

Morphological Cues in Children's Processing of Ambiguous Sentences: a Study of Subject / Object Ambiguities in Greek

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1. Introduction

In this paper, we investigate the on-line processing of locally ambiguous sentences, in which the ambiguity is resolved by morphological means, namely by S-V agreement and Case on DPs. Moreover, we compare the parsing strategies employed by adult readers with those used by children in order to examine the development of the parser.

The method used is an on-line measure, more specifically a self-paced reading task. The structures we tested involve subject/object ambiguities, in which the verb of a pre-posed adverbial clause is optionally transitive and followed by a DP which could be either the object of the embedded verb (1a) or the subject of the main verb (1b):

- (1) a. While she was eating **the pizza** she fell on the floor.
- (1) b. While she was eating **the pizza** fell on the floor.

Various parsing models (Frazier & Fodor, 1978; Frazier, 1987; Pritchett, 1988; 1992; Weinberg, 2001) make the prediction that the object reading should be favored over the subject reading. The reason is either the operation of Late Closure, that is the preference of the parser to attach new constituents (i.e. *the pizza*) to the phrase currently being processed (in (1a) and (1b) the embedded verb), or the cost associated with the analysis of the DP *the pizza* as the subject of the main verb due to its attachment to a new thematic domain (the one defined by the main verb). The preference for the object reading has been empirically supported by the results of several on-line studies in English. So, in

an early eye-tracking study study, Frazier & Rayner (1982) found that English adults experience the garden-path effect when processing the main verb in sentences like (1b). Similarly, Mitchell (1987) obtained the same result, not only when the embedded verbs were optionally transitive but also when they were intransitive. The object reading preference for sentences like (1b) has been replicated by a recent eye-tracking study (Pickering & Traxler 2003) with English adults.

With respect to child sentence processing, Traxler (2002) conducted three self-paced reading experiments, in which he examined the way 10- to 11-year-old English children process sentences like (1b) under three conditions: in the first condition the DP following the embedded verb was a plausible object of the verb, in the second an implausible object and in the third condition the embedded verb was intransitive. All three tasks showed that the children preferred to analyze the DP after the embedded verb as its object rather than as the subject of the main verb. Traxler interpreted this result as evidence for the priority of the syntactic processor over the thematic processor in child sentence processing. The fact that the children seem to rely more on grammatical cues rather than on thematic/semantic/pragmatic cues has also been obtained by other studies on child sentence processing (see Felser et al., 2003).

The present study reports on the findings of two on-line experiments conducted with Greek adults and children on sentences such as (1a) and (1b). In the first experiment, the ambiguity was resolved on the main verb by means of S-V agreement, while the DP following the embedded verb was unmarked for Case and, thus, could not provide any information about its syntactic function as Subject or Object. In the second experiment, the DP following the embedded verb was marked for either Accusative or Nominative case, thus, its syntactic function was explicit and disambiguated the sentences:

- (2) a. Kathos etroghe ta biskota epese sto patoma.
while was-eating the cookies fell-3sg on-the floor
“While (s)he was eating the cookies (s)he fell on the floor.”
- (2) b. Kathos etroghe tus ahinus epese sto patoma.
while was-eating the-pl-acc sea-urchins-acc fell-3sg on-the floor
“While (s)he was eating the sea-urchins (s)he fell on the floor.”

2. Method

2.1. Procedure

The procedure used in both experiments was an on-line self-paced reading measure. The sentences were presented in a word-by-word fashion. Once the subjects read each word, they had to press the spacebar to proceed to the next one. The button presses resulted in the disappearance of the segment and the appearance of the next one (moving-window technique). In addition, the participants had to perform a grammaticality judgment task at the end of each

sentence, by pressing the button “YES” if they thought the sentence was grammatical and “NO” if they thought it was ungrammatical.

2.2. Materials

Each experiment consisted of four versions. Each version comprised 96 sentences, half of which was grammatical and half ungrammatical.

Our critical items were distributed across four conditions, which resulted from the manipulation of two variables with two levels each: the argument structure of the embedded verb (optionally transitive vs. intransitive verbs) and the syntactic function of the DP following the embedded verb (object of the embedded verb vs. subject of the main verb).

