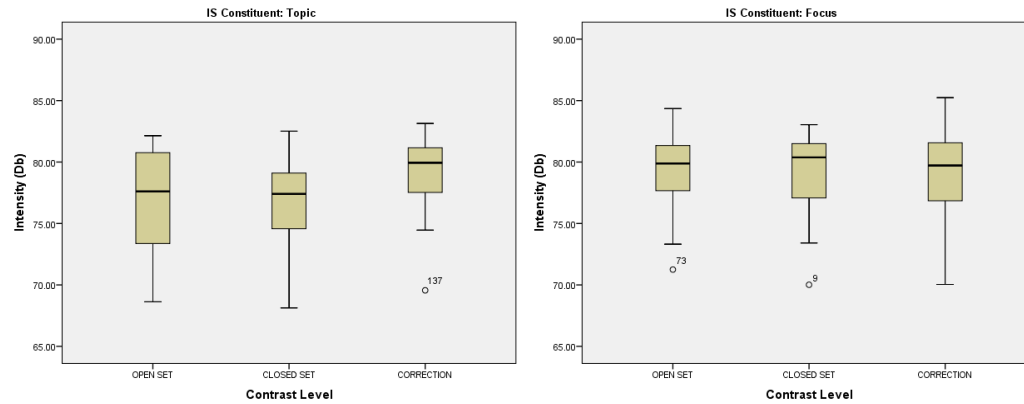
Accordingly, the effect of contrast on duration (Fig. 12) was significant ( $\chi^2(4) = 60.873, p < 0.001$ ) as well as the effect of IS ( $\chi^2(3) = 9.992, p < 0.019$ ). There was also a significant interaction between IS and contrast ( $\chi^2(2) = 27.223, p < 0.001$ ).



**Figure 12.** Accented syllable duration (in seconds) in topic and focus phrases.

Further analysis showed that differences in duration were also dependent on the stronger boundary aligned with the edge of the contrasted phrase, suggesting that boundary strength affects the accented syllable as well. The model with "boundary strength" as an extra factor was shown to be a better fit for our data, with the effect of boundary tone being statistically significant ( $\chi^2(2) = 25.184, p < 0.001$ ).

Likelihood ratio tests showed a significant effect on mean intensity of both Information Structure ( $\chi^2(3) = 43.111, p < 0.001$ ) and Contrast level ( $\chi^2(4) = 52.812, p < 0.001$ ), as well as a significant interaction between these two variables ( $\chi^2(2) = 20.578, p < 0.001$ ). The intensity values of CORRECTION in topic ( $\mu = 79.17 \text{ dB}$ ) were similar to those in focus ( $\mu = 79.24, 79.09$  and  $79.24 \text{ dB}$  for OPENSET, CLOSEDSET and CORRECTION focus respectively). On the other hand, post hoc tests showed that OPENSET ( $\mu = 76.99$ ) and CLOSEDSET ( $\mu = 76.6 \text{ dB}$ ) topics were produced with significantly lower intensity than CORRECTION topics ( $\mu = 79.17 \text{ dB}$ ).



**Figure 13.** Mean accented syllable intensity in topic and focus phrases.

## 2.3 Interim discussion

The first experiment examined the prosodic realisation of three contrast levels (CORRECTION, OPENSET and CLOSEDSET) across topic and focus constituents, through tonal measurements (pitch accent on the topic or focus; presence and type of boundary tone) as well as segmental ones (duration of the accentual and pre-boundary syllables and amount of /s/-voicing). The finding that Information Structure affected phrasing agrees with previous research (Baltazani & Jun 1999; Baltazani 2002, 2003, 2006; Arvaniti et al. 2006; Revithiadou 2004; Haidou 2012). In particular, topics were more often separated from the rest of the utterance by a boundary, while utterance initial foci were not, but were instead followed by de-accented material.

Within topics, an additional effect of contrast was found: CORRECTION topics were produced with stronger boundaries, which were realized with different and often more complex edge tones (L-H%), than the other two contrast levels. They were also produced with significantly more pre-boundary lengthening and less /s/-voicing in comparison to OPENSET and CLOSEDSET topics, which further support the presence of strong boundaries.

Regarding the pitch accents, there were two main findings. First, CORRECTION was found to be orthogonal to the focus-topic distinction, as both corrective topics and corrective foci were realized with the same pitch accent, L+H\*. Gradient differences in tone scaling and alignment were shown to depend primarily on the stronger boundary associated with corrective topics and could be interpreted as a result of leftward shifting of the H tone under pressure from the following boundary tone. Second, contrast level affected the choice of pitch accent only in topic phrases, where CORRECTION was realized with a different accent (L+H\*) from OPENSET and CLOSEDSET topics (L\*+H and L\*) and also with increased intensity and duration of the accented vowel in CORRECTION topic compared to the other two contrast levels. However, there was no such effect on focus phrases where the same accent, L+H\*, was used across all contrast levels, showing that at least in utterance initial position, Greek does not verify cross-linguistic reports of differences between contrast levels (Gussenhoven 2008; Greif 2010). There were some gradient differences, such as later alignment of the H tone and increased F0 excursion,

indicating a more clearly enunciated accent in the case of CORRECTION, but the effects did not reach significance.

One possible reason behind this result is that Greek, just like Germanic and Romance languages, has a default right edge nuclear pitch accent (NPA) in Subject-Verb-Object word orders (Alexiadou 1999:42; Keller & Alexopoulou 2001; Baltazani 2003, 2007 for Greek; Büring 2009; Truckenbrodt 1995 for Germanic languages) and any non-final NPA is a deviation from the “default” prosodic pattern typically resulting in the deletion of post-focal accents, so that the focused constituent becomes the right most and maximally prominent (Büring 2009; Truckenbrodt 1995). Our hypothesis is that this grammatical constraint causes a marked production of all contrast levels in focus, which are realized with a L+H\* accent. To test this hypothesis a second experiment was conducted investigating the three contrast levels in sentence final focus position, which, as the default, is not marked and therefore possible effects of contrast on pitch accent realisation would be revealed.

## 3. Experiment 2

In Experiment 2 we re-examine the pitch accent realisation for focus. In addition to contrast level, we also test utterance position. The assumption that the right edge is the default predicts that prosodic differences among the different pragmatic focus conditions will be evident in utterance final position (see example 10 below). Under this assumption, differences are expected to be evident only in final position and neutralised in any non-final position. We therefore compared final focus position with a medial one.

### 3.1 Method

#### 3.1.1 Experimental design, measurements, speakers and stimuli

We designed target utterances and matching appropriate contexts intended to trigger the desired pragmatic interpretation, testing the same three levels of contrast (OPENSET; CLOSEDSET; CORRECTION) as in experiment 1 and two utterance positions (final, non-final). This resulted in six combinations of 3 contrast levels x 2 utterance positions (Table 4).

In this experiment we expected three types of pitch accent to be produced – L+H\*, H\* and H\*+L – as the typical nuclear pitch accents of statements (Arvaniti & Baltazani 2005; Lohfink et al. 2019). In all three accents the peak is aligned within the accentual vowel (Arvaniti & Baltazani 2005). However, quantitative labeling criteria exist only for L+H\*, as mentioned in section 1.1, but not for the other two accents. We therefore based our classification on the published impressionistic descriptions which rely on criteria such as the shape of  $f_0$  movements<sup>4</sup> to distinguish among them. After this manual

---

<sup>4</sup> Note that pragmatic interpretation criteria are also used in GRTtoBI for the classification, e.g., the H\* is used to signal broad focus and H\*+L, in addition to signaling broad focus, has the meaning of “stating the

classification, the same measurements were taken for the L and H tonal targets as in Experiment 1 (see 2.1.2). Note that for all three accents the peak aligns within the accentual vowel therefore the normalised mean value (see 2.1.4) of the accentual H is expected to be below 1.

The same eight speakers participated in this experiment and the same recording method was followed as in experiment 1 (see 2.1 above). Four matrix sentences were designed (10-13), different from those of experiment 1, paired with 6 different contexts resulting in a corpus of 192 produced utterances (4 matrix sentences X 6 contexts X 8 speakers).

