
Prosodic effects in the production of structural ambiguities: Do they exist?¹

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Abstract

The aim of the present study is to explore whether Greek adults, who are non-trained speakers and naïve to the purpose of the task, use distinguishable prosodic cues, while producing ambiguous sentences. We report on the findings from a production task conducted with 30 participants (15 females), which contained subject/object ambiguities. Results revealed that participants use prosodic cues to denote the subject or the object reading, but not consistently so in order to distinguish the two meanings. We argue that our findings are in line with the Syntax-Phonology mapping, according to which prosodic phrasing goes in tandem with syntactic segmentation, though prosodic phrasing was not consistently employed by our speakers to differentiate the two meanings of the ambiguous sentences.

Key words: language production, structural ambiguity, prosody

1. Introduction

The debate on whether naïve and non expert speakers insert disambiguating prosody into their ambiguous utterances is still ongoing. Research on the use of prosodic cues during sentence processing is often based on data from speech carefully prepared by phoneticians or phonologically trained speakers, like radio announcers and actors (Kang & Speer 2004; Clifton, Carlson & Frazier 2006; Price et al. 1991; Pynte 1996; Schafer et al. 1996; Schafer et al. 2000a) or even the use of synthesised stimuli (Kjelgaard & Speer 1999; Lee & Garnsey 2008).

However, the extracted results may be completely different if the speakers are untrained and/or naïve with respect to the purpose of the experiments and the existence of the ambiguous structures. For instance, Allbritton, McKoon & Ratcliff (1996) as well as Snedeker and Trueswell (2003), who conducted a reading task and a

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cooperative game-playing task respectively, concluded that participants provided informative prosodic cues, only if they were trained to do so, or if they realized that they needed to use prosody in order to succeed on the given task.

On the other hand, Millotte, Wales & Christophe (2007), who conducted a reading task consisting of ambiguous sentences, as well as Schafer et al. (2000b), Kraljic and Brennan (2005) and Speer, Warren & Schafer (2011), who also conducted cooperative game-playing tasks, found that even naïve speakers tended to produce prosodic phrasing in line with the syntactic constituents regardless of their addressees' needs. However, speech production in these studies is not necessarily natural, since the tasks involved reading a text and contributing to a game whose outcome depends on how clear the participants' productions are. In conclusion, it seems that the issue of whether naïve, untrained speakers automatically insert disambiguating prosody into their ambiguous utterances, is still far from settled.

The aim of the present study is to shed light on this issue, by investigating whether Greek speakers employ prosody to disambiguate subject/object ambiguities, such as:

- (1) ka'θos 'erave to ku'bi 'ylistrise sto 'patoma.
 while was-sewing-3SG the-NEUT.SG.NOM/ACC button-NEUT.SG.NOM/ACC slip-PAST.3SG on the floor
 While (s)he was sewing the button (she/he) slipped on the floor.

Additionally, we used Praat (Boersma & Weenink 2010) and the GRT0BI (Arvaniti & Baltazani 2000) for the description of the intonation pattern and the duration measurements, which provide strict scientific criteria for the data analysis. Furthermore, two theoretical accounts, *Syntax-Phonology (edge-based) mapping* and the *Phonological (binarity-driven) mapping*, related to the Syntax-Phonology interface are empirically tested. The *Syntax-Phonology (edge-based) mapping* dictates edges of syntactic constituents to be aligned with prosodic ones (Selkirk 1981, 1995; Truckenbrodt 1995, 1999; see Spyropoulos & Revithiadou 2009; Revithiadou & Spyropoulos 2011 for Greek), while the *Phonological (binarity-driven) mapping* operates on the basis of the prosodic size of constituents and requires the construction of binary-branched structures, namely of structures consisting of at least two Phonological words (PW) (Selkirk 2000, based on Itô & Mester 1992, 1995; Ghini 1993). Note here that functional elements, such as “ka'θos”, and their projections are not considered as PW (Truckenbrodt 1999). Thus, in the subject reading, the Syntax Phonology mapping, predicts the phrase accent, which marks the ending of the

phonological phrase, to be found before the ambiguous DP (accompanied in some cases by a second phrase accent just after the ambiguous DP- before the recursion), while the Phonological mapping predicts one phrase accent just after the ambiguous DP (2a). As for the object reading, both accounts predict a phrase accent after the ambiguous DP (2b).

