THE INTERACTION OF MULTIPLE CONSTRAINTS FOR THE INTERPRETATION OF CLITICS

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Περίληψη

Παρουσιάζουμε τα αποτελέσματα δυο πειραμάτων, όπου οι συμμετέχοντες συμπλήρωναν ημιτελείς προτάσεις που κατέληγαν σε κλιτικά. Τα πειράματα μελέτησαν την αλληλεπίδραση μεταξύ πραγμάτωσης σε θέση υποκειμένου, συντακτικού παραλληλισμού, εγγενούς αιτιότητας, και οντολογικής υπόστασης (έμψυχο-άψυχο) στην επιλογή ηγουμένων για τα κλιτικά. Τα πειράματα έδειξαν πως η επίδραση κάθε μελετούμενου παράγοντα ήταν εξαρτημένη από το είδος και την ισχύ των παραγόντων με τους οποίους βρισκόταν σε συμφωνία/ ανταγωνισμό, καθώς και ότι η αλληλεπίδραση μεταξύ παραγόντων μπορεί να είναι μη γραμμική. Τα αποτελέσματα αυτά παρέχουν περαιτέρω στήριξη σε πιθανοτικά μοντέλα ικανοποίησης πολλαπλών περιορισμών για την επίλυση της επαναφοράς .

Λέξεις - κλειδιά

anaphora resolution, clitics, subjecthood, implicit causality, parallelism, animacy

1.   Introduction

The two experiments reported here investigated the effects of parallelism, subjecthood, implicit causality, and animacy on pronoun resolution. Although addressing specific proposals in the literature regarding the effects of each individual factor was one of the aims of the experiments, emphasis was placed on the manner in which the factors interact in determining interpretations. The experiments were conducted in Greek because, unlike English, where object pronouns canonically follow the verb, in Greek weak object pronouns precede it, and hence make it possible to investigate the effects of the four factors independently of other confounding factors, such as verb-semantics in the clause/sentence containing the pronoun.

     The view of anaphora resolution adopted here is that proposed by Arnold (1998), who suggests that anaphora resolution be viewed as a type of ambiguity resolution, much like lexical and syntactic ambiguity resolution. She proposes a model based on the probabilistic constraints approach to language representation and processing (MacDonald, pearlmutter, and Seidenberg, 1994), and the related Competition Model (Bates and MacWhinney, 1989). Arnold postulates that constraints on processing are probabilistic, each partially activating representations. Representations can be activated to varying degrees on the basis of the input and its interaction with the comprehender's knowledge in long-term memory. She models anaphora resolution as a process of competition among constraints, using an interactive-activation architecture. The advantage of such an approach is that it makes use of the same type of mechanism used for lower level language processing (lexical and syntactic) in order to account for discourse processing. A constraint-based approach to anaphora resolution contrasts with psycholinguistic work inspired by computational models, such as Centering Theory (Grosz, Joshi, and Weinstein, 1995), which are based on distributional generalisations rather than cognitive/ psychological principles (Almor, 2000).

Two basic predictions can be derived from Arnold's model about the nature and interaction of constraints in anaphora resolution:

1. The effect of a constraint is determined by the nature and strength of constraints it competes/converges with.

2. Interactions among constraints are non-linear: information that does not constrain interpretations when considered in isolation becomes very constraining when considered in conjunction with other information.

The two experiments reported below provide experimental support for these two predictions.

2. Experiment 1

Experiment 1 investigated the effects of parallelism, subjecthood, and implicit causality as possible constraints on clitic interpretation. Participants provided oral completions to fragments consisting of a subject NP and a clitic (case-marked accusative or genitive). The clitic could be co-referential with one of two NPs used in the previous sentence as arguments of experiential verbs. The verbs were either stimulus-experiencer (henceforth S-E), such as 'eksorgizo' ('infuriate'), or experiencer-stimulus (henceforth E-S), such as 'miso' ('hate'). Accusative clitics in the fragments shared the same grammatical role with the object of the experiential-verb sentence, while genitive clitics did not. The experiential-verb sentence was preceded by a neutral context sentence. Examples of the texts used appear in Table 1.