- (10) *o istori 'kos mele 'tuse tus ro 'meus mo 'narçes*  
the-NOM historian-NOM study-3SG the-ACC roman-ACC monarchs-ACC  
“The historian studied the Roman monarchs.”
- (11) *i astino'mia si'nelave tus ru'manus la'θreborus*  
the-NOM police-NOM arrest-3SG the-ACC romanian-ACC smugglers-ACC  
“The police arrested the Romanian smugglers.”
- (12) *to nomo'sçeðio voi'θa tus xami'lomisθus ikojeni'arçes*  
the-NOM bill-NOM helps-3SG the-ACC low-income-ACC family-leaders-ACC  
“The bill helps low-income family-leaders.”
- (13) *i ðioryano'tes a'cirosan tus a'nilikus ðjayoni'zomenus*  
the-NOM organizers-NOM disqualified-3PL the-ACC non-adult-ACC contestants-ACC  
“The organizers disqualified non-adult contestants.”

The target utterances had a Subject-Verb-Object word order, as in Experiment 1. In this experiment the object comprised a modifier followed by a noun, e.g., *ro 'meus mo 'narçes* ‘Roman monarchs.’

**Table 4.** Examples of stimuli for experiment 2. A = context; B = target utterances.

	Condition		Example
1.	Final	OPEN SET	A: <i>pçus ro 'meus mele 'tuse o istori 'kos</i> which roman-ACC study-3SG the-NOM historian-NOM “Which Romans did the historian study?” B: <i>o istori 'kos mele 'tuse tus ro 'meus mo 'narçes</i> the-NOM historian-NOM study-3SG the-ACC roman-ACC monarchs-ACC “The historian studied the Roman [monarchs] <b>Focus</b> ”
2.		CLOSED SET	A: <i>pçus ro 'meus mele 'tuse o istori 'kos tus mo 'narçes i tus strati 'yus</i> which roman-ACC study-3SG the-NOM historian-NOM the-ACC monarchs-ACC or the-ACC generals-ACC Which Romans did the historian study? The monarchs or the generals? B: <i>o istori 'kos mele 'tuse tus ro 'meus mo 'narçes</i> the-NOM historian-NOM study-3SG the-ACC roman-ACC monarchs-ACC “The historian studied the Roman [monarchs] <b>Focus</b> ”
3.		CORRECTION	A: <i>o istori 'kos mele 'tuse tus ro 'meus strati 'yus</i> the-NOM historian-NOM study-3SG the-ACC roman-ACC generals-ACC “The historian studied the Roman generals.” B: <i>o istori 'kos mele 'tuse tus ro 'meus mo 'narçes</i> the-NOM historian-NOM study-3SG the-ACC roman-ACC monarchs-ACC “The historian studied the Roman [monarchs] <b>Focus</b> ”
4.	Non	OPENSET	A: <i>pçus mo 'narçes mele 'tuse o istori 'kos</i>

obvious”. Due to our experimental design it was impossible to control for such pragmatic interpretation factors without further complicating the task we asked the speakers to perform.

	Final		B:	<i>which monarchs-ACC study-3SG the-NOM historian-NOM</i> “Which monarchs did the historian study?” <i>o istori 'kos mele 'tuse tus ro 'meus mo 'narçes</i> the-NOM historian-NOM study-3SG the-ACC roman-ACC monarchs-ACC “The historian studied [the Roman] <b>Focus</b> monarchs”
5.		CLOSEDSET	A:	<i>pçus mo 'narçes mele 'tuse o istori 'kos tus ro 'meus i tus 'elines</i> <i>which monarchs-ACC study-3SG the-NOM historian-NOM the-ACC roman-ACC or the-ACC greek-ACC</i> “Which monarchs did the historian study? The Roman or the Greek?” B:
			B:	<i>o istori 'kos mele 'tuse tus ro 'meus mo 'narçes</i> the-NOM historian-NOM study-3SG the-ACC roman-ACC monarchs-ACC “The historian studied [the Roman] <b>Focus</b> monarchs”
6.		CORRECTION	A:	<i>o istori 'kos mele 'tuse tus 'elines mo 'narçes</i> the-NOM historian-NOM study-3SG the-ACC greek-ACC monarchs-ACC “The historian studied the Greek monarchs” B:
			B:	<i>o istori 'kos mele 'tuse tus ro 'meus mo 'narçes</i> the-NOM historian-NOM study-3SG the-ACC roman-ACC monarchs-ACC “The historian studied [the Roman] <b>Focus</b> monarchs”

The same procedure, measurements, and statistical analysis method (mixed-effects models and ANOVA) were followed as in experiment 1. Contrast level and utterance position were set as fixed factors with pitch accent type as the dependent variable. The effect of contrast in each position was also examined for gradient variables with contrast level as a fixed factor. Post hoc tests with Bonferroni adjustment were run to assess the effect of each level. Unless otherwise stated only CORRECTION was shown to significantly differ from other levels.

### 3.1.2 Hypotheses

H1: CORRECTION will be predominantly realized as L+H\*

H2: There will be an effect of contrast in final position. CORRECTION is expected to be realized mainly with a L+H\* pitch accent; OPENSET and CLOSEDSET on the other hand are expected to have a more variable realization, including L+H\* (note that L+H\* has been associated with narrow focus in the literature, Arvaniti & Baltazani 2005), but also H\* or H\*+L. We also expect CORRECTION to be marked through gradient tonal and segmental differences, including later H tone alignment, increased F0 excursion, as well as increased duration and intensity of the accentual syllable.

H3: The effect of contrast will be neutralized in non-final position, where L+H\* will be used across contrast levels.

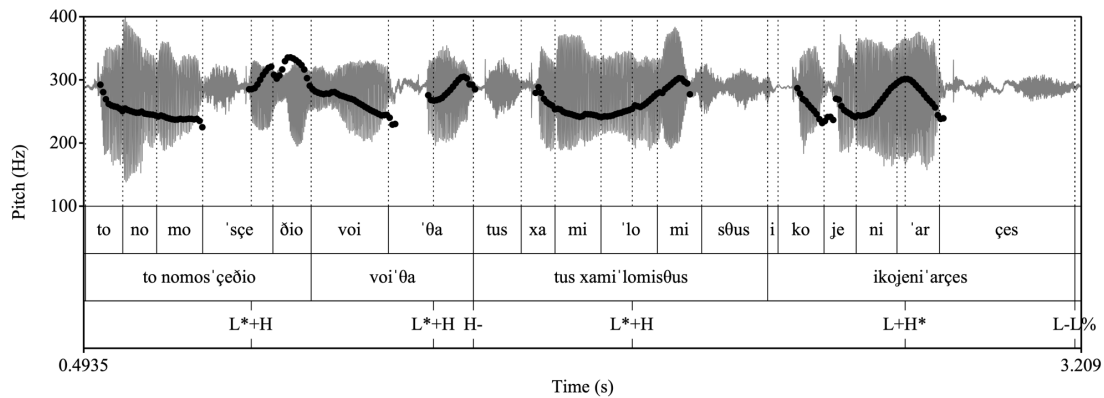
## 3.2 Results

We first present the results about H alignment in the three accent types with which the speakers produced the utterances in this experiment in section 3.2.1. The effects of contrast and focus position are then discussed in 3.2.2.

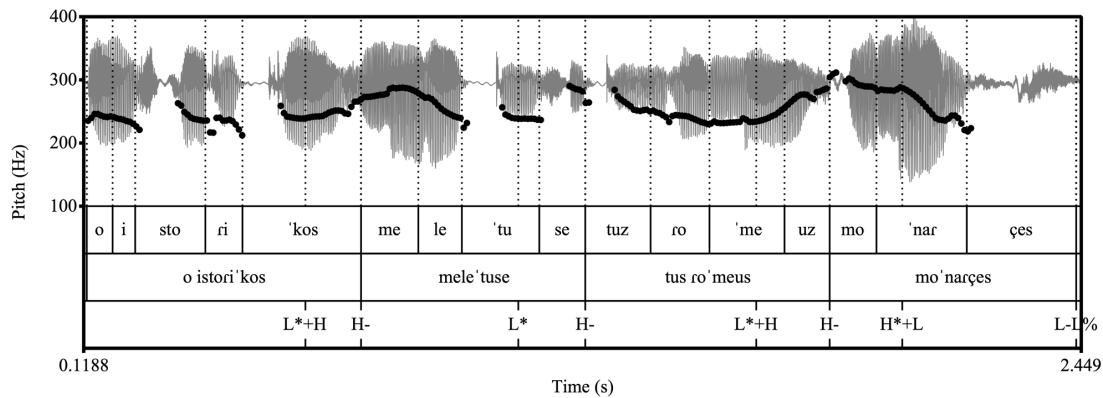
### 3.2.1 Phonetic realisation of pitch accent types and annotation validation

Before we present the results related to our hypotheses, we present an analysis to validate the consistency of the annotation of pitch accents. For this, we ran a one-way ANOVA with H alignment as the dependent variable and accent type as the independent variable.