(2a)	Comp. V₁	DP	V₂P DP	Subj. – reading
	[ka'θos 'erave]PPh	[to ku'bi]PPh	['epese sto 'patoma]PPh	S-P mapping
	[ka'θos 'erave]PPh	[to ku'bi	'epese sto 'patoma]PPh	S-P mapping
	[ka'θos 'erave	to ku'bi]PPh	['epese sto 'patoma]PPh	P mapping
(2b)	Comp. V₁	DP	V₂P DP	Obj. – reading
	[ka'θos 'erave	to ku'bi]PPh	['epese sto 'patoma]PPh	S-P mapping
	[ka'θos 'erave	to ku'bi]PPh	['epese sto 'patoma]PPh	P mapping

2. The present study

In this section, we describe the method adopted in this study and we present the findings obtained in detail.

2.1 Method

2.1.1 Participants

Thirty unimpaired adults, native speakers of Greek, participated in the second experiment (Table 1). None of them was a linguist, a trained speaker (i.e. radio producer, actor/actress) or a professional musician. Furthermore, none of them reported to have any neurological, learning or hearing problems. Half of the participants were females (age range: 18-35) and half were males (age range: 18-39). All of them have received 12 to 17 years of education. Participants took part in the experiment voluntarily.

Participants	N	Years of age	Years of education
Females	15	26.8 (3.32)	16 (2.12)
Males	15	27 (5.54)	15 (1.78)

Table 1. Profile of the participants (SDs in parenthesis)

2.1.2 Materials

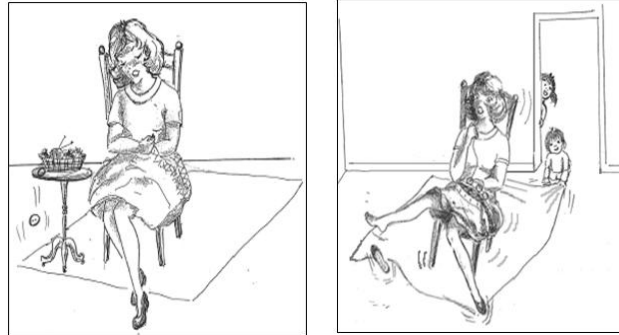
The experimental items consisted of 12 totally ambiguous sentences. The ambiguity of these sentences resulted from the argument structure of the embedded verb and the syntactic role of the following DP. More specifically, the embedded verb was an optionally transitive verb and the following DP was a singular noun in neuter gender and, thus, it was ambiguous regarding its syntactic function as subject or object, since neuter nouns in Greek are identical in nominative and accusative cases. For example, the globally ambiguous sentence in (3a) has a twofold meaning: either the person who was sewing the button is the one who falls or alternatively the button is the one that falls. For each of the ambiguous sentences, two pictures were created, so that each picture depicted one possible interpretation of the sentence. Thus, the experimental items consisted of 12 ambiguous sentences and 24 pictures.

Furthermore, two unambiguous sentences were constructed for each of the 12 experimental sentences, thus in total 24 unambiguous sentences, accompanied by an equivalent number of pictures, which served as fillers. These sentences had a similar structure with the experimental items, but differed in that the ambiguity was resolved via the case of the DP, which was morphologically marked for nominative or accusative case. For example, in sentence (3b), the DP is marked for nominative case and, hence, it is analyzed as the subject of the main verb. On the other hand, in (3c) the DP is marked for accusative case and, thus, it is construed as the object of the subordinate verb. These sentences were included in the study for control purposes; namely, the baseline prosodic patterns for the subject and the object reading were extracted from these sentences.

Lastly, we constructed an additional ambiguous filler sentence for each of the 12 experimental items. In these sentences the DP could be interpreted either as the object of the subordinate verb or the subject of the main verb (3d), as also illustrated on the accompanied pictures. To put it differently, these sentences allowed for only one interpretation but two structural representations (object vs subject reading). This type of fillers intended to provide data that would indicate a possible preference for the object or the subject interpretation. The ambiguous filler sentences and their accompanied pictures were twelve.

- (3a) Optionally transitive verb; subject / object reading (experimental item).

ka'θos 'erave to ku'bi 'γlistrise sto 'patoma.
 while was-sewing_{-3SG} the_{-NEUT.SG.NOM/ACC} button_{-NEUT.SG.NOM/ACC} slip_{-PAST.3SG} on the floor
 While (s)he was sewing the button (she/he) slipped on the floor.