Table 1: Example stimuli for Experiment 1

Stimulus-Experiencer Verb
[1] Η Μάρθα, ο Βασίλης και ο Δημήτρης ήταν συνηθισμένοι να δουλεύουν μόνοι τους, αλλά εκείνο το διάστημα, εξαιτίας της ανακαίνισης που γινόταν στην εταιρεία, ήταν αναγκασμένοι να δουλεύουν στο ίδιο γραφείο.   [2] Ο Βασίλης ενοχλούσε το Δημήτρη.   [3] Η Μάρθα τον.../ του...
Experiencer-Stimulus verb
[1] Οι καυγάδες ανάμεσα στον Ορέστη, την Άννα και τη Ζωή ήταν συχνοί.   [2] Η Ζωή φοβόταν την Άννα.   [3] Ο Ορέστης τη(ν).../ της...   Orestes-nom clitic-acc…/ clitic-gen…

In what follows, I will discuss the three factors investigated and present the predictions for the experiment.

2.1 Syntactic Parallelism

Syntactic parallelism effects in pronominal interpretation emerge when a pronoun is biased to co-refer with an antecedent that occupies the same grammatical role in the preceding utterance

(Chambers and Smyth, 1998; Smyth, 1992; 1994; Stevenson et al., 1995; Pearson et al. 2000). For instance, in (1) below, ʹherʹ is preferentially interpreted as co-referential with Anne instead of Nicky:

(1)   Nicky gave Anne the shirt and John passed *her* the scissors.

However, strong preferences for an antecedent having the same syntactic role have been obtained only when there is both semantic and syntactic parallelism between the clause/sentence containing the pronoun and the preceding clause/ sentence (Smyth, 1992; Chambers and Smyth, 1998) and when the two clauses/ sentences share the same global constituent structure (Smyth, 1994; Stevenson et al., 1995). In the absence of semantic parallelism/ common global constituent structure, *p*references for a parallel antecedent are significantly reduced.

In our experiment participants were asked to complete fragments which ended with a clitic and from which the verb was missing. Therefore, effects due to parallelism of syntactic role were teased apart from effects attributable to semantic parallelism and/or common constituent structure. Moreover, with semantic parallelism and congruence of constituent structure not playing a role, we could assess the proposal that parallelism biases operate in such general terms as: subject pronouns are resolved to subjects, while non-subject pronouns are resolved to non-subjects. This proposal has been put forward within the framework of Local Focusing (Suri and McCoy, 1993), a computational model that attempts to account for parallelism effects in the interpretation of anaphors. Local Focusing assumes a very loose notion of parallelism, which has not been supported by experimental evidence: Smyth (1992; 1994) and Stevenson et al. (1995) have shown that the degree of semantic/ syntactic parallelism and common global constituent structure between utterances are crucial in determining preferred interpretations. Here we were interested in seeing whether the same pattern of results would hold when semantic parallelism and equivalence of global constituent structure do not obtain.

2.2   Subjecthood/Initial Mention

There is a large body of experimental research demonstrating that there is a tendency for pronouns to be interpreted as co-referential with an antecedent realised in grammatical subject position (see Arnold, 1998 for a review), on the assumption that grammatical subjects are more salient than entities realised in other grammatical roles (Brennan, Friedman, and Pollard, 1987) and that pronouns select salient antecedents (Gundel, Hedberg, and Zacharski, 1993). The primacy of subjecthood has been most forcefully argued in work based on Centering Theory (Grosz, Joshi, and Weinstein, 1995), a computational model of focusing and local coherence. Experimental research within the Centering framework has adopted the view that salience is solely determined by surface structural considerations and serial linear position (Gordon, Grosz, and Gilliom, 1993; Gordon and Scearce, 1995; Hudson-DʹZmura and Tanenhaus, 1998), such that grammatical subjects and first-mentioned entities are more salient than entities realised in other roles/ positions and are hence more likely candidate antecedents for referentially ambiguous pronouns.
Nevertheless, studies on parallelism cited earlier have demonstrated that the primacy of subjecthood is subject to modification by influences due to the grammatical role of the pronoun.