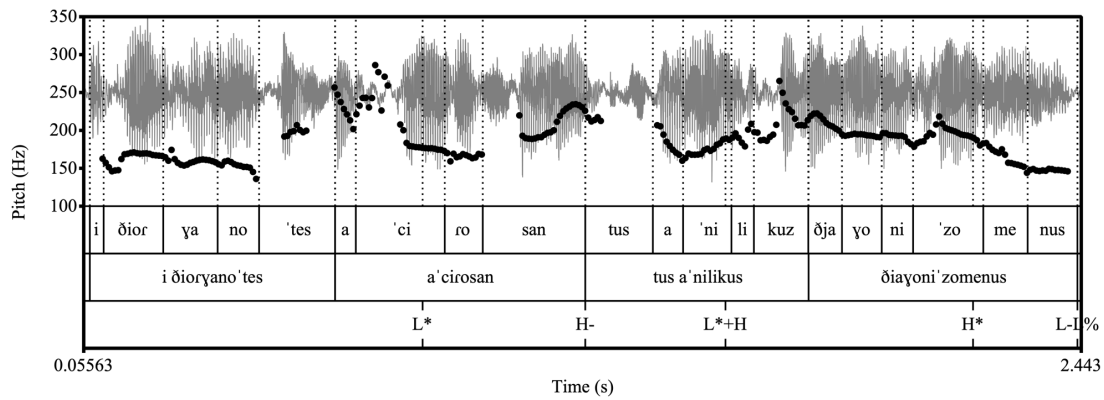
The analysis showed that the effect of pitch accent type on H tone alignment was significant ( $F(2) = 31.115$ ,  $p < 0.001$ ,  $\eta^2 = 0.251$ ). These results confirm the impressionistic descriptions in previous literature regarding the alignment behavior of the H tone in the three pitch accent types examined (Arvaniti & Baltazani 2005). The peak in L+H\* aligned later– around the middle of the stressed vowel ( $\mu = 0.512$ ) – compared to H\* ( $\mu = 0.295$ ), whose average alignment point was one third into the stressed vowel, and H\*+L ( $\mu = 0.051$ ), at the beginning of the accented vowel or even earlier. Figures 14, 15 and 16 are examples of the different accent types associated with CORRECTION (L+H\*), OPENSET and CLOSEDSET (H\*+L and H\*).



**Figure 14.** Example of a L+H\* pitch accent on *ikojeni'arçes* (CORRECTION focus).



**Figure 15.** Example of an H\*+L pitch accent on *mo'narçes* (CLOSEDSET focus).



**Figure 16.** Example of an H\* accent on *ðjaʝoni'zomenus* (OPENSET focus).

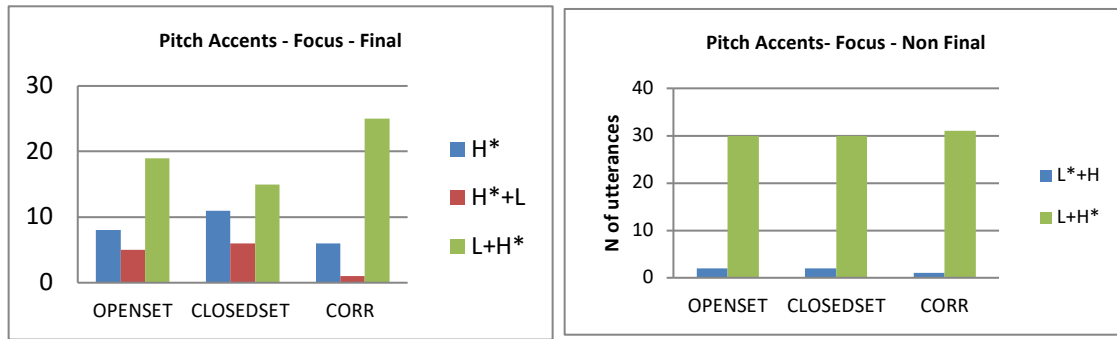
### 3.2.2 Effect of contrast and utterance position on focus realisation

The analysis of pitch accent distribution (Table 5 and Figure 17) revealed no effect of contrast in non-final position, where L+H\* was predominantly used across all contrast levels, confirming H1 and H3 (Figure 17 right panel). Additionally, there was an effect of contrast in utterance final position, confirming H2 (Figure 17 left panel). In utterance final position, the L+H\* accent was predominantly chosen by speakers to produce CORRECTION (78% of the cases) while there was more variability in the realisation of OPENSET (59% L+H\*, 25% H\*, 16% H\*L) and CLOSEDSET (47% L+H\*, 34% H\*, 19% H\*L), where pitch accent choice varied between L+H\* (53%) and the rest of the cases (47%). In accordance, likelihood ratio tests revealed a significant effect of contrast level on pitch accent choice in final position ( $\chi^2(4) = 20.448, p < 0.001$ ).

**Table 5.** Distribution of pitch accent types in final and non-final utterance position.

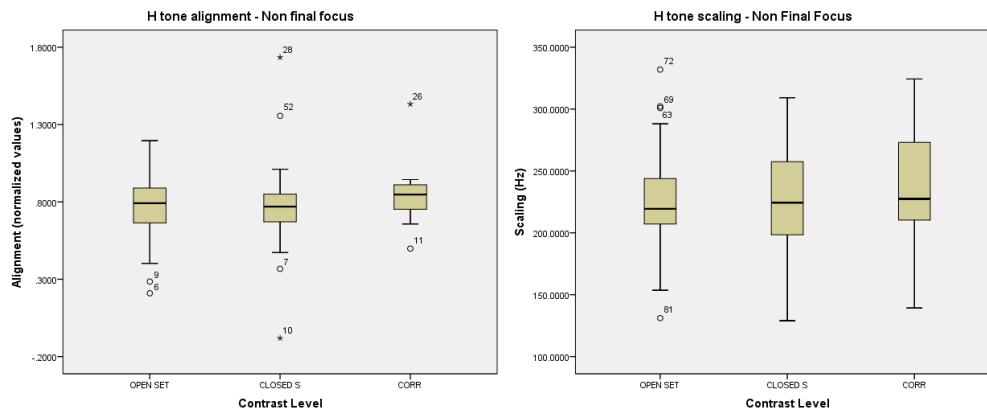
	Pitch accents	L*+H		H*		H*+L		L+H*	
		count	%	count	%	count	%	count	%
NON-FINAL POSITION	OPENSET	2	6%	-	-	-	-	30	94%
	CLOSEDSET	2	6%	-	-	-	-	30	94%
	CORRECTION	1	3%	-	-	-	-	31	97%
FINAL POSITION	OPENSET	-	-	8	25%	5	16%	19	59%
	CLOSEDSET	-	-	11	34%	6	19%	15	47%
	CORRECTION	-	-	6	19%	1	3%	25	78%