- (3b) Optionally transitive verb & DP in nominative; subject reading (filler)

ka'θos 'erave i 'fusta 'γlistrise sto 'patoma
 while was-sewing_{-3SG} the_{-FEM.SG.NOM} skirt_{-FEM.SG.NOM} slip_{-PAST.3SG} on the floor
 While (s)he was sewing the skirt slipped on the floor.



- (3c) Optionally transitive verb & DP in accusative; object reading (filler)

ka'θos 'erave ti 'fusta 'γlistrise sto 'patoma
 while was-sewing_{-3SG} the_{-FEM.SG.ACC} skirt_{-FEM.SG.ACC} slip_{-PAST.3SG} on the floor
 While (s)he was sewing the skirt (she/he) slipped on the floor.



(3d) Optionally transitive verb; subject / object reading (filler).

ka'thos 'eravan to nifi'ko
 while was-sewing_{-3SG} the_{-NEUT.SG.NOM/ACC} wedding dress_{-NEUT.SG.NOM/ACC}
 'ylistrise sto 'patoma
 slip_{-PAST.3SG} on the floor

While they were sewing the wedding dress (the wedding dress) slipped on the floor.



The in total 48 sentences (12 experimental sentences and 36 fillers) and the 60 pictures (24 pictures for the experimental sentences and 36 for the fillers) were presented to participants by means of the PowerPoint software. Materials were divided into two presentations, each consisting of 12 experimental sentences accompanied with pictures depicting one of their two possible readings and 18 filler sentences accompanied with their corresponding pictures. The experiment was divided into two sessions (one for each presentation), which participants undertook with a period of at least 4 days between them. All participants were shown both presentations.

2.1.3 Procedure

Participants were informed they were going to be presented with sentences, each one accompanied by two pictures. They were instructed to read each of the sentences carefully and silently and to try to understand and memorize it. Then they were informed that, after observing carefully the two pictures, they would have to point out the picture they believed was being described by the sentence. After their selection, only the correct picture would remain on the screen, in order to help them remember the sentence, which they would have to produce aloud.

Sentences were presented to participants in a pseudo randomized order, without having any commas. Above each sentence there were two pictures, one of them

illustrated one of the two possible sentence meanings and the other was irrelevant to the description of the sentence. This procedure was followed in order to ensure that participants would pay attention to the pictures. As mentioned earlier, participants were never presented with the two experimental pictures in the same session.

Participants' productions were recorded using the recorder Marantz (PMD661) and an external condenser microphone (RODE M3). In cases in which participants pointed out the wrong picture, presentation was continued by the next pair of pictures. Each session lasted around 15 to 20 minutes depending on the time participants needed to read, understand, memorize and produce the sentences.

2.2 Results

2.2.1 Intonation analysis

Unambiguous Fillers

We first report on the results from the investigation of the prosodic cues used by participants, while producing the unambiguous filler items. This analysis will provide the baseline prosodic patterns for the subject and the object interpretation. The remaining items, ambiguous fillers and experimental sentences, will be evaluated according to these baseline patterns.

The results of the subject condition revealed that the most common intonation pattern attested was characterized by the production of a phrase accent just after the embedded verb (97.4%) which, in some cases, was followed by a second phrase accent just after the DP (2.6%). These results are consistent with the Syntax-Phonology mapping.

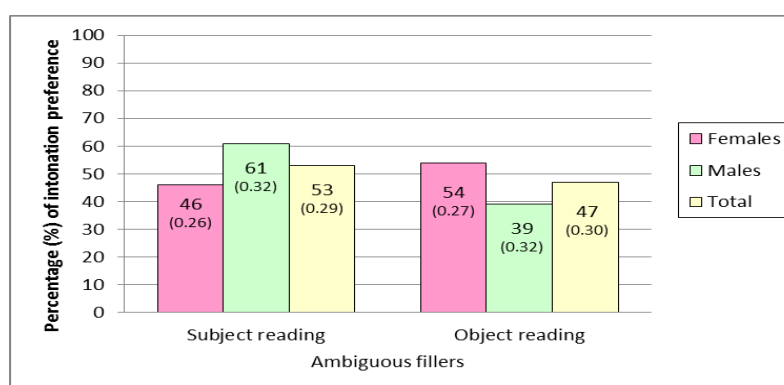
As for the unambiguous sentences in which the DP was the object of the subordinate verb the results revealed that in most of the cases (98%) the intonation pattern was characterized by the presence of a phrase accent just after the DP.