Here we were interested in determining whether the grammatical role of the clitic alone would be enough to override any subjecthood/initial mention effects.

2.3 Implicit Verb Causality

With certain interpersonal verbs, the cause of the state/event denoted by the verb is attributed to one of its arguments (Brown and Fish, 1983; Au, 1986; Corrigan, 1988; inter alia). Implicit causality verbs are of two types, either subject-biasing or object-biasing. For instance, the verb 'eksapato' ('deceive') is a subject-biasing verb, since the underlying cause of the event denoted by the verb is realized in subject position, while 'katigoro' ('accuse') is an object-biasing verb, as the underlying cause is realized in object position. It is an open question whether implicit causality functions as a focusing mechanism, making the argument assumed to be the cause more salient and hence more accessible for pronominal reference (Greene and McKoon, 1995; McDonald and McWhinney, 1995; Koornneef et al., 2002); or if, when utilized in comprehension, it is registered as a late effect occurring during the integration of propositions (Garnham et al., 1996; Stewart et al., 2000). In all the studies cited above, however, implicit causality did affect the final interpretation of pronouns.

In the present experiment we focused on a subset of verbs claimed to induce implicit causality effects in pronoun resolution, interpersonal state verbs, either S-E, such as 'eksorgizo' or E-S, such as 'miso'. This was done in order to address the claim that state verbs lack a focusing structure, and any preferences for resolution of a pronoun to either of their arguments are attributable to a causal link between the pronoun-containing and the biasing-verb-containing utterances. In the materials used for our experiment, there was no explicit/implicit causal link between the two utterances in question, and, if anything, the structure of the materials biased toward a parallel rather than a causal relation. Moreover, by placing the clitic and the interpersonal verb in separate sentences, we were able to assess the proposal that verb semantics influences pronoun resolution *intra*-sententially but not *inter*-sententially (Miltsakaki, 2002).

2.4 Predictions

Centering Theory would predict that both types of clitic with both types of verb would be resolved to the subject. Following Local Focusing claims, one would expect both types of clitic, regardless of case-marking and verb type, to be resolved to the grammatical object. More interactive approaches would expect individual effects of subjecthood in the previous utterance, the syntactic role of the anaphor and that of the potential antecedents, and implicit causality to interact to give the preferred interpretation. If this is the case, further questions arise: what is the strength of each of these constraints and in what manner do they interact? Two scenarios were a priori considered to be possible, given the research outlined above and theoretical considerations:

1. Linear interaction of constraints: the effects of the various factors are simply additive. Genitive clitics are resolved to the grammatical subject (subjecthood effect), but subjecthood effects are stronger for genitive clitics following S-E than E-S verbs (implicit causality effect). Accusative clitics are resolved to the grammatical object (structural parallelism effect), but preferences for the object with accusative clitics are stronger in the context of E-S than S-E verbs (implicit causality effect).

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2. <u>Non-linear interaction of constraints</u>: All clitics are resolved to the grammatical subject apart from accusative clitics after sentences with E-S verbs. In this scenario, syntactic parallelism and implicit causality have no effect independently; when both point to the same antecedent, then that antecedent is preferred.

2.5   Method

Subjects. 20 native Greek speakers (12 female, 8 male; mean age 26.5±3.5 years) participated in this experiment as volunteers.

Materials and design. The materials consisted of a context sentence in which 3 animate entities, NP1, NP2, and NP3[i], were introduced by proper name. Two of the entities, NP1 and NP2, were of the same gender and always appeared in a co-ordinate NP, while the third entity, NP3, was always the first-mentioned entity in the context sentence. The second sentence used NP1 and NP2 from the context sentence with 10 stimulus-experiencer (S-E) and 10 experiencer-stimulus (E-S) verbs. All the verbs used were pre-tested in a free listing of causes task, to ensure that they exhibited implicit causality effects in the predicted direction. The final sentence introduced NP3 in subject position (i.e., marked nominative), and was followed by a clitic case-marked accusative or genitive. The accusative clitic shared the same case-marking as the object (NP2) of the previous sentence, while the genitive clitic did not. In short, two factors were manipulated in this experiment: type of verb (S-E versus E-S) and type of clitic (accusative versus genitive).