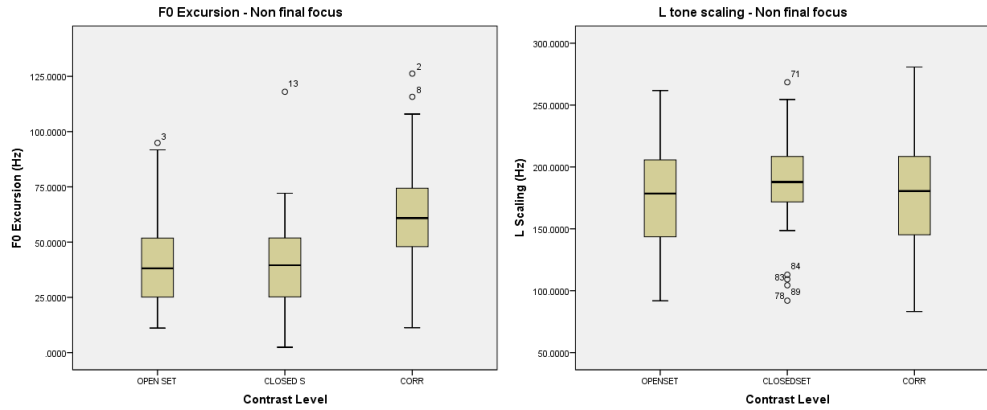




**Figure 17.** Pitch accent distribution in utterance final (left panel) and non-final (right panel) position.

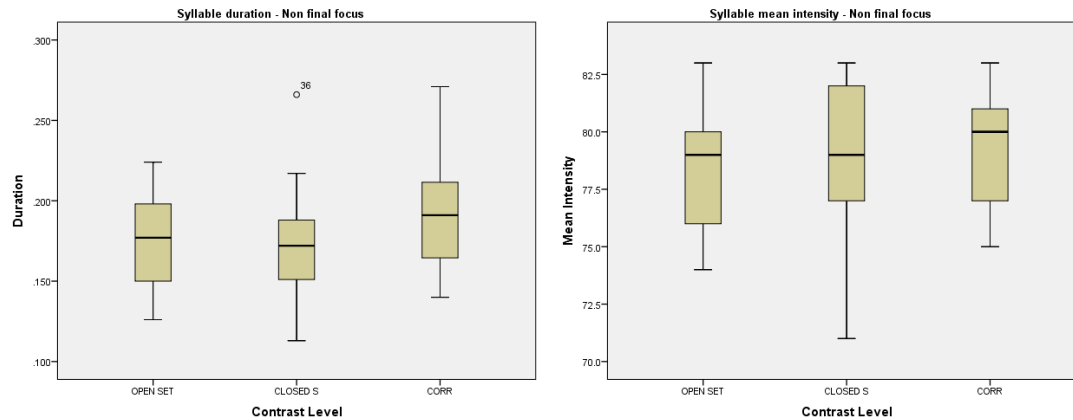
Gradient differences were found across contrast levels in the tone alignment, scaling and  $f_0$  excursion of the L+H\* accent in non-final position (Figure 18). Concretely, although the peak was aligned in the second half of the accentual vowel in all contrast levels, it was aligned later in CORRECTION compared to OPENSET and CLOSEDSET ( $\mu = 0.81$  versus  $\mu = 0.725$  and  $\mu = 0.74$ ;  $\chi^2(4) = 29.409$ ,  $p < 0.001$ ). The mean value of the  $f_0$  excursion was higher for CORRECTION compared to OPENSET and CLOSEDSET (62 Hz, 42 Hz and 41 Hz;  $\chi^2(4) = 14.655$ ,  $p = 0.005$ ). Both effects were significant. On the contrary, non-significant differences were detected for the H and L tone scaling. L tone scaling was lower in CORRECTION ( $\mu = 174.9$ ) compared to OPENSET ( $\mu = 180.72$ ) and CLOSEDSET ( $\mu = 184.31$  Hz;  $\chi^2(4) = 445.402$ ,  $p = 0.115$ ), while the H tone scaled higher ( $\mu = 237$  Hz versus  $\mu = 225$  Hz and  $\mu = 224$  Hz for CORRECTION, OPENSET and CLOSEDSET respectively;  $\chi^2(4) = 3.701$ ,  $p = 0.448$ ).





**Figure 18.** Counterclockwise from bottom left:  $f_0$  excursion, L tone scaling, H tone scaling and alignment as a function of contrast level in non-final focus position.

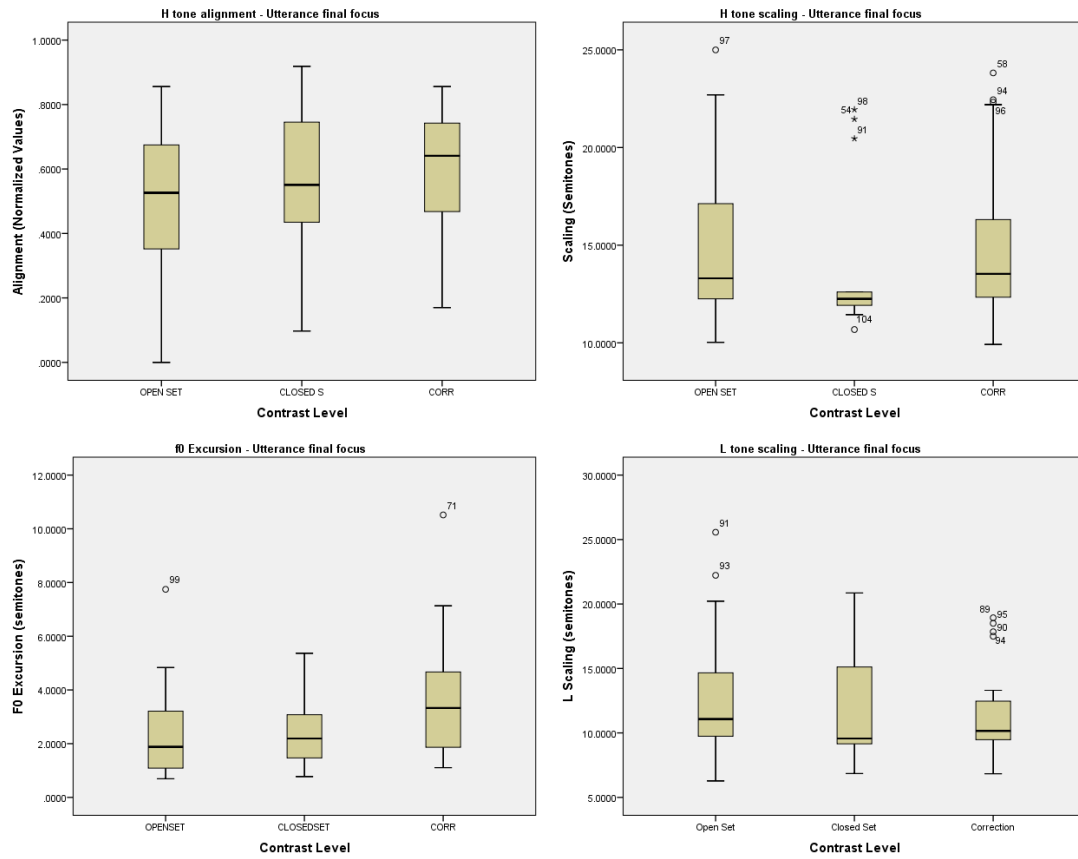
In addition to the tonal differences among the three contrast levels in non-final position, segmental differences were detected as well in the target word (Figure 19). CORRECTION was realized with higher intensity ( $\mu = 79.23$  dB) compared to other levels ( $\mu = 78.43$  dB and 78.93 dB for OPENSET and CLOSEDSET respectively), as well as longer duration ( $\mu = 190$  ms, 176 ms and 173 ms respectively). The effect was significant for duration ( $\chi^2(4) = 12.965$ ,  $p = 0.0114$ ), but not intensity ( $\chi^2(4) = 5.043$ ,  $p = 0.283$ ).



**Figure 19.** Duration and intensity as a function of contrast level in non-final focus position.

A similar analysis was carried out for the L+H\* accent in utterance final position (Figure 20). The analysis revealed that the H tone in L+H\* was aligned later in CORRECTION ( $\mu = 0.567$ ) compared to OPENSET ( $\mu = 0.466$ ) and CLOSEDSET ( $\mu = 0.475$ ). The effect was statistically significant ( $\chi^2(4) = 22.245$ ,  $p < 0.001$ ). CORRECTION also scaled slightly higher compared to OPENSET and CLOSEDSET ( $\mu = 15.052$ , 14.790 and 14.029;  $\chi^2(4) = 12.314$ ,  $p = 0.015$ ). The L tone in CORRECTION scaled lower compared to OPENSET and CLOSEDSET (11.6, 13.7 and 12.3 semitones respectively) but the effect did not reach significance ( $\chi^2(4) = 5.154$ ,  $p = 0.27$ ). On the contrary, there was a significant effect of contrast on  $f_0$  excursion ( $\chi^2(4) = 24.710$ ,  $p < 0.001$ ), which was higher for CORRECTION.

