LEXICAL EFFECTS IN SENTENCE PROCESSING: EVIDENCE FROM MODIFIER ATTACHMENT IN GREEK

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Περίληψη
Στόχος της εργασίας αυτής είναι η εξέταση των προβλέψεων της θεωρίας Construal (Frazier & Clifton, 1996), κατά τη συντακτική επεξεργασία αμφίσημων αναφορικών προτάσεων. Σύμφωνα με αυτό το μοντέλο προτασιακής επεξεργασίας, οι μη-πρωταρχικές φράσεις, όπως είναι οι αναφορικές προτάσεις, συνδέονται με το θεματικό πεδίο που ο επεξεργαστής ανέλυσε τελευταία. Στο άρθρο αυτό παρουσιάζουμε τα αποτελέσματα από δύο πειράματα, ένα ερωτηματολόγιο και ένα πείραμα μέτρησης των χρόνων ανάγνωσης, με φυσικούς ομιλητές της Ελληνικής, στα οποία διερευνήθηκαν οι προτιμήσεις προσάρτησης αναφορικών προτάσεων, όταν προηγείται μία σύνθετη ΟΦ του τύπου: ΟΦ1 - Προθ - ΟΦ2. Εξετάστηκαν οι προτιμήσεις αυτές όταν η κεφαλή της ΠΦ ήταν η πρόθεση *με* ή μια από τις δύο τοπικές προθέσεις, *δίπλα σε* και *κοντά σε*. Τα αποτελέσματα του ερωτηματολογίου έδειξαν ότι υπάρχει μία προτίμηση σύνδεσης της αναφορικής με την ΟΦ2 και, έτσι, επαλήθευσαν τις προβλέψεις της θεωρίας Construal. Ωστόσο, τα αποτελέσματα από το πείραμα μέτρησης των χρόνων ανάγνωσης σε παρόμοιες προτάσεις έδειξαν διαφορετικές προτιμήσεις για τις σύνθετες ΟΦ με την πρόθεση *με* και τις τοπικές προθέσεις. Οι διαφορετικές προτιμήσεις προσάρτησης των αναφορικών προτάσεων με τα δύο είδη προθέσεων ήταν εμφανείς, ακόμη και στις αναλύσεις στις οποίες ελέγχθηκαν τυχόν σημασιολογικές διαφορές ανάμεσα στις δύο προθέσεις. Τα αποτελέσματά μας δείχνουν ότι οι θεματικές πληροφορίες δεν είναι ο μόνος παράγοντας που καθορίζει τις προτιμήσεις προσάρτησης αναφορικών προτάσεων και προτείνουμε ότι προσωδιακοί παράγοντες μπορεί να αλληλεπιδρούν με τις θεματικές πληροφορίες και να επηρεάζουν τις προτιμήσεις αυτές.

Keywords
sentence processing, structural ambiguity, construal, relative clauses

1.   Introduction

In sentence processing research many studies have been conducted on the processing of structurally ambiguous sentences, as the way people resolve syntactic ambiguities can give us insight into the nature of the human sentence processing mechanism.

One ambiguity that has recently received a lot of attention is the relative clause (RC) attachment ambiguity, which is illustrated in (1) below:

(1)   The woman saw the psychiatrist of the actress who was having a glass of wine.

In (1), the RC *who was having a glass of wine* is preceded by a complex NP, *the psychiatrist of the actress* and, therefore, can be attached either to the first NP, *the psychiatrist*, or to the second one, *the actress*. Studies conducted in a variety of different languages have shown that some languages, like English

(Cuetos & Mitchell, 1988; Frazier, & Clifton, 1996; Gilboy, & Sopena, Clifton & Frazier, 1995), Norwegian and Swedish (Ehrlich, Fernandez, Fodor, Stenshoel & Vinereanu, 1999), exhibit an NP2-attachment preference, whereas languages like Spanish (Cuetos & Mitchell, 1988; Carreiras & Clifton, 1993; 1999; Gilboy et al., 1995), German (Hemforth, Konieczny, Scheepers & Strube, 1998), French (Frenck-Mestre & Pynte, 2000; Zagar, Pynte & Rativeau, 1997) and Greek (Papadopoulou, 2001; Papadopoulou & Clahsen, 2003) display an NP1-attachment preference.