Thus, the overall results of the unambiguous fillers revealed that participants used different intonation patterns in order to denote the subject or the object reading, based on the syntactic structure of the sentences. Therefore, their productions were consistent with the Syntax-Phonology mapping.

Ambiguous Fillers

Since participants used different patterns in order to distinguish the two interpretations, it is interesting to explore which of the two intonation patterns they

use in sentences in which the object of the subordinate verb is also the subject of the main verb. Participants' utterances were judged according to the Syntax-Phonology mapping, since this mapping was in line with their unambiguous utterances. More specifically, utterances having a phrase accent just after the embedded verb (in some cases followed by a second phrase accent just after the DP) were considered to be in line with the subject reading, whereas utterances having a phrase accent just after the DP were considered as being in line with the object reading condition. The participants' preferences for the subject and the object reading are illustrated in the following Graph.



Graph 1. Preference (%) towards the subject or the object intonation phrasing per group for the condition of the ambiguous fillers

Before the main statistical analysis, a Shapiro-Wilk Test² was conducted in order to check whether the distribution of the sample is normal. The tested variables were the utterances produced by the male and the female participants with intonation favouring the subject or the object reading. The results revealed that the data were normally distributed (Females: subject reading: $p=.444$; object reading: $p=.342$, Males: subject reading: $p=.116$; object reading: $p=.116$).

Thus, the statistical analysis adopted was a 2 (Gender: female vs male) x 2 (Intonation: subject vs object) ANOVA, with Gender as the between-subject and Intonation as the within-subject variables. The results showed no significant effect of Intonation either in the subject ($F_{1(1,28)} = .427$, $p=.519$) or the object analysis ($F_{2(1,20)} = .978$, $p=.335$) and no significant effect of Gender in either of the two analyses (F_1

² The Shapiro-Wilk Test was conducted before every analysis to be reported in order to check the normality of the variables. If the data were normally distributed, the analysis run was a parametric one. In the opposite case, the analysis conducted was a non-parametric one. Due to space limitations, we will not refer to the exact results of the Shapiro-Wilk Test again throughout this paper.

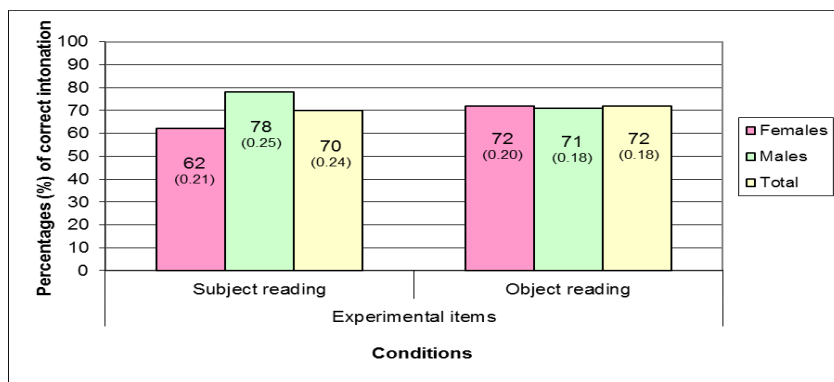
(1,28) = 1.000, $p=.326$; $F_2(1,20) = 1.000$, $p=.329$). As for the relation between the two variables, there was no interaction in the participant analysis ($F_1(1,28) = 1.784$, $p=.192$), but there was a marginally significant interaction of Intonation and Gender in the item analysis ($F_2(1,20) = 4.084$, $p=.057$).

A further analysis was run in order to examine the direction of this (marginal) interaction. Within group comparisons, using Paired Samples T-tests, showed no significant difference between the two intonation patterns in the subject analysis for either group (Females: $t_1(14)=.535$, $p=.601$, two-tailed; Males: $t_1(14)=1.292$, $p=.217$, two-tailed). As for the item analysis, it presented no significant differences for the group of females ($t_2(10)=.590$, $p=.568$, two-tailed), but a statistically significant difference between the two intonation patterns for the group of males ($t_2(10)=3.103$, $p=.011$, two-tailed), indicating a preference for the subject intonation pattern.