More specifically, mean excursion was 2.19, 1.96 and 3.5 semitones for OPENSET, CLOSEDSET and CORRECTION conditions respectively.



**Figure 20.** Counterclockwise from bottom left:  $f_0$  excursion, L scaling, H tone scaling and alignment as a function of contrast level in final focus position.

Among the segmental effects of contrast, syllable duration was significantly longer ( $\chi^2(4) = 11.095$ ,  $p = 0.004$ ) in utterance final CORRECTION ( $\mu = 208$  ms) compared to OPENSET ( $\mu = 195$  ms) and CLOSEDSET ( $\mu = 193$  ms). There were no significant differences in intensity (78.09, 77.34 and 77.41 dB for OPENSET, CLOSEDSET and CORRECTION conditions respectively;  $\chi^2(4) = 3.187$ ,  $p = 0.527$ ).

### 3.3 Interim discussion

The results confirmed our hypothesis that CORRECTION is prosodically different from the other two contrast levels. In utterance final position speakers produced the focus word mainly with a L+H\* accent in CORRECTION while in the other two levels in addition to the L+H\* they also used H\* and H\*+L accents. Systematic differences were found among these three accents in the alignment of the peak, which appeared around the middle of the stressed vowel in L+H\*, around 30% into the vowel in H\* and at the very beginning of the vowel in H\*+L.

Furthermore, these findings suggest that the lack of differentiation in the case of focus in the first experiment was due to the utterance initial position of the focus phrase, which caused a similarly emphatic realization for all contrast levels. As predicted, in utterance final position CORRECTION was distinguished from OPENSET and CLOSEDSET in terms of accent type as well as gradient phonetic details such as H tone alignment and scaling,  $f_0$  excursion and syllable duration.

In non-final position, on the other hand, all contrast levels were encoded with the same accent type (L+H\*), in line with our observations from the first experiment, where the focus phrase was utterance initial. Still, speakers systematically differentiated the production of CORRECTION, even when the same accent was used for all three contrast levels, through significantly later alignment, higher scaling, increased excursion and syllable duration compared to the other two levels. This is contrary to the phonetic analysis results of the first experiment: even though the direction of the difference was the same, the difference itself did not always reach statistical significance. We discuss the results of the two experiments in more detail in the following section.

## 4. General discussion

The two experiments presented here investigated the prosody speakers use to produce topic and focus phrases in experiment 1 and focus phrases in experiment 2 for three levels of contrastive meaning, called CORRECTION, OPENSET and CLOSEDSET. No evidence was found to distinguish between OPENSET and CLOSEDSET in the prosody of Greek, even though previous work argues for the representation of this distinction in the grammar (see Dik 1980, Molnár 2002, Krifka 2007 for a review of different contrast levels proposed in the literature and how they are reflected in the grammar). On the contrary we found that the prosodic realisation of the CORRECTION category was distinctive in a number of ways.

To begin with, in the first experiment, the prosodic realisation of CORRECTION in phrase initial position was found to be independent of the focus-topic division, as both corrective topics and corrective foci were realized with the same early peak accent, L+H\*. Gradient differences in the alignment and scaling of the H tone of the L+H\* accent, as well as differences in the duration of the accentual syllable were due to the stronger boundary associated with corrective topics. In other words, if we put aside expected differences related to phrasing, CORRECTION was realized in the same manner across topic and focus.

Moreover, CORRECTION was the only contrast level realized with L+H\* within topics while the other two levels were typically realized with a late peak L\*+H or a L\* pitch accent. In addition to this categorical difference, several gradient effects distinguished CORRECTION from the other two levels, including increased intensity and duration of the accented vowel in CORRECTION topics. The distinction of CORRECTION topics was also signaled through stronger boundaries, more complex edge tones (L-H%), significantly more pre-boundary lengthening and less /s/-voicing.

In focus constituents, the first experiment failed to detect any differences among the different contrast levels. In phrase initial position, the L+H\* accent was used for all

contrast levels. We attributed this result to the strong requirement in Greek to align the nucleus with the right prosodic edge (Baltazani 2007): the right edge is the unmarked default position of sentence stress for Greek and in non-final positions focus constituents have a marked rendition with the emphatic L+H\*. We maintain that this requirement overrides the requirement to differentiate CORRECTION from the other two contrast levels and therefore the difference is neutralized. As further support, the same requirement seems to apply to topic constituents as well, as shown in an unpublished pilot research examining topic phrases bearing the nuclear pitch accent in non-final phrase position (see Stavropoulou, 2017:139 for more information). All topics irrespective of their contrast level were rendered with a L+H\* accent displaying a behavior similar to non-final foci. This is an example of the contexts examined:

- (14) A: *pço 'meros tis 'notias ameri'cis e'leɣxun i parayo'ji koka'inis*  
 “What part of South America do cocaine dealers control?”  
 B: *i kolomvia'ni parayo'ji koka'inis e'leɣxun to 'noto i vrazi'ʎani*  
*parayo'ji koka'inis e'leɣxun to vo'ra*  
 “The Colombian cocaine dealers control the north; [the Brazilian L+H\*  
 cocaine dealers] L-H% control the south.”

To eliminate this confound, the second experiment examined the realisation of focus in final and non-final position. To begin with, for focus in final position, the results showed that CORRECTION was predominantly realized with a L+H\* pitch accent, while the other two levels in final position had a variable realisation (H\*, H\*+L as well as L+H\*) confirming our hypothesis. In addition to the categorical difference in pitch accent choice, gradient differences were also found between CORRECTION and the other two contrast levels, in the peak alignment and scaling, pitch excursion and syllable duration. Variability in the realisation of pitch accents and category overlap in pitch accent choice in declaratives in Greek have been noted before in the literature (Lohfink et al. 2019). The question of which other factors regulate pitch accent choice is left open here.

Secondly, in non-final position no variability in pitch accent type was found. All contrast levels were realized with the L+H\* accent, replicating the results of the first experiment and thus further corroborating our claim that non-final focus positions are marked. Crucially, the neutralization detected in all non-final positions was not complete, but only applied to the categorical choice of pitch accent type. A comparison of the realisation of the L+H\* accent in the three contrast levels revealed that the distinction between CORRECTION and the other two contrast levels was signaled through gradient tonal and segmental differences. Concretely, CORRECTION was systematically associated with significantly later peak alignment, higher peak scaling, increased pitch excursion and longer syllable duration compared to the other two levels.

Finally, the results of the two experiments confirm the descriptions in previous literature (Arvaniti & Baltazani 2005; Lohfink et al. 2019) regarding the alignment of the peak in three pitch accent types directly compared here, L+H\*, H\* and H\*+L. The quantitative comparisons reveal very fine but systematic differences in the H alignment which occurs

at the left edge of the vowel in H\*+L, the early part of the vowel in H\* and the middle of the vowel in L+H\*.

Taken together the results from the two production experiments suggest that CORRECTION has special status expressed prosodically in the same way in both topic and focus phrases in Greek but differently from other types of contrastive meanings. These results confirm the higher scaling and later alignment findings for contrastive focus compared to the non-contrastive cases reported in Georgakopoulos and Skopeteas (2010), but do not agree with the findings about prosodic differences between contrastive topics and foci reported in Gryllia (2008), who also found no differences between contrastive and non-contrastive focused constituents in initial and final sentence positions. The differences between the study presented here and in Gryllia (2008) are probably due to the fact that the conditions that licensed contrast for each level in Gryllia (2008) were different: contrastive topics were associated with implicit sub-questions and partial topic shift (the new topic was a member of the previously established topic set), while contrastive foci were linked to CORRECTION.

As the results presented here make clear, pitch accent choice is influenced by many factors, among which position in the utterance and contrast level. These results also confirm the special status enjoyed by CORRECTION in several other languages (Portuguese, Catalan, German, Mandarin Chinese, Efik, among others). In Greek, CORRECTION is distinguished from other levels in terms of both gradient and categorical factors (L+H\* accent).