However, when the second NP is headed by a lexical preposition, like *with* in (2) below, an NP2-attachment preference is yielded even with languages that prefer to attach the RC to the first NP in sentences such as (1) (DeVincenzi & Job, 1993; 1996; Frenck-Mestre & Pynte, 2000; Gilboy et al., 1995; Traxler, Pickering & Clifton, 1998 among others):

(2)   The woman saw the psychiatrist with the actress who was having a glass of wine]

One parsing model that captures the divergent attachment preferences in (1) and (2) is *Construal* (Frazier & Clifton, 1996). According to *Construal*, non-primary phrases, like RCs, are attached within the last processed thematic domain. In sentences like (2), the last processed thematic domain is the one instantiated by the lexical preposition *with* and, hence, the RC will be preferentially attached to the second NP, *the actress*. On the other hand, in (1) the last processed thematic domain incorporates both NPs, as *of* is a functional preposition and does not assign a theta-role to the following NP. Therefore, *Construal* predicts that an NP2-attachment preference should be obtained with all lexical prepositions across different languages.

This was borne out by the data thus far. However, most of the studies that have investigated RC-attachment preferences in complex NPs incorporating lexical prepositions have tested only the preposition *with*. Only two studies have included other types of lexical prepositions in their material. In an attachment judgement off-line questionnaire, Mendelsohn & Pearlmutter (1999) found an NP2-attachment preference for sentences like (2), but a preference for neither attachment site in sentences in which a locative preposition linked the two NPs. In addition, Gibson, Pearlmutter, Canseco-Gonzalez & Hickock (1996) investigated RC attachment preferences when the RC is preceded by three possible attachment sites by using an on-line grammaticality judgement task. The three NPs were linked either by a functional or by various lexical prepositions. The results showed that native speakers of both English and Spanish preferred to attach the RC to the third NP. However, the second favorable attachment site was the first NP, which demonstrates that the NPs outside the last processed thematic domain were still available to host the RC.

The purpose of the present study is to investigate RC attachment preferences when the complex NP incorporates various kinds of lexical prepositions, in order to test the predictions of the *Construal* hypothesis. Recall that *Construal* predicts an NP2- attachment preference with all kinds of lexical prepositions. We will report the results from a questionnaire and a self-paced reading task carried out with native speakers of Greek.

2.   Off-line task: attachment judgement questionnaire

2.1.   Method

Materials

Our critical sentences consisted of 19 globally ambiguous sentences, in which a subject-RC was preceded by a complex NP. Inside the complex NP, the second NP was headed either by the preposition *με* (= with), or by the locative prepositions *κοντά σε* (= near) and *δίπλα σε* (= next to), as shown in (3) below:

(3)   Ένας κύριος κοίταξε τον μαθητευόμενο με / κοντά στον / δίπλα στον μηχανικό που είχε πάει στην αυλή για διάλειμμα
"A man saw the apprentice with / near / next to / the engineer who had gone to the yard for a break."

The nouns used inside the complex NP were always animate, marked for masculine gender and they denoted professions.

In addition, 25 fillers were included in order to divert the subjects' attention from the nature of the task. That gave a total of 44 sentences.

Procedure

The 44 sentences were typed in paper and each of them was followed by a question that could be answered by choosing between the two alternatives. For the critical sentences, the question concerned the attachment of the RC and the subjects had to choose one of the two possible attachment sites, as shown in (4) below:

(4)   Ποιος είχε πάει στην αυλή για διάλειμμα;
a. ο μηχανικός   b. ο μαθητευόμενος
"Who went to the yard for a break?
a. the engineer   b. the apprentice"

In half of the critical sentences the first NP was presented first and for the other half it was the second one that was presented first. The subjects were asked to read the sentences as quickly and as carefully as possible and to circle the option that better answered the questions. The whole experiment lasted about half an hour.

Subjects

28 native speakers of Greek participated in this experiment. They were all naive with respect to the purpose of the experiment.

2.2. Results

The table below describes the percentages for NP1 and NP2 responses for each one of the following three conditions:

Table 1. *Percentages for NP1 and NP2 responses for each preposition*

	Me	Dhipla se	Konda se
NP1	22	27	24
NP2	78	73	76

Paired-samples t-tests for each preposition showed that there were significantly more low attachment than high attachment responses across the board (με: $t1(27) = 5.605$, $p<0.01$; $t2(18) = 6.553$, $p<0.001$; δίπλα σε: $t1(27) = 3.855$, $p<0.01$; $t2(18) = 8.231$, $p<0.001$; κοντά σε: $t1(27) = 5.351$, $p<0.001$; $t2(18) = 5.942$, $p<0.001$).

A clear NP2-attachment preference was obtained across different lexical prepositions. This finding supports the predictions of the *Construal* theory.