Thus, the results from the fillers revealed that the participants of the present study used different intonation patterns in their unambiguous utterances, in order to mark the subject or the object reading. As for the ambiguous filler items, results revealed that, even though the female group revealed no preference towards the subject or the object reading, the male group showed a statically significant preference towards the subject reading.

Experimental items

There were 32 cases which were excluded from any further analysis, since participants indicated the wrong picture. The accuracy percentages for each condition and each group are depicted in Graph 2.



Graph 2. Correct usage (%) of intonation patterns per group and condition

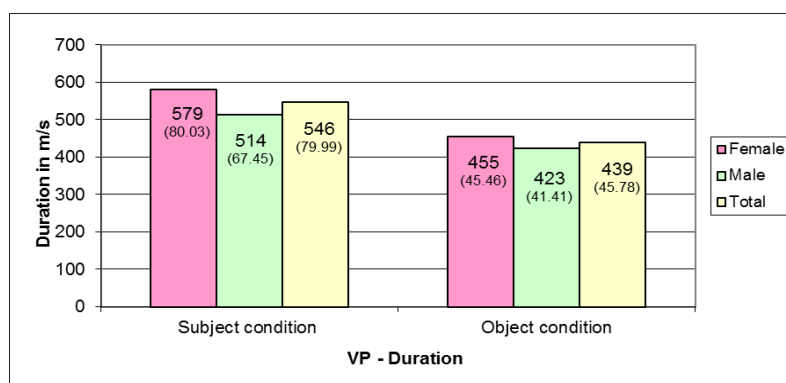
A 2 (Gender: female vs male) x 2 (Intonation: subject vs object) ANOVA was conducted, which revealed no main effect of Intonation in either the subject ($F_1(1, 28) = .108, p=.745$) or the item analysis ($F_2(1,22) = .002, p=.964$). Moreover, no significant interaction of Gender and Condition was found either in the subject ($F_1(1, 28) = .106, p=.124$), or in the item analysis ($F_2(1,22) = 1.890, p=.183$). Lastly, as for the variable of Gender, there was no significant effect, again either in the subject ($F_1(1, 28) = 1.982, p=.170$), or in the item analysis ($F_2(1,22) = 2.654, p=.118$).

2.2.2 Duration measurements

The durations of the embedded verb, the ambiguous DP and the pauses before and/or after the ambiguous DP, if they existed, were measured for each of the 720 totally ambiguous utterances. Duration measurements were conducted only for the experimental items, as only these sentences were comparable. According to the phrase-final lengthening proposal, when a word appears at the end of a phrase, it tends to have longer duration than in any other phrasal position. Thus, the embedded verb is expected to have longer duration in the subject condition, compared to the object one, whereas the duration of the DP is expected to be longer in the object than in the subject condition. This difference could be more pronounced in the embedded verb compared to the DP, since there are 19 cases, in the subject condition, which, although they are in line with the subject reading, have two phrase accents. Thus, in these cases, the DP in the subject condition may have duration as long as the DP of the object condition, since both of them are at the end of a phonological phrase.

Duration of the VP

The duration of the VP per condition and group is depicted in the following Graph.

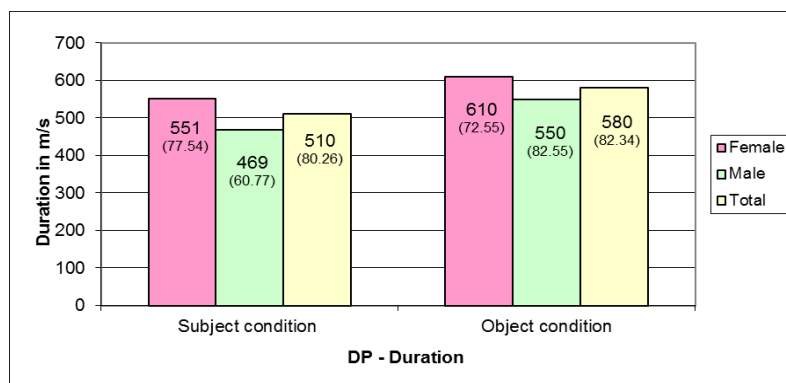


Graph 3. Means (and standard deviations) of the VP-duration of the correct utterances per group and per condition

