Ambiguity resolution in Greek: an eye-tracking-while-reading study

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Abstract

The present study uses an eye-tracking-while-reading methodology to investigate how reading is affected in the context of temporary direct object/sentence complement ambiguity and how morphological and subcategorization cues are integrated at different stages of parsing. Our results suggest that morphological cues are initially overridden by participants' strong transitivity preferences, but are re-integrated later in time, revising participants' initial parsing strategies. This provides evidence for distinct strategies between subcategorization and morphosyntactic processing.

Keywords: sentence processing, syntactic ambiguity, comprehension, eye-tracking

Introduction

In temporally ambiguous structures, known as "*garden-path sentences*" (e.g., *While Mary kissed the baby spit up on the bed*), the parser encounters an ambiguous part of the sentence with more than one possible interpretations and seeks to efficiently repair the misinterpretation and recover from the plausible, but incorrect, syntactic decisions that were initially made. It has been observed that syntactic ambiguity resolution is typically associated with increased reading times and regressions into earlier parts of the sentence, especially in sentence regions requiring re-analysis. Despite rigorous psycholinguistic research, there is still no consensus on how the language processor handles ambiguity and how parser's preferences are built during sentence processing.

Studies have shown that syntactically-based cues, like argument structure or subcategorization frame information, affect the parser's decisions at the early stages of sentence processing in sentences that contain subject-object ambiguities. English-speaking readers, for example, have been shown to be sensitive to differences in verbs' transitivity information, revealing a strong tendency for an *object-reading* preference (e.g., Ferreira & Henderson, 1991; Frazier & Rayner, 1982). Such preference is considered less demanding, in line with universal parsing principles like Late Closure, since the parser immediately attaches each new constituent to the phrase being processed rather than initiating a new clause. In languages with rich morphosyntactic paradigms, the

resolution of garden path effects has also been shown to be mediated by morphological cues (for Greek see Papadopoulou & Tsimpli, 2005). For instance, with the use of a self-paced reading paradigm Papadopoulou & Tsimpli (2005) show that Greek-speaking children are highly effective at using morpho-syntactic cues (case & agreement) to override syntactically based parsing strategies like Late Closure, at the initial stage of parsing. Thus, despite previous evidence for strong reliance in syntactic heuristics that favour the *object reading* in sentences with temporal ambiguities, Papadopoulou & Tsimpli (2005) failed to replicate such preference for Greek (cf. Papangeli & Marinis (2009) who found a preference for the object reading while using a self-paced listening task). Moreover, it is also unclear whether morphological information is directly employed at the initial parsing decisions, or these cues are initially ignored and are only subsequently integrated, when a complete and successful reanalysis is accomplished.

In the present study, we used an eye-tracking-while-reading approach to probe the mechanisms of local syntactic ambiguity in Greek-speaking adults and investigate the role of morphology in guiding garden-path resolution processes.

Methodology

Participants

Sixty (60) monolingual Greek-speaking adults (mean age = *28.4* years, *SD* = *11.38)* participated in the study. The study was approved by the Ethics Committee of the National and Kapodistrian University of Athens and informed consents were obtained from all participants.

Materials

The task comprised of sentences involving subject/object ambiguities. We manipulated the *argument structure of the subordinate verb* (optionally transitive vs. intransitive verbs; (1) vs. (2) and (3) vs. (4)) and the *syntactic function of the DP* following the subordinate verb (object vs. subject; (1a) vs. (1b), (2a) vs. (2b), (3a) vs. (3b), (4a) vs. (4b)). Local syntactic ambiguity was resolved either by the verbal inflection of the main verb (*Agreement condition 1 & 3*) or the morphological case carried by the DP following the subordinate verb (*Case condition 2 & 4*). Six lists of 34 sentences (half grammatical, half ungrammatical) were created. After the participants finished reading the sentence, they answered to a recall question to establish attention maintenance throughout the experiment. An SR Research Eyelink Portable Duo eye-tracker was used for the experiment.