Importantly, however, there is not a one-to-one correspondence between CORRECTION and the L+H\* NPA accent. Our findings showed that the same accent can be used in OPENSET and CLOSEDSET utterance final, narrow focus, and it is always used in non-final utterance position. This indicates that the association between CORRECTION and L+H\* is merely secondary. Consequently, we propose the introduction of an independent marker of emphasis, which is structurally encoded through the L+H\* accent, and is associated with the broader notion of speaker's assumption about the interlocutor's beliefs and attention state. In this line of thought, the low degree of predictability is identified as one of the conditions giving rise to emphasis (cf. Zimmerman 2008). This allows for a unified interpretation of two seemingly unrelated cases: On the one hand, CORRECTION is a least expected contribution to the conversation, so the speaker uses a marked rendition to draw the hearer's attention to the least predictable part of the utterance signaling the unexpected correction speech act itself. On the other hand, deviations from the typical phrase structure also lend themselves to a more marked rendition. As such, non-final focus position is the least predictable organization of information in the utterance, thus signaled through the use of the L+H\* emphasis marker.

In conclusion, the work presented here supports the systematic, structural distinction between two types of contrast: an “alternatives”-based one and an “emphasis”-based one (cf. Molnár, 2002; Repp, 2014). The former affects phrasing in the broader sense of determining the prosodic prominence relations in the utterance, the latter affects the exact realization of the prominent constituent. Namely, in Greek, “alternatives” contrast

determines the location of the nuclear pitch accent, while “emphasis” contrast determines its type. Crucially, the choice of accent type in the latter case is independent of the topic-focus distinction.

### **Funding**

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

## **5. References**

Alexiadou, A. (1999). Greek word order patterns. In Alexiadou, A., Horrocks, G. & Stavrou, M. (Eds.), *Studies in Greek syntax*. Dordrecht: Kluwer Academic Publishers, 45–65.

Armstrong, M. E. & Prieto, P. (2015). The contribution of context and contour to perceived belief in polar questions. *Journal of Pragmatics*, 81: 77–92.

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

Arvaniti, A. & Ladd, D.R. (2009). Greek wh-questions and the phonology of intonation. *Phonology* 26: 43–74.

Arvaniti, A. & T. Pelekanou. (2002). Postlexical rules and gestural overlap in a Greek spoken corpus. *Recherches en linguistique grecque*, vol. I: 71–74. Paris: L' Harmattan.

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

Arvaniti, A., D. R. Ladd & I. Mennen (2000). What is a starred tone? Evidence from Greek. In M. Broe & J. Pierrehumbert (Eds.), *Papers in Laboratory Phonology V: Acquisition and the Lexicon*. Cambridge University Press, 119–131.

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

Baltazani, M. (2002). *Quantifier scope and the role of intonation in Greek*. PhD thesis, UCLA.

Baltazani, M. (2003). Broad Focus across sentence types in Greek. *8<sup>th</sup> European Conference on Speech Communication and Technology* (EUROSPEECH 2003 - INTERSPEECH 2003), 89–92.

[http://www.isca-speech.org/archive/eurospeech\\_2003/e03\\_0089.html](http://www.isca-speech.org/archive/eurospeech_2003/e03_0089.html).

Baltazani, M. (2006). On /s/-voicing in Greek. Ms, *The 7th International Conference on Greek Linguistics*, York, UK. Downloaded from <http://users.uoi.gr/mbaltaz/en/ICGL7-Baltazani.pdf>, 26/09/2016.

Baltazani, M. (2007). Intonation of polar questions and the location of nuclear stress in Greek. In C. Gussenhoven & T. Riad (Eds.), *Tones and Tunes, Volume II: Experimental Studies in Word and Sentence Prosody*, Mouton de Gruyter, Berlin, 387–405.

Baltazani, M., & Jun, S. A. (1999). Focus and topic intonation in Greek. In *Proceedings of the XIVth International Congress of Phonetic Sciences*, vol. 2:1305–1308.

Baltazani, M., Gryllia, S. & Arvaniti, A. (2020). The intonation and pragmatics of Greek wh-questions. *Language and Speech*, 63(1), 56–94. DOI: 10.1177/0023830918823236.

Baumann, S. & Kügler, F. (2015). Prosody and information status in typological perspective - Introduction to the Special Issue. *Lingua* 165(B), 179–182.

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

Boersma, Paul & Weenink, David (2011). Praat: doing phonetics by computer [Computer program]. Version 5.2.37 2011 from <http://www.praat.org/>.

Bolker, B. M., Brooks, M. E., Clark, C. J., Geange, S. W., Poulsen, J. R., Stevens, M. H. H., & White, J. S. S. (2009). Generalized linear mixed models: a practical guide for ecology and evolution. *Trends in ecology & evolution*, 24(3), 127–135.

Borras-Comes, J., Vanrell, M. D. M., & Prieto, P. (2014). The role of pitch range in establishing intonational contrasts. *Journal of the International Phonetic Association*, 44(01), 1–20.

Brehenya, R., Katsos, N. & Williams, J. (2006). Are generalised scalar implicatures generated by default? An on-line investigation into the role of context in generating pragmatic inferences. *Cognition*, 100(3), 434–463.  
<https://doi.org/10.1016/j.cognition.2005.07.003>

Brown, M., Salverda, A. P., Gunlogson, C., & Tanenhaus, M. K. (2015). Interpreting prosodic cues in discourse context. *Language, Cognition and Neuroscience*, 30(1–2), 149–166.

Büring, D. (2007). Semantics, intonation and information structure. *The Oxford handbook of linguistic interfaces*, 445–474.



Büring, D. (2009). Towards a typology of focus realization. *Information structure*, 177–205.

Calhoun, S. (2009). What makes a word contrastive: Prosodic, semantic and pragmatic perspectives. In Barth Weingarten, D., N. Dehé, & A. Wichmann (Eds.), *Where prosody meets pragmatics: Research at the interface*. Bingley: Emerald, 53–78.

Chafe, W. (1974). Language and consciousness. *Language* 50, 111–33.

Dik, S. (1980). On the typology of Focus Phenomena in Perspectives on Functional Grammar. *Glot. Leids Taalkundig Bulletin Voorschoten*, 3(3–4), 41–74.

Frota, S. (2014). *Prosody and focus in European Portuguese: Phonological phrasing and intonation*. Routledge.

Genzel, S., Ishihara, S., & Surányi, B. (2015). The prosodic expression of focus, contrast and givenness: A production study of Hungarian. *Lingua*, 165(B), 183–204.

Georgakopoulos, T., & Skopeteas, S. (2010). Projective vs. interpretational properties of nuclear accents and the phonology of contrastive focus in Greek. *The Linguistic Review*, 27(3), 319–346.

Greif, M. (2010). Contrastive focus in mandarin Chinese. In *Proceedings of Speech Prosody 2010*, 1–4.

Gryllia, S. (2008). *On the nature of preverbal Focus in Greek*. PhD Thesis, Utrecht: LOT Publications.

Gussenhoven, C. (2008). Notions and subnotions in information structure. *Acta Linguistica Hungarica*, 55(3–4), 381–395.

Haidou, K. (2012). *The syntax-pragmatics interface of focus phenomena in Greek*. Haidou, Ph.D. Thesis, School of Oriental and African Studies.

Halliday, M.A.K. (1967). Notes on Transitivity and Theme in English, Part II. *Journal of Linguistics* 3:199–244.

Horrocks, G. (1983). The order of constituents in Modern Greek. In G. Gazdar, E. Klein & G. K. Pullum (eds.) *Order, concord and constituency*, 95–111. Dordrecht: Foris Publications.

Jackendoff, R. (1972). *Semantic interpretation in generative grammar*. Cambridge, MA: MIT press.

Kainada, E. (2007). Prosodic Boundary Effects on Durations and Vowel Hiatus in Modern Greek. In *Proceedings of the XVIth ICPhS*. Saarbrücken, Universität des Saarlandes, 1225–1228.

Kainada, E. (2010). Pre- and post-boundary lengthening in Modern Greek. In *Proceedings of ISCA Tutorial and Research Workshop on Experimental Linguistics 2010*, EKPA, Athens, 69–72.

Kainada, E. (2012). The acoustics of prosodic conditioning of vowel hiatus resolution in Modern Greek. In G. Fragaki, T. Georgakopoulos & C. Themistocleous (Eds.), *Current Trends in Greek Linguistics*. Newcastle: Cambridge Scholars Publishing, 246–269.

Katsika, A. (2012). *Coordination of prosodic gestures at boundaries in Greek*. PhD Thesis, Yale University.