As the data in Graph 3 indicate, the female group used longer duration of the VP (579 m/s (SD= 80.03)) in their utterances which were in line with the subject reading, compared to the duration of the embedded verb in productions which were in line with the object reading (455 m/s (SD= 45.46)). Similarly, men spent more time to produce the embedded verb in the subject condition (514 m/s (SD=67.45)) than in the object condition (423 m/s (SD= 41.41)). Thus, overall the VP had longer duration in the subject (546 m/s (SD= 79.99)) than in the object condition (439 m/s (SD= 45.78)). A 2x2 ANOVA (Gender x Condition) demonstrated a significant effect of Condition in both the participant ($F_1(1,28) = 66.623, p = .000$) and the item analysis ($F_2(1,22) = 154.088, p = .000$), no interaction between Condition and Gender in either analyses ($F_1(1,28) = 1.584, p = .219$; $F_2(1,22) = .892, p = .355$) and a significant main effect of Gender in the participants ($F_1(1,28) = 7.526, p = .010$), but not in the item analysis ($F_2(1,22) = 1.587, p = .221$). Thus, women used statistically significantly longer VPs compared to men for both the subject and the object conditions. Furthermore, both men and women produced longer VPs in the subject condition compared to that of the object condition.

Duration of the DP

The mean durations of the DP following the embedded verb per condition and group are presented in Graph 4.



Graph 4. Means (and standard deviations) of the DP-duration of the correct utterances per group and per condition

As the data in Graph 4 illustrate, the productions of the DP were longer in the object reading (580 m/s (SD= 82.34)), compared to those in the subject reading (510 m/s (SD= 80.26)). The same pattern is attested in both the females and the males.

In order to explore whether these differences are significant, we ran a 2x2 ANOVA (Gender x Condition). The results revealed a significant effect of Condition in both

the subject and the item analysis ($F_1(1,28) = 30.101, p = .000$; $F_2(1,22) = 147.985, p = .000$), no interaction between Condition and Gender in either analyses ($F_1(1,28) = .730, p = .400$; $F_2(1,22) = .041, p = .841$) and a main effect of Gender in the participant ($F_1(1,28) = 9.080, p = .005$) but not in the item analysis ($F_2(1,22) = 3.785, p = .065$). Thus, both groups produced statistically significantly longer DPs in the object than in the subject condition. Moreover, the male group produced shorter DPs compared to the female one, in both the subject and the object conditions.

However, this difference is not as distinctive as that attested in the duration of the VP. Namely, the duration difference between the two readings is 70 ms in the case of the DP, while the duration difference between the two readings increases to 107 ms in the case of the VP. As has already been mentioned, this divergence could be attributed to the fact that there are 19 cases in which participants, especially women (14 cases), used two phrase accents, one before and one just after the ambiguous DP, when uttering sentences in line with the subject reading. Thus, the position of a phrase accent just after the DP in the subject condition results in long DPs, potentially as long as those in the object condition which are always followed by a phrase accent.

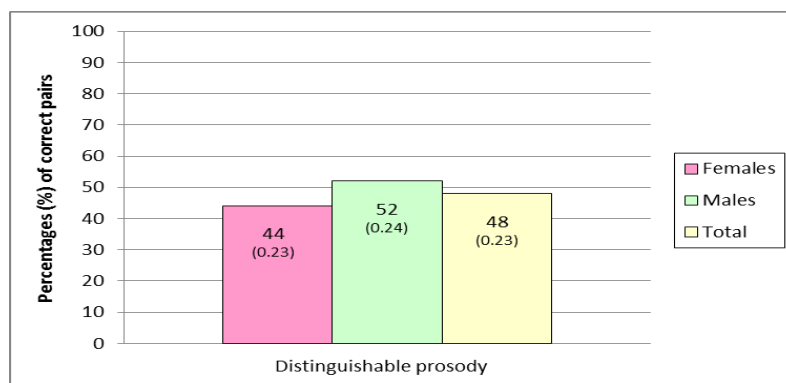
Thus, the duration of the embedded verb and the DP in the subject and the object condition is in line with the intonation patterns. Furthermore, the group of females tended to produce longer phrases compared to the males.