The experimental items were twenty-four quartets, with one member of each quartet representing each condition. The three members of each quartet were grammatical and the fourth one was ungrammatical, as can be seen in (2)–(5) below:

- (3) Optionally transitive verb; object reading (TO)
Kathos majireve ta makaronja kaik**e** stin katsarola.
while was-cooking the spaghetti-pl burnt-herself-3sg on the pot
“While (s)he was cooking the spaghetti (s)he burnt herself on the pot.”
- (4) Optionally transitive verb; subject reading (TS)
Kathos majireve ta makaronja kaik**an** stin katsarola.
while was-cooking the spaghetti-pl burnt-3pl in the pot
“While (s)he was cooking the spaghetti burnt in the pot.”
- (5) Intransitive verb; object reading (ungrammatical; IO)
* Kathos etrehe ta makaronja kaik**e** stin katsarola.
while was-running the spaghetti-pl burnt-herself-3sg in the pot
“*While (s)he was running the spaghetti (s)he burnt herself on the pot.”
- (6) Intransitive verb; subject reading (IS)
Kathos etrehe ta makaronja kaik**an** stin katsarola.
while was-running the spaghetti-pl burnt-3pl in the pot
“While (s)he was running the spaghetti burnt in the pot.”

In the Case Experiment, the materials were similar with those of the Agreement Experiment, but they differed in the way the ambiguities were resolved. In this task, the ambiguity was resolved via the morphological Case (Accusative or Nominative) carried by the DP following the embedded verb:

- (7) Optionally transitive verb; object reading (TO)
Kathos majireve **tus** astak**us** kaik**e** stin katsarola.
while was-cooking the-acc lobsters-acc burnt-herself-3sg on the pot
“While (s)he was cooking the lobsters (s)he burnt herself on the pot.”
- (8) Optionally transitive verb; subject reading (TS)
Kathos majireve **i** astak**i** kaik**an** stin katsarola.

while was-cooking the-nom lobsters-nom burnt-3pl in the pot

“While (s)he was cooking the lobsters burnt in the pot.”

(9) Intransitive verb; object reading (ungrammatical; IO)

* Kathos etrehe **tus** astak**us** kaike stin katsarola.

while was running the-acc lobsters-acc burnt-herself-3sg in the pot

“*While (s)he was running the lobsters (s)he burnt herself on the pot.”

(10) Intransitive verb; subject reading (IS)

Kathos etrehe **i** astaki kaikan stin katsarola.

while was running the-nom lobsters-nom burnt-3pl in the pot

“While (s)he was running the lobsters burnt in the pot.”

In each experimental version there were twenty-four critical sentences, six of which were ungrammatical. Each experimental version was designed so that each subject was exposed to all conditions and all materials but never saw the same experimental item more than once.

2.3. Subjects

All the subjects participating in the experiments were naive with respect to the purpose of the study. The following Table presents more detailed information about the subjects:

Table 1. The profile of the subjects

Subjects	Number	Gender	Age range
adults	80	30 M; 50 F	20-40 years
children	53	24M; 29 F	10-11 years

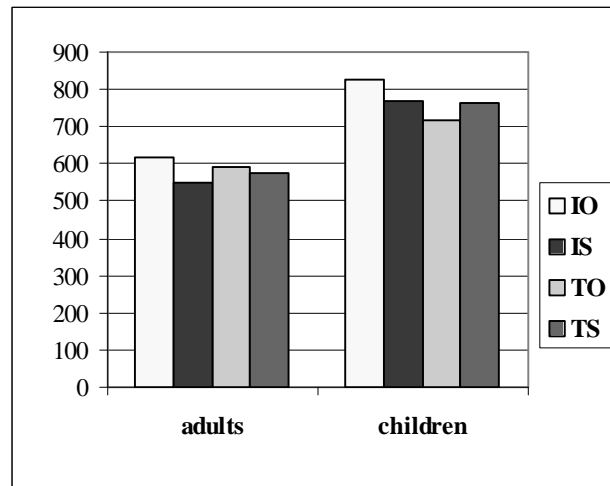
2.4. Data analysis

Only subjects who were accurate more than 60% were included in the data analyses. This resulted in the exclusion of one child. In addition, all erroneous responses to the grammaticality judgments as well as RTs above 2000 ms and above 1.5 SD from the mean RT of each subject per segment were eliminated.

3. Agreement Experiment

3.1. Results

The following Graph depicts the mean RTs for the disambiguating segment that is the main verb:



Graph1. Main Verb: Mean RTs per group

We ran a two-way repeated-measures ANOVA for each group separately with Verb type (transitive vs. intransitive verbs) and Syntactic function of the DP following the embedded verb (subject vs. object) as within-subjects variables. The adult data revealed a significant main effect of Syntactic function ($F(1,37)=7,578$; $p<0,01$), due to the faster RTs for the subject reading, and a marginally significant interaction between the two variables ($F(1,37)=3,479$; $p=0,070$). The latter finding is due to the fact that the ungrammatical condition (IO) was read significantly slower than the IS one ($t(38)=2,568$; $p<0,02$), whereas there were no significant differences between the TO and the TS condition. The child data showed a significant main effect of Verb type ($F(1,25)=5,811$; $p<0,03$) due to the longer RTs for the ungrammatical condition.