A total of 50 filler texts were also constructed, which were similar in structure to the experimental passages.

Procedure. Subjects were tested individually on a personal computer. The texts appeared sentence-by-sentence on the screen, and subjects controlled rate of presentation by pressing any key on the keyboard. While no time restrictions were imposed for reading the first two sentences of each passage, subjects were allowed 10 seconds to provide an oral continuation for the fragment. Answers were recorded by inbuilt sound recording software. The experimenter also noted down the responses in a booklet containing all the critical passages. At the end of the experiment, *p*articipants were given the booklet with the critical items and the completions they had provided and were asked to circle the intended antecedent for each clitic.

At the beginning of each session, five practice items were included. Each session lasted approximately 40 minutes.

Results. For each subject and item in each condition, the proportion of object (NP2) assignments for the fragment-final clitic was calculated, and the subject means for each condition appear in Figure 1.

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Figure 1: Proportion of grammatical object (NP2) assignments per condition for Experiment 1
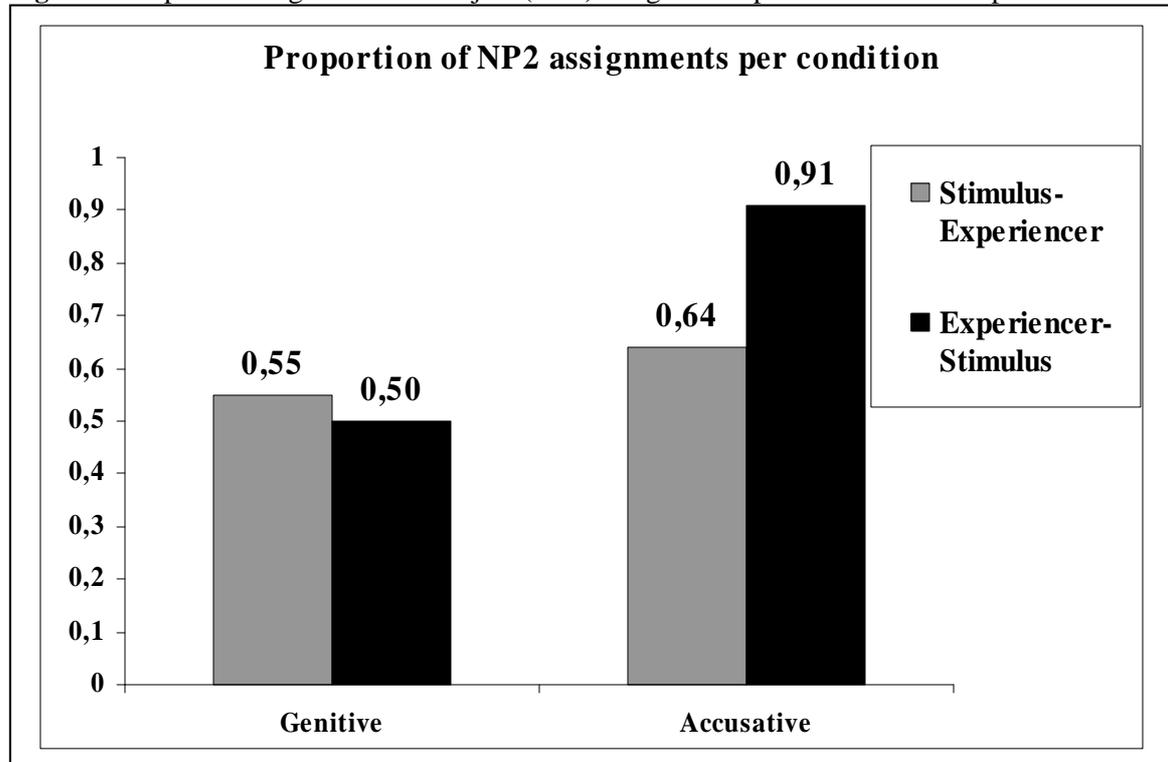
10.50% of the data were missing (participants did not provide a continuation within the time limits). A further 1% of the data was discarded (incoherent continuations, continuations where the case of the clitic had been changed, or reference was made to a third entity).