2.3 Distinguishable prosody

The prosodic analysis revealed that participants used different prosodic cues in order to mark the object reading (72%) and different ones while producing sentences in line with the subject reading (70%). However, a further aim of this study is to investigate whether the participants consistently use distinguishable prosody in order to help listeners to disambiguate the two meanings.

Thus, we proceeded to an analysis in which we maintained only the pairs of sentences in which participants used the proper prosodic cues in each member of the experimental pairs; this strategy indicates the participants' intention to distinguish between the two meanings. Therefore, pairs containing one wrong picture choice and a correct use of prosody were excluded from any further analysis, while pairs of sentences which contained at least one sentence produced with the opposite prosodic cues from the expected ones were marked as being wrong.

The descriptive statistics revealed that both groups used distinguishable prosody on the amount of 48%. More specifically, females used the prosodic cues to facilitate the perception of the two different meanings on the amount of 44%, while males on the amount of 52% (Graph 5).



Graph 5. Means (and standard deviations) of pairs of sentences produced with distinguishable prosody

We performed a one-way ANOVA on the data to examine whether the male group differs from the female group. The results demonstrated no statistically significant difference between the two groups in the participant ($F_1(1,28) = .871, p = .359$) or in the item analysis ($F_2(1,22) = 1.163, p = .292$). Therefore, both females and males used distinguishable prosody only on the amount of 48%, which is at chance level. Thus, our data suggest that speakers do not consistently use prosodic cues in order to disambiguate between the two interpretations of structural ambiguities.

3. Discussion - Conclusion

The overall findings from both the accuracy scores and the duration measurements demonstrated that native speakers of Greek impose different intonation patterns on their subject or object utterances, while producing totally ambiguous sentences. However, the participants did not consistently employ prosodic cues to differentiate between the two meanings of the ambiguous constructions.

More specifically, the findings from the unambiguous fillers and the participants' accuracy scores on the experimental items prioritize the Syntax – Phonology mapping, since the participants' prosodic phrasing was in line with the syntactic phrasing. These findings can be considered as being in agreement with the results

presented by Schafer et al. (2000b), Kraljic and Brennan (2005) and Millotte et al. (2007), according to which speakers use prosody to mark the different conditions.

As for the two groups of the present experiment, they exhibited two main differences; females used longer duration of the words just before the phrase accent, while men performed better on the subject condition. Women's tendency to lengthen the duration of the word and the vowels or the consonants prior the end of the phonological phrase has been attested in previous studies (Hillenbrand et al. 1995; Fitzsimons, Sheahan & Staunton 2001). It seems that women, on contrary to men who only use the intonation pattern, they also use the duration, in order to clarify these types of linguistic boundaries (Elyan 1978; Wu & Childers 1991; Whiteside 1996). Thus, as Whiteside (1996) suggests, this might be the reason why men are considered to speak more quickly.

On the other hand, the females' preference towards the object reading can be related to frequency issues on one hand and to developmental differences between the genders on the other. As it was demonstrated in the introduction part there are two main accounts referring to the way ambiguous sentences like the ones used in the present study will be produced. As it can be easily noticed the most common pattern of these two accounts is the phrase accent to be placed just after the ambiguous DP, whereas the pattern in which the phrase accent is placed before the ambiguous DP is only predicted by the Syntax-Phonology mapping and only for the subject reading.

Furthermore, according to developmental studies (Portwood 2000) females have better language capabilities, whereas men have better visual/spatial abilities. Thus, in an experiment, like the one presented above, which requires both linguistic and visual/spatial abilities (in order to identify the correct picture), the two genders used divergent processing routines. More specifically, it seems that females, although they chose the correct picture, they were mostly based on their language skills and thus produced the utterances by adopting the most common strategy. On the other hand, men, who are freer from language biases, they used their visual/spatial abilities by focusing on the given pictures of the present experiment and by producing utterances in line with the subject reading.

However, although speakers do use different prosodic patterns to produce the two different conditions, the data revealed that they do not consistently use prosodic cues in order to disambiguate their utterances. It seems that, in general, speakers rely more

on the linguistic context or on pragmatics and not on the use of prosody in order to help listeners understand the intended meaning. Thus, our findings are in line with studies claiming that distinguishable prosodic cues are not consistently apparent in speakers who are not trained, not aware of the ambiguity of their utterances or not instructed to use prosody (Allbritton et al. 1996; Tree & Meijer 2000; Snedeker & Trueswell 2003).

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