3.2. Agreement results: Discussion

First of all, the fact that the ungrammatical condition was read significantly longer than the grammatical ones points toward two directions. The first is that both groups successfully used S-V agreement information to process sentences on-line. The second is that, when encountering the main verb, the subjects had already accessed the argument structure of the embedded verb, and, hence, at this point the thematic processor was in operation.

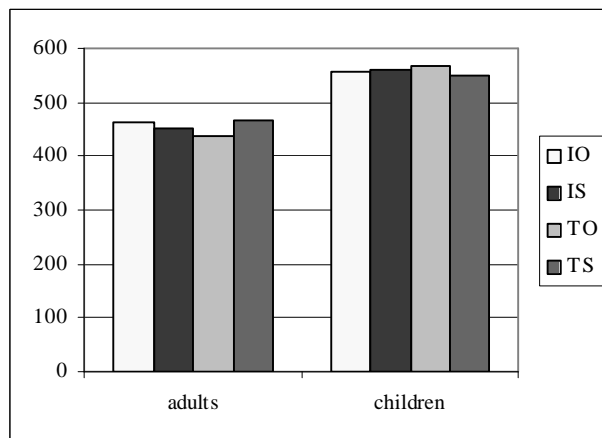
Moreover, our findings clearly show that Greek differs from English, in that the well-documented object reading preference in English is not found in the Greek data. This result indicates that there might be cross-linguistic variation in sentence processing due to morphological richness and associated properties of individual languages, e.g. word order variation. We propose that the observed differences between Greek and English are attributed to the fact that Greek

readers rely more on morphological cues when parsing Greek sentences than on parsing principles such as Late Closure. Furthermore, we maintain that the absence of any unambiguous morphological cues, like the DPs unmarked for case in the Agreement task, might have resulted in the generation of the two possible structures in parallel (c. Frazier & Clifton, 1996 for non-primary phrases). This is why the Greek readers do not exhibit a garden-path effect when the syntactic function of the DP becomes explicit.

4. Case Experiment

4.1. Results

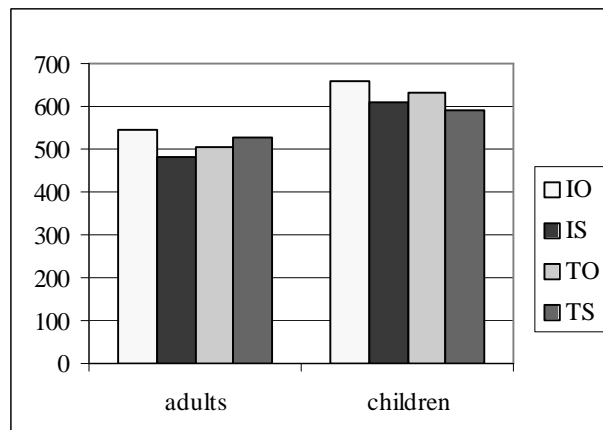
The following Graph presents the adults' and children's RTs on the Determiner:



Graph 2. Determiner: Main RTs per condition for both groups

The statistical analyses were conducted as for the Agreement task. In the adult data, there was a significant interaction between Verb type and Syntactic function ($F(1,39)=9,212$; $p<0,01$). Paired-samples t-tests showed that there was a significant difference only between the two transitive verb conditions ($t(39)=4,111$; $p<0,001$) but not between the intransitive ones. No significant effects were obtained from the child data.

The RTs on the Noun are reported in Graph 3:



Graph 3. Noun: Mean RTs per condition for both groups

The adult data showed that the main effect of Syntactic function was significant ($F(1,39)=4,786; p<0,04$) due to the slower RTs for the object reading than for the subject reading and that the interaction between Verb type and Syntactic function was significant ($F(1,39)=13,077; p<0,01$). Paired-samples t-tests revealed the IO condition was significantly slower than the IS ($t(39)=4,109; p<0,01$), whereas there was not a significant difference between the two transitive verb conditions. On the other hand, the child data yielded a significant main effect of Syntactic function ($F(1,25)=4,181; p=0,052$), namely the sentences in which the DP turned out to be the subject of the main verb were read significantly faster than the ones in which the DP was the object of the embedded verb.