3. On-line task: self-paced reading task

3.1. Method

Materials

24 critical sentences were used in the self-paced reading task, fifteen of which were similar to those of the off-line experiment. In contrast to the sentences in the off-line task, here the sentences were ambiguous until the auxiliary of the RC. The ambiguity was resolved via number information on the auxiliary resulting in either NP1- or NP2-attachment, as shown in (5) below:

(5)   Ένας κύριος κοίταξε / τον μαθητευόμενο με (κοντά στον / δίπλα στους) τους μηχανικούς / που / είχε(αν) / πάει στην αυλή για διάλειμμα.
"A man looked-at / the apprentices with (near / next to) the engineers / that / had-**3sg(3pl)** / gone to the yard for a break."]

That resulted in 6 conditions. In half of the sentences the first noun was in the singular, whereas in the other half the second one was in the singular. 96 filler sentences were included to prevent the subjects from forming any strategical responses.

Procedure

The sentences were presented via the non-cumulative moving window technique in a phrase-by-phrase fashion. More specifically, the sentences were divided into five segments, as indicated in (5) through the slashes. Subjects had to read each segment and press a button, which triggered the

appearance of the next segment, while the previous one disappeared. At the end of all the critical sentences and half of the fillers there was a yes/no comprehension question.

Subjects

The same subjects who participated in the off-line task also took part in the on-line task.

3.2. Results

In this paper, we will only report the results from the critical segment, that is the auxiliary verb of the RC, where the ambiguity is resolved (the fourth segment). The mean RTs in milliseconds are shown in the following table:

Table 2. *Mean RTs for NP1- and NP2-attachment for each preposition - Segment 4*

	Me	**Dhipla se**	**Konda se**
NP1	501	403	397
NP2	397	382	369

A Repeated-measures two-way ANOVA was performed on the data with "Attachment" and "Preposition" as the within-subjects factors. Both the "Preposition" ($F_1(2,26) = 4.739$, $p<0.02$; $F_2(2,22) = 9.590$, $p<0.01$) and the "Attachment" ($F_1(1,27) = 7.118$, $p<0.02$; $F_2(1,23) = 5.150$, $p<0.04$) effects were significant. This shows that the sentences disambiguated towards the second NP were read faster than those disambiguated towards the first noun. Moreover, the sentences with the preposition $\mu\varepsilon$ were read slower than those with the locative prepositions. Furthermore, paired samples t-tests for each preposition type revealed that the sentences with forced NP1-attachment were read significantly slower only in the $\mu\varepsilon$-condition ($t_1(27) = 2.723$, $p <0.02$; $t_2(23) = 2.240$, $p <0.04$), whereas the difference between NP1- and NP2-attachment did not reach significance in the conditions involving locative prepositions.

3.3. Discussion

The findings from the on-line task indicate that in the conditions where the second NP was headed by a locative preposition the first NP was still available to host the RC. This contradicts the predictions of *Construal.*

If thematic information does not determine RC attachment preferences, which is the factor that resulted in divergent results for the two types of lexical prepositions? One possibility could be the difference in the semantics of the prepositions. *Δίπλα σε* and *κοντά σε* are local prepositions whereas $\mu\varepsilon$ is not. In what way do the semantics of these prepositions differ and how could this influence attachment preferences?

The preposition $\mu\varepsilon$ differs from locative prepositions in that it can also have a comitative reading. In this reading, $\mu\varepsilon$ is a relator joining X and Y, where X is a participant that accompanies or

associates with Y (Lehmann & Shin, 2000). In the sentences used in our experiment, when the two NPs were connected with the preposition *με* and the auxiliary was in the plural, as shown in example (6) below, the RC could attach either to the NP that agreed with the auxiliary in number (i.e. the engineers) or to the conjoined NP (i.e. the apprentice and the engineers).

> (6) Ένας κύριος κοίταξε τον μαθητευόμενο με τους μηχανικούς που **είχαν** πάει στην αυλή για διάλειμμα.
> "A man saw the apprentice with the engineers who had gone to the yard for a break."

In the joint interpretation, both the apprentice and the engineers had gone to the yard for a break. This joint interpretation is not available when the two NPs are connected with a locative preposition.

In order to test whether a joint interpretation was indeed imposed on the complex NPs with the preposition *με* (but also with the locative prepositions), we distributed a plausibility test.