Two ANOVAs were conducted assuming subjects (*F1*) and items (*F2*) as random variables. These analyses revealed a significant main effect of clitic type ($F1(1, 19)=34.723$, $p<.001$; $F2(1,18)=16.719$, $p<.001$). The main effect of verb type was significant in the subjects analysis ($F1(1,19)=6.434$, $p<.05$) but marginally significant in the items analysis ($F2(1,18)=3.852$; $p=.065$). These effects were qualified by a significant verb-type by clitic-type interaction ($F1(1,19)=9.279$, $p<.01$; $F2(1,18)=8.765$, $p<.01$).

Pairwise comparisons (employing Bonferroni's adjustment procedure) confirmed that the condition containing an accusative clitic in the context of an E-S verb (E-S-acc) differed significantly from all other conditions (E-S-acc/S-E-acc: $t1(19)=4.049$, $p=.001$; $t2(13.555)=4.602$, $p=.000$; E-S-acc/S-E-gen: $t1(19)=5.880$, $p=.000$; $t2(12.435)=4.565$, $p=.001$; E-S-acc/E-S-gen: $t1(19)=8.451$, $p=.000$; $t2(9)=5.362$, $p=.000$). None of the other comparisons yielded significant results

Finally, one-sample t-tests on each condition tested whether the proportion of object assignments differed significantly from chance. The results were significant for the two accusative-clitic conditions (S-E-acc: $t1(19)=2.384$, $p<.05$; $t2(9)=2.382$, $p<.05$; E-S-acc: $t1(19)=16.610$, $p<.001$; $t2(9)=14.527$, $p<.001$).

2.6   Discussion

Although none of the original predictions were upheld, the results are quite interesting regarding the effects and manner of interaction of the three constraints investigated.

There was no subjecthood/initial mention preference in any of the conditions of the experiment; only a null result for genitive conditions and a preference for the grammatical object in the accusative conditions. This result does not support claims made within the framework of Centering Theory that grammatical subjects constitute the default assignment for any indeterminate pronoun in both Greek (Miltsakaki, 2001) and English (Hudson-D'Zmura and Tanenhaus, 1998). Apparently, when the context is neutral, subjecthood/initial mention is not a determinant of preferences.

Unsurprisingly, Local Focusing claims were not upheld either: non-subject pronouns are not invariably resolved to non-subjects, since there was no preference for either antecedent in the genitive-clitic conditions. On the other hand, there was a preference for syntactically parallel antecedents when both the clitic and the antecedent shared exactly the same case-marking/syntactic role. This preference for syntactically parallel antecedents demonstrates that parallelism effects can emerge independently of semantic parallelism or congruence of global constituent structure. And, as the results for the condition containing an accusative clitic in the context of a stimulus-experiencer verb show, choice of the syntactically parallel antecedent can become almost obligatory if that choice is reinforced by another converging constraint.

The results regarding implicit causality effects are particularly interesting. In the absence of strict syntactic parallelism between anaphor and antecedent, implicit causality had no effect on antecedent selection. However, when syntactic parallelism held, the choice of a parallel antecedent was almost obligatory (91%), when that antecedent was also the stimulus argument. This is the type of non-linear effect predicted by probabilistic models based on connectionist architectures: information that is not very constraining on its own (implicit causality without syntactic prallelism) becomes very constraining when considered in conjunction with other information (implicit causality *and* parallelism).

Importantly, this effect of verb semantics held *across* sentences, contrary to suggestions in Miltsakaki (2002), and in the absence of an explicit/implicit causal link between the two utterances in question, contrary to suggestions by Stevenson et al. (2000).

3.   Experiment 2

Experiment 1 demonstrated that when the clitic shares the same grammatical role with one of the potential antecedents, there is a preference for that antecedent, which is almost absolute when the antecedent is also the stimulus argument. In Experiment 2 we were interested in investigating whether these preferences could be overridden in the presence of a competing constraint, animacy. We, therefore, looked at the joint effects of parallelism and implicit causality, when one of the potential antecedents (the stimulus argument of experiential verbs) is inanimate. Examples of the texts used appear in Table 2 below.