Keller, F. & Alexopoulou, T. (2001). Phonology completes with syntax: Experimental evidence for the interaction of word order and accent placement in the realization of Information Structure. *Cognition*, 79(3), 301–372. [https://doi.org/10.1016/S0010-0277\(00\)00131-1](https://doi.org/10.1016/S0010-0277(00)00131-1).

Kiss, K. É. (1998). Identificational focus versus information focus. *Language*, 245–273.

Krifka, M. (2007). Basic notions of information structure. In C. Fery and M. Krifka (Eds.), *Interdisciplinary Studies of Information Structure 6*. Potsdam, 2007.

Laskaratou, C. (1998). Basic characteristics of Modern Greek word order. In Anna Siewierska (Ed.), *Constituent Order in the Languages of Europe*, Berlin: Mouton de Gruyter, 151–174.

Lohfink, Georg, Argyro Katsika, & Amalia Arvaniti. (2019). Variability and category overlap in the realization of intonation. *Proceedings of 19th ICPhS, Melbourne 2019*. <https://assta.org/proceedings/ICPhS2019/>

Molnár, V. (2002). Contrast—from a contrastive perspective. *Language and Computers*, 39(1), 147–161.

Moulin B. (1995). Discourse spaces: A pragmatic interpretation of contexts. In: Ellis G., Levinson R., Rich W., Sowa J.F. (Eds.) *Conceptual Structures: Applications, Implementation and Theory*. ICCS 1995. Lecture Notes in Computer Science (Lecture Notes in Artificial Intelligence), vol. 954. Springer, Berlin, Heidelberg. [https://doi.org/10.1007/3-540-60161-9\\_31](https://doi.org/10.1007/3-540-60161-9_31).

Nespor, M., & Vogel, I. (2007). *Prosodic phonology* (Vol. 28). Walter de Gruyter.

Ostendorf, M., Price, P. J., & Shattuck-Hufnagel, S. (1995). The Boston University radio news corpus. *Linguistic Data Consortium*, 1–19.

Philippaki-Warbuton, I. (1982). I simasia tis siras rima ipokimeno antikimeno sta Nea Ellinika [The importance of the VSO order in Modern Greek]. *Studies in Greek Linguistics* 3. 135–158.

Pierrehumbert, J. (1980). *The phonology and phonetics of English intonation*. MIT Linguistics PhD thesis. Distributed by the Indiana University Linguistics Club, Bloomington, Indiana.

Pierrehumbert, J. & Hirschberg, J. (1990). The Meaning of Intonational Contours in the Interpretation of Discourse. In Cohen, P. & J. Morgan & M. Pollock (Eds.) *Intentions in Communications*. Cambridge, MA: MIT Press. 271–311.

Prieto, P. (2014). The intonational phonology of Catalan. *Prosodic typology*, 2, 43–80.

Prince, E. F. (1981). Toward a taxonomy of given-new information. In P. Cole (ed.), *Radical Pragmatics*. Academic Press, 223–254.

Repp, S. (2010). Defining ‘contrast’ as an information-structural notion in grammar. *Lingua* 120, 1333–1345.

Repp, S. (2014). Contrast: Dissecting an Elusive information-structural notion and its role in grammar. *The Oxford Handbook of Information Structure*. Oxford: Oxford University Press.

Revithiadou, A. (2004). Prosodic cues in p-phrasing. The case of Greek declaratives. *Studies in Greek Linguistics*, 24, 580–591.

Revithiadou, A. (2005). Prosodic phrasing and focus in Greek declaratives. In in G. Catsimali, E. Anagnostopoulou, A. Kalokerinos, and I. Kappa (Eds.), *Proceedings of the 6th International Conference of Greek Linguistics*, 64–74.

Roberts, C. (1996). Information structure in discourse: Towards an integrated formal theory of pragmatics. *Working Papers in Linguistics-Ohio State University Department of Linguistics*, 91–136.

Rochemont, M. S. (1986). *Focus in generative grammar* (Vol. 4). John Benjamins Publishing.

Rooth, M. (1992). A theory of focus interpretation. *Natural language semantics*, 1(1), 75–116.

Selkirk, E. (1995). Sentence Prosody: Intonation, Stress and Phrasing. In Goldsmith, J. (Ed.), *Handbook of Phonological Theory* 550–569. Cambridge, MA: Blackwell.

Stavropoulou, P. (2017). *Prosodic realization of information structure in Greek: the case of contrast*. PhD Thesis, University of Ioannina.

<https://phdtheses.ekt.gr/eadd/handle/10442/44415>

Steedman, M. (2000). Information structure and the syntax-phonology interface. *Linguistic Inquiry*, 31(4), 649–689.

Steedman, M. (2007). Information-structural semantics for English intonation. In C. Lee, M. Gordon, and D. Büring (Eds.), *Topic and Focus: Crosslinguistic perspectives on meaning and intonation* (Studies in linguistics and philosophy 82). Dordrecht: Kluwer, 245–264.

Steube, A. (2001). Correction by contrastive focus. *ZAS Papers in Linguistics*, 23, 211–230.

Sudhoff, S. (2010). Focus particles and contrast in German. *Lingua*, 120(6), 1458–1475.

Truckenbrodt, H. (1995). *Phonological phrases--their relation to syntax, focus, and prominence*. PhD Thesis, Massachusetts Institute of Technology.

Tsimpli, I. M. (1990). The clause structure and word order in Modern Greek. *UCL Working Papers in Linguistics* 2, 226–255.

Vallduví, E. (1992). *The informational component*. New York, Garland.

Vallduví, E. & Engdahl E. (1996). The linguistic realization of information packaging. *Linguistics* 34(3), 459–519.

Vallduví, E., & Vilkuna, M. (1998). On rheme and kontrast. *Syntax and semantics*, 79–108.

Wightman, C. W., Shattuck-Hufnagel, S., Ostendorf, M., & Price, P. J. (1992). Segmental durations in the vicinity of prosodic phrase boundaries. *The Journal of the Acoustical Society of America*, 91(3), 1707–1717.

Zimmermann, M. (2008). Contrastive focus and emphasis. *Acta Linguistica Hungarica*, 55(3), 347–360.

## Appendix

Fixed factors	-2 Log Likelihood	$\chi^2$ test	Effect tested
Contrast Level * Information category	-655.413		
Contrast Level, Information category	-616.712	$\chi^2(2) = 38.701, p < 0.001$	Interaction Effect
Contrast Level	-607.103	$\chi^2(3) = 9.609, p = 0.02$	Information Category effect
Information Category	-586.473	$\chi^2(4) = 30.239, p < 0.001$	Contrast Level effect

Experiment A - Likelihood ratio tests. Dependent variable: Pre-boundary Lengthening

Fixed factors	-2 Log Likelihood	$\chi^2$ test	Effect tested
Contrast Level * Information category	124.457		
Contrast Level, Information category	130.264	$\chi^2(2) = 5.807, p = 0.0548$	Interaction Effect
Contrast Level	132.413	$\chi^2(3) = 2.149, p = 0.2035$	Information Category effect
Information Category	140.561	$\chi^2(4) = 10.297, p = 0.036$	Contrast Level effect

Experiment A - Likelihood ratio tests. Dependent variable: /s/ voicing

Fixed factors	-2 Log Likelihood	$\chi^2$ test	Effect tested
Contrast Level * Information category	781.515		
Contrast Level, Information category	802.273	$\chi^2(2) = 20.578, p < 0.001$	Interaction Effect
Contrast Level	845.384	$\chi^2(3) = 43.111, p < 0.001$	Information Category effect
Information Category	823.607	$\chi^2(4) = 52.812, p < 0.001$	Contrast Level effect

Experiment A - Likelihood ratio tests. Dependent variable: Mean Intensity

Fixed factors	-2 Log Likelihood	$\chi^2$ test	Effect tested
---------------	-------------------	---------------	---------------

Contrast Level * Information category	-911.655		
Contrast Level, Information category	-884.432	$\chi^2(2) = 27.223, p < 0.001$	Interaction Effect
Contrast Level	-874.440	$\chi^2(3) = 9.992, p = 0.0186$	Information Category effect
Information Category	-823.559	$\chi^2(4) = 60.873, p < 0.001$	Contrast Level effect