4.   Plausibility test

The plausibility test consisted of the same 24 sentences used in the on-line task. In half of the sentences the ambiguity was resolved towards the first noun, whereas in the other half, it was resolved towards the second noun. The subjects were presented with two possible interpretations of the sentences: one in which the RC was attached to the NP that agreed with the auxiliary verb in number (that is either the first or the second NP) and the other one in which the RC was attached to the entire complex NP:

> (7) *Ο διευθυντής κοιτάζει* **τους μαθητευόμενους με τον μηχανικό** *που* **έχουν** *πάει στην αυλή για διάλειμμα.*
> a.   Οι μαθητευόμενοι έχουν πάει στην αυλή για διάλειμμα.
> b.   Οι μαθητευόμενοι και ο μηχανικός έχουν πάει στην αυλή για διάλειμμα.
> "The director looks at **the apprentices with the engineer** who **have** gone to the yard for a break.
> a.   The apprentices have gone to the yard for a break.
> b.   The apprentices and the engineer have gone to the yard for a break."

The subjects were asked to read the sentences carefully and then to rate the plausibility of each possible interpretation on a scale from 0% to 100%, 0 being not at all plausible and 100 totally plausible. Twenty native speakers of Greek performed the task.

The results showed that the subjects indeed had considered the joint interpretation as highly possible, particularly for the preposition *με*, as the table illustrates:

Table 3. *Mean plausibility percentages for the joint interpretation.*

Me	Konda se	Dhipla se
77,03%	47,89%	46,56%

The findings from the plausibility task suggest that the divergent attachment preferences between the preposition *με* and the locative prepositions may have resulted from the difference in the semantics of the prepositions - the joint interpretation was more plausible with the preposition *με* than with the local prepositions. In order to further explore this, we performed separate statistical analyses for the sentences in which the auxiliary was in the plural (and hence, the joint interpretation was feasible) and for the sentences in which the auxiliary was in the singular (and hence, the joint interpretation was not possible). In the following section, we report the results from those two analyses.

5. Auxiliary in the plural versus in the singular

When the auxiliary was in the plural, the two-way ANOVA with "Attachment" and "Preposition" as within-subjects factors showed no significant main effects or interactions.

On the other hand, when the auxiliary was in the singular, both main effects of "Attachment" $(F_1(1,27) = 9.900; p < 0.01)$ and "Preposition" $(F_1(1,27) = 10.794; p < 0.01)$ were significant, which shows that the sentences with forced NP2-attachment were read faster than the sentences with forced NP1-attachment and that that the sentences containing the preposition *με* were read slower than those containing locative prepositions. Furthermore, the interaction between "Attachment" and "Preposition" $(F_1(1,27) = 6.459; p < 0.02)$ was also significant, which indicates that the prepositions used yielded different RC attachment patterns. Paired samples t-tests revealed that the sentences with forced NP1- and NP2-attachment differed significantly only in the *με*-condition $(t_1(27) = 3.043; p < 0.01)$, whereas they did not differ in the conditions involving locative prepositions.

Given that the difference in the patterns of RC attachment between the preposition *με* and the locative prepositions remained when we excluded the joined interpretation (auxiliary in the singular), this difference cannot have resulted from the difference in the semantics of the prepositions. In what follows, we offer a plausible explanation for our data, though we are still in the process of investigating this issue further and, thus, our proposal should be taken as tentative.

6. Implicit Prosody Hypothesis (Fodor, 1998; 2002)

Recently, Fodor (1998, 2002) has proposed that parsing preferences are affected by the prosodic phrasing of the sentences. She suggested that even in silent reading native speakers of a certain language impose the prosodic phrasing on the sentences they read. Bradley, Fernandez & Lovric (2003) and Jun (2003) tested this hypothesis in sentences with RC attachment ambiguities and found

that a pause between the complex NP and the RC leads to an NP1-attachment preference, whereas, when there is no pause between the complex NP and the RC, an NP2-attachment preference is obtained.

Within this account, the sentences with the preposition *με* should not have a pause between the complex NP and the RC, as this preposition is light, it is not stressed and it is cliticised onto the following NP. This might have biased the subjects towards an NP2-attachment preference. In addition, thematic cues also bias for the attachment to the most recent NP, and so the influence of both factors is likely to have resulted in the robust NP2-attachment preference with the preposition *με*. On the other hand, the locative prepositions used were complex prepositions, trisyllabic and stressed. Due to the length and stress pattern, subjects may have introduced a pause between the complex NP and the RC, which in turn, may have biased towards NP1 attachment. However, another factor may have interacted with this one. As the first NP was outside the last processed thematic domain, this may have biased towards NP2-attachment. These two factors may have cancelled each other out and resulted in no clear attachment preference.

We are currently investigating the viability of our explanation by conducting experiments in which the subjects orally produce sentences that are similar to those examined in this study and are forced either towards NP1- or NP2-attachment. Analysis of the pauses introduced can reveal whether the difference in the attachment preferences between *με* and local prepositions we found in our on-line task are the result of different prosodic phrasing.

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