Table 2: Example stimuli for Experiment 2

Stimulus-Experiencer Verb
[1] Η Μαρία και ο Γιάννης, επαγγελματίες κασκαντέρ, είχαν βρεθεί πολλές φορές σε κίνδυνο στα γυρίσματα διάφορων ταινιών στις οποίες είχαν συμμετάσχει. [2] Ο κίνδυνος γοήτευε το Γιάννη. [3] Η Μαρία τον...
Experiencer-Stimulus Verb
[1] Όταν ξέσπασε η φωτιά στο γειτονικό χωριό, η Δάφνη και η Ασημίνα πήγαν στην κορυφή του λόφου, για να δουν τί γινόταν. [2] Η Ασημίνα φοβόταν τη φωτιά. [3] Η Δάφνη τη(ν)...

It is a widely held assumption that animate entities are inherently more salient than inanimate entities (Bock, 1982; Byrne and Davidson, 1985; Prat-Sala and Branigan, 2000; inter alia). Since pronouns are claimed to select salient antecedents, we would expect them to be preferentially resolved to animate rather than inanimate entities. In Experiment 2, therefore, we predicted a reversal of the pattern of results obtained in the two accusative conditions in Experiment 1: more object assignments for clitics after S-E verbs than E-S verbs, since the object/ experiencer argument of S-E verbs is animate, while the object/stimulus argument of E-S verbs is inanimate.

3.1 Method

Subjects. 20 Greek native speakers (13 female, 7 male; mean age 25.5±4.5) participated. 7 subjects were replaced (1 because of a large number of missing observations; 1 because 50% of his data were instances of left dislocation and hence the clitic had been construed as the definite article; 5 because of an element of rote in their responses).

Materials and design. A set of 16 (8 S-E and 8 E-S) verbs was selected from the same pool of verbs used for Experiment 1. The structure of the materials was the same as for Experiment 1, with the sole exception that the two NPs which functioned as the arguments of the experiential verb in the second sentence did not appear in a co-ordinate NP in the context sentence.

Only accusative clitics were used in this study, since the set of verbs with which inanimate entities can appear in indirect object position (i.e., case-marked genitive) is limited. All clitics had syntactically parallel potential antecedents. Hence the only variable manipulated was verb type, which yielded two conditions in total. The fillers for this experiment were the same as for Experiment 1 (N=50).

*Procedure.* The procedure was identical to that for Experiment 1.

Results. For each subject and item, the proportion of grammatical object assignments was calculated in each condition. The subject means for the two conditions appear in Figure 2.

7.5% of the data were missing (subjects failed to provide a continuation within the time limits). Ungrammatical continuations, instances where the case-marking of the clitic had been

changed or the clitic had been construed as the definite article were also discarded (1.56%). Instances of clitic doubling (4.38%) were included in the analyses, since the clitic had been construed as such.