Agreement condition

(1) Optionally transitive verb; object-subject reading; (grammatical) reading

(a) "Kathos etroge/ ta revithia/ ***jemise***/ me fuskales"
While (s)he was eating/ the chickpeas/ (s)he blistered herself/ with cysts

(b) "Kathos etroge/ ta revithia/ ***jemisan***/ me fuskales"
While (s)he was eating/ the chickpeas/ blistered/ with cysts

(2) Intransitive verb; object (ungrammatical) - subject grammatical reading
(a) "*Kathos etrehe/ ta revithia/ ***jemise***/ me fuskales"
While (s)he was running/ the chickpeas/ (s)he blistered herself/ with cysts
(b) "Kathos etrehe/ ta revithia/ ***jemisan***/ me fuskales"
While (s)he was running/ the chickpeas/ blistered/ with cysts

Case condition

(3) Optionally transitive verb; object-subject reading; (grammatical) reading
(a) "Kathos etroge/ ***ton lukuma***/ jemise/ me fuskales"
While (s)he was eating/ the_ACC donut_ACC/ (s)he blistered herself/ with cysts
(b) "Kathos etroge/ ***o lukumas***/ jemise/ me fuskales"
While (s)he was eating/ the_NOM donut_NOM/ blistered/ with cysts

(4) Intransitive verb; object (ungrammatical) - subject grammatical reading
(a) "*Kathos etrehe/ ***ton lukuma***/ jemise/ me fuskales"
While (s)he was running/ the_ACC donut_ACC/ (s)he blistered herself / with cysts
(b) "Kathos etrehe/ ***o lukumas***/ jemise/ me fuskales"
While (s)he was running/ the_NOM donut_NOM/ blistered/ with cysts

Results

Linear mixed-effects models were used with eye-tracking measures as the dependent variable, and object/subject, case/agreement and interest areas (IA) as the independent variables. IAs were grouped together as follows: beginning of sentence (IA 1 and 2), first critical region (IA 3 and 4, the DP), second critical region (IA 5, main verb), and the end of the sentence (IA 6 and 7, PP). We report results for second-past time and total reading times.

In the second-past time measure (i.e., all refixations on an IA of text after the eye has already moved past that region in the text) (1i), longer *subject reading* durations were found in optionally transitive verbs in the first critical region of the Agreement condition (b= -0.28, SE= 0.10, t(1427)=-2.591, $p=0.009$) and the beginning of the sentence in the Case condition (b= -0.23, SE= 0.09, t(1429)=-2.41, $p=0.016$) but longer object reading durations only in the Agreement condition of intransitive verbs, specifically in the second critical region (b= 0.28, SE= 0.108, t(1425)=2.61, $p=0.008$) and in the end of sentence (b= 0.67, SE= 0.3, t(1421)=2.24, $p=0.024$). In the total reading times measure (i.e., the sum of all fixations in an IA) (1ii), longer object reading durations were observed only in intransitive verbs in the second critical region of the Agreement condition (b= 0.32, SE= 0.095, t(3881)=3.389, $p< 0.001$), and longer subject reading durations only in optionally transitive verbs for both the first critical region (b= -0.17, SE= 0.07, t(3896)=-2.19, $p=0.028$) and the beginning of sentence (b= -0.24, SE= 0.067, t(3897)=-3.63, $p<0.001$) of the Case condition.

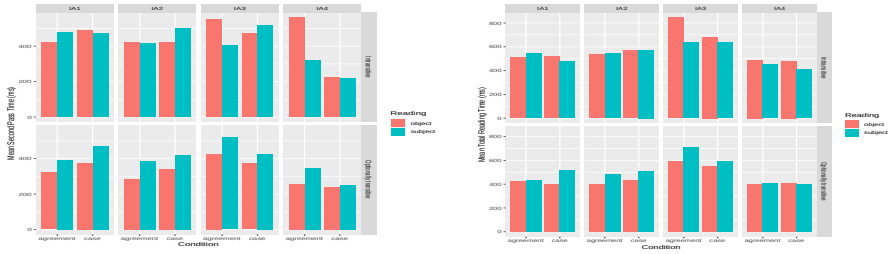

Figure 1. Second-pass time and total reading time across conditions.

Discussion

Our data provide robust evidence for the mechanisms that underlie temporal ambiguity resolution, by showing that neurotypical participants are able to successfully integrate morphosyntactic information and revise initial (mis)parses of garden-path sentences, although distinct strategies between subcategorization and morphosyntactic processing were attested; the precedence of subcategorization frame at the earliest stages of processing has emerged, suggesting that these two types of cues are used independently.

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