Experiment A - Likelihood ratio tests. Dependent variable: Duration

Fixed factors	-2 Log Likelihood	$\chi^2$ test	Effect tested
Information Category, Contrast Level, Boundary Strength	-909.616		
Information Category, Boundary Strength	-861.089	$\chi^2(4) = 48.527, p < 0.001$	Contrast Level
Contrast Level, Boundary Strength	-898.858	$\chi^2(3) = 10.758, p = 0.0131$	Information Category
Information Category, Contrast Level	-884.432	$\chi^2(2) = 25.184, p < 0.001$	Boundary Strength

Experiment A - Likelihood ratio tests. Dependent variable: Duration

Fixed factors	-2 Log Likelihood	$\chi^2$ test	Effect tested
Contrast Level * Information category	-149.165		
Contrast Level, Information category	-27.327	$\chi^2(2) = 121.838, p < 0.001$	Interaction Effect
Contrast Level	53.118	$\chi^2(3) = 80.445, p < 0.001$	Information Category effect
Information Category	17.911	$\chi^2(4) = 45.238, p < 0.001$	Contrast Level effect

Experiment A - Likelihood ratio tests. Dependent variable: H tone alignment

Fixed factors	-2 Log Likelihood	$\chi^2$ test	Effect tested
Contrast Level	-137.494		

Null Model	-133.262	$\chi^2(4) = 4.234, p = 0.3755$	Contrast Level Effect
------------	----------	---------------------------------	-----------------------

Experiment A - Likelihood ratio tests. Dependent variable: H tone alignment (Focus)

Fixed factors	-2 Log Likelihood	$\chi^2$ test	Effect tested
Information Category	-109.344		
Null Model	-89.219	$\chi^2(3) = 20.125, p < 0.001$	Information Category Effect

Experiment A - Likelihood ratio tests. Dependent variable: H tone alignment (Correction in Topic and Focus)

Fixed factors	-2 Log Likelihood	$\chi^2$ test	Effect tested
Contrast Level	875.478		
Null Model	878.652	$\chi^2(4) = 3.174, p = 0.529$	Contrast Level Effect

Experiment A - Likelihood ratio tests. Dependent variable: H tone scaling (Focus)

Fixed factors	-2 Log Likelihood	$\chi^2$ test	Effect tested
Information Category	595.321		
Null Model	606.259	$\chi^2(3) = 10.983, p = 0.0121$	Information Category Effect

Experiment A - Likelihood ratio tests. Dependent variable: H tone scaling (Correction in Topic and Focus)

Fixed factors	-2 Log Likelihood	$\chi^2$ test	Effect tested
Contrast Level	804.891		
Null Model	811.393	$\chi^2(4) = 6.502, p = 0.1647$	Contrast Level Effect

Experiment A - Likelihood ratio tests. Dependent variable: L tone scaling (Focus)

Fixed factors	-2 Log Likelihood	$\chi^2$ test	Effect tested
Information Category	478.474		
Null Model	491.362	$\chi^2(3) = 12.883, p = 0.004$	Information Category Effect

Experiment A - Likelihood ratio tests. Dependent variable: L tone scaling (Correction in Topic and Focus)

Fixed factors	-2 Log Likelihood	$\chi^2$ test	Effect tested
Contrast Level	410.610		
Null Model	418.739	$\chi^2(4) = 8.129, p = 0.0870$	Contrast Level Effect

Experiment A - Likelihood ratio tests. Dependent variable: F0 Excursion (Focus)

Fixed factors	-2 Log Likelihood	$\chi^2$ test	Effect tested
Information Category	584.022		
Null Model	594.576	$\chi^2(3) = 10.554, p = 0.014$	Information Category Effect

Experiment A - Likelihood ratio tests. Dependent variable: F0 Excursion (Correction in Topic and Focus)

Fixed factors	-2 Log Likelihood	$\chi^2$ test	Effect tested
Information Category * Boundary Strength	574.307		
Information Category, Boundary Strength	575.333	$\chi^2(2) = 1.026, p = 0.5987$	Interaction Effect
Information Category	584.022	$\chi^2(3) = 8.689, p = 0.013$	Boundary Strength
Boundary Strength	578.827	$\chi^2(3) = 3.494, p = 0.3215$	Information Category Effect

Experiment A - Likelihood ratio tests. Dependent variable: F0 Excursion (Correction in Topic and Focus)

Fixed factors	-2 Log Likelihood	$\chi^2$ test	Effect tested
---------------	-------------------	---------------	---------------



Contrast Level	869.198		
Null Model	880.343	$\chi^2(4) = 29.409, p < 0.001$	Contrast Level Effect

Experiment B - Likelihood ratio tests. Dependent variable: H Alignment (Non-final position)

Fixed factors	-2 Log Likelihood	$\chi^2$ test	Effect tested
Contrast Level	240.334		
Null Model	244.035	$\chi^2(4) = 3.701, p = 0.448$	Contrast Level Effect

Experiment B - Likelihood ratio tests. Dependent variable: H tone scaling (Non-final position)

Fixed factors	-2 Log Likelihood	$\chi^2$ test	Effect tested
Contrast Level	437.968		
Null Model	445.402	$\chi^2(4) = 445.402, p = 0.115$	Contrast Level Effect

Experiment B - Likelihood ratio tests. Dependent variable: L tone scaling (Non-final position)

Fixed factors	-2 Log Likelihood	$\chi^2$ test	Effect tested
Contrast Level	225.339		
Null Model	239.994	$\chi^2(4) = 14.655, p = 0.005$	Contrast Level Effect

Experiment B - Likelihood ratio tests. Dependent variable: F0 Excursion (Non-final position)

Fixed factors	-2 Log Likelihood	$\chi^2$ test	Effect tested
Contrast Level	373.791		
Null Model	378.834	$\chi^2(4) = 5.043, p = 0.2829$	Contrast Level Effect

Experiment B - Likelihood ratio tests. Dependent variable: Intensity (Non-final position)

Fixed factors	-2 Log Likelihood	$\chi^2$ test	Effect tested
---------------	-------------------	---------------	---------------

	<b>Likelihood</b>		
Contrast Level	-459.907		
Null Model	-446.942	$\chi^2(4) = 12.965, p = 0.011$	Contrast Level Effect

Experiment B - Likelihood ratio tests. Dependent variable: Duration (Non-final position)

<b>Fixed factors</b>	<b>-2 Log Likelihood</b>	<b><math>\chi^2</math> test</b>	<b>Effect tested</b>
Contrast Level	-384.572		
Null Model	-362.327	$\chi^2(4) = 22.245, p < 0.001$	Contrast Level Effect

Experiment B - Likelihood ratio tests. Dependent variable: H alignment (Final position)

<b>Fixed factors</b>	<b>-2 Log Likelihood</b>	<b><math>\chi^2</math> test</b>	<b>Effect tested</b>
Contrast Level	796.201		
Null Model	808.515	$\chi^2(4) = 12.314, p = 0.015$	Contrast Level Effect

Experiment B - Likelihood ratio tests. Dependent variable: H scaling (Final position)

<b>Fixed factors</b>	<b>-2 Log Likelihood</b>	<b><math>\chi^2</math> test</b>	<b>Effect tested</b>
Contrast Level	860.716		
Null Model	865.870	$\chi^2(4) = 5.154, p = 0.27$	Contrast Level Effect

Experiment B - Likelihood ratio tests. Dependent variable: L tone scaling (Final position)

<b>Fixed factors</b>	<b>-2 Log Likelihood</b>	<b><math>\chi^2</math> test</b>	<b>Effect tested</b>
Contrast Level	854.265		
Null Model	878.975	$\chi^2(4) = 24.710, p < 0.001$	Contrast Level Effect

Experiment B - Likelihood ratio tests. Dependent variable: F0 excursion (Final position)

Fixed factors	-2 Log Likelihood	$\chi^2$ test	Effect tested
Contrast Level	367.964		
Null Model	371.151	$\chi^2(4) = 12.965, p = 0.527$	Contrast Level Effect

Experiment B - Likelihood ratio tests. Dependent variable: Intensity (Final position)

Fixed factors	-2 Log Likelihood	$\chi^2$ test	Effect tested
Contrast Level	-418.434		
Null Model	-407.339	$\chi^2(4) = 11.095, p = 0.0039$	Contrast Level Effect

Experiment B - Likelihood ratio tests. Dependent variable: Duration (Final position)