Two t-tests were performed to test generality over subjects (*t1*) and items (*t2*), which did not yield any significant results, despite the sizeable numerical difference between the means of the two conditions (14%). One-sample t-tests were conducted on each condition to test whether assignments differed significantly from chance. For the E-S condition, there was a marginally significant result in both subjects and items analyses (*t1*(19)=2.027, *p*=.057; *t2*(7)=1.989, *p*=.087).
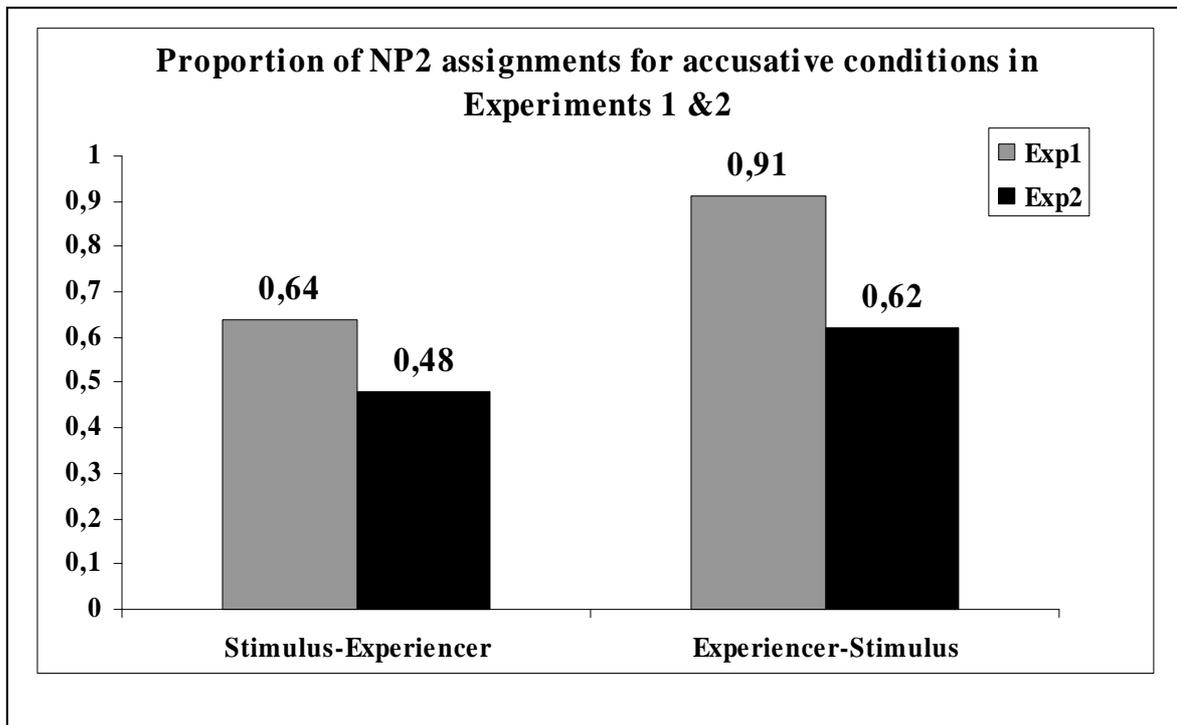
Figure 2 Mean proportion of grammatical object (NP2) assignments per condition for Experiment 2
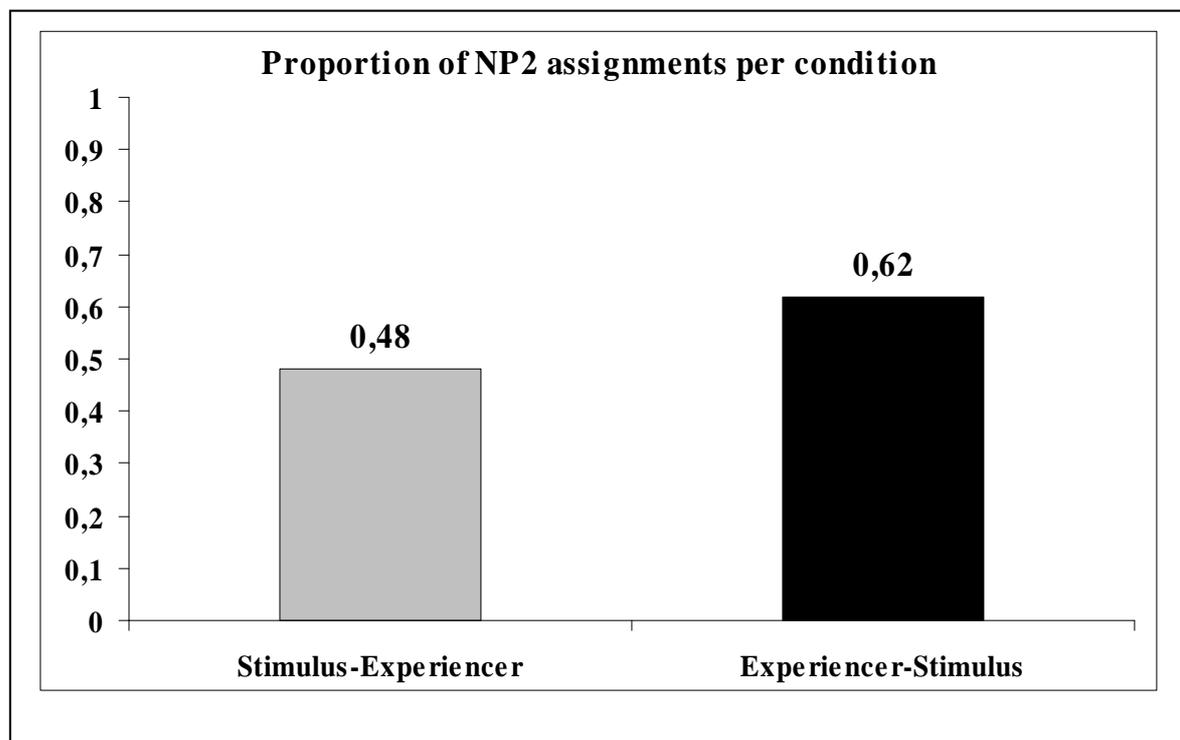
3.2 Discussion

Despite the lack of a statistically significant difference between the two conditions, numerically, the direction of the results is exactly opposite to that predicted. Instead of more assignments to the animate entity in both conditions (the grammatical object with S-E verbs and the grammatical subject with E-S verbs), there was a general reduction of parallel assignments across conditions. This becomes apparent in a comparison between this experiment and the two equivalent conditions of Experiment 1 (see Figure 3 below). Two ANOVAs (one by subjects (*F1*) and one by items (*F2*)[ii]) were performed with verb-type and experiment as factors in order to compare the two experiments. On the basis of our initial predictions, there should have been an interaction between verb type and experiment, but that was not the case. The main effect of experiment was significant (*F1*(1,38)=34.328, *p*<.001; *F2*(1,10)=5.893, *p*<.05) and so was the main effect of verb type (*F1*(1,38)=9.951, *p*<.01; *F2*(1,10)=9.325, *p*<.05) but there was no interaction between the factors.

Figure 3 Mean proportions of object (NP2) assignments for conditions containing an accusative clitic in Experiments 1 &2.

Proportion of NP2 assignments for accusative conditions in Experiments 1 &2

	Stimulus-Experiencer	Experiencer-Stimulus
Exp1	0,64	0,91
Exp2	0,48	0,62

An explanation of the present results would take into account the semantic distance between an animate and an inanimate entity versus two animate entities. The degree of discreteness between two animate entities in the absence of pragmatic focusing is very low indeed, so there is greater reliance on structural parallelism in antecedent assignment. An inanimate and an animate entity, on the other hand, are highly discrete, so there is a reduction of reliance on structural parallelism in antecedent assignments.

4. General Discussion

The contribution of the present experiments is twofold: First, they provide clarification of the effects of individual constraints affecting pronoun resolution in a language other than English: subjecthood has no effect when the context is neutral; structural-parallelism biases are obtained in the absence of semantic parallelism/ congruence of global constituent structure; implicit causality affects interpretations in the absence of a causal link between utterances and inter-sententially; animacy, quite unexpectedly, reduces reliance on bottom-up factors, such as parallelism, but does not predict antecedent preferences. Second, the experiments provide support for a constraint-based approach to anaphora resolution as outlined in Arnold (1998). The experiments add to the growing body of research demonstrating that the effects of individual factors are dependent on the nature and strength of factors with which they compete/ converge. More importantly, the experiments show that the interaction of constraints can be non-linear, as directly predicted by the constraint-based approach, thus supporting the potential of the approach to provide a unified account of processing architecture from the lexical to the discourse level.

Future work will address the manner in which the constraints investigated here interact over time in on-line comprehension.

Σημειώσεις
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[i] Although the labels NP1, NP2, and NP3 are rather confusing and not-applicable here, they are used in order to make clear the position of the arguments in the sentence containing the experiential verb (sentence 2 in the materials).
[ii] The items analysis was performed including only the items that were common between the two experiments (7 out of 8 for S-E verbs and 5 out of 8 for E-S verbs).

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