4.2. Case results: Discussion

The results from the Case experiment indicate that the processing of the experimental sentences involves two stages, on the Determiner and the Noun respectively. The two-stage processing is found in both children and adults.

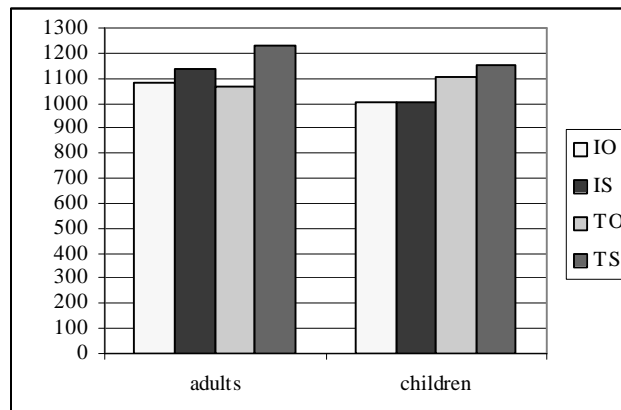
During the first stage, the adult data show a Late Closure effect, which does not seem to be affected by the argument structure of the verb. Note, however, that during the second stage, the object preference disappears while the grammaticality effect is evident. The latter indicates that the argument structure of the embedded verb is available to the readers at this stage. On the other hand, the fact that the object reading preference disappears implies that the garden-path effect manifested on the Determiner is not as conscious as is in English.

During the first stage (i.e. the Determiner), the child data are similar with the adult in that no grammaticality effect is obtained while at the same time children

show no preference for subject or object reading. Thus, for children Late Closure effects are not shown at all. During the second stage, the thematic processor is available as indicated by the grammaticality effect. However, unlike adults, children show a preference for the subject reading which appears to be an early closure effect. As we will see in the accuracy data, the fast RTs for the subject reading have adverse effects on accuracy.

4. Grammaticality Judgements: RTs & Accuracy

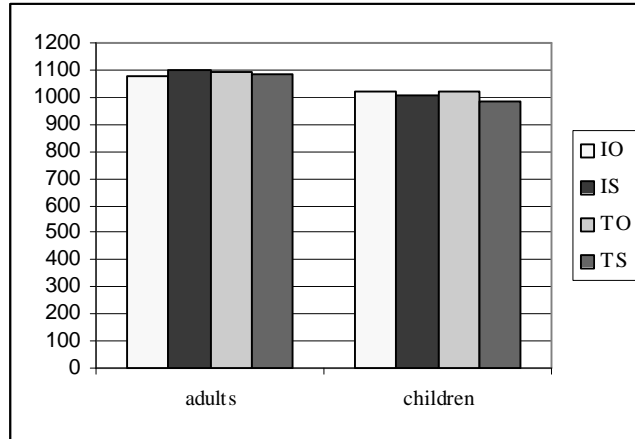
In this section, we report on the data from the judgement task. In Graph 4, the response times for the Agreement Experiment are presented per group:



Graph 4. Agreement Experiment: Mean RTs on GJs per group

The adults responded to the TO condition significantly faster than to the TS condition ($t(37)=2,386$; $p<0,03$), which resembles a garden-path effect albeit at the recall stage. The children responded more slowly to the transitive than to the intransitive verbs ($F(1,25)=6,704$; $p<0,02$), which might be attributed to the construction of two parallel structures in the on-line processing of the DP unmarked for case.

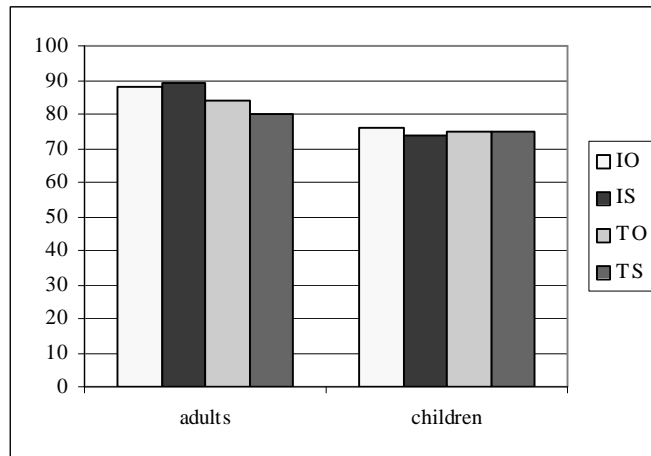
Graph 5 shows the RTs for the Case task:



Graph 5. Case Experiment: Mean RTs on GJs per group

The results showed no significant effects for either the adults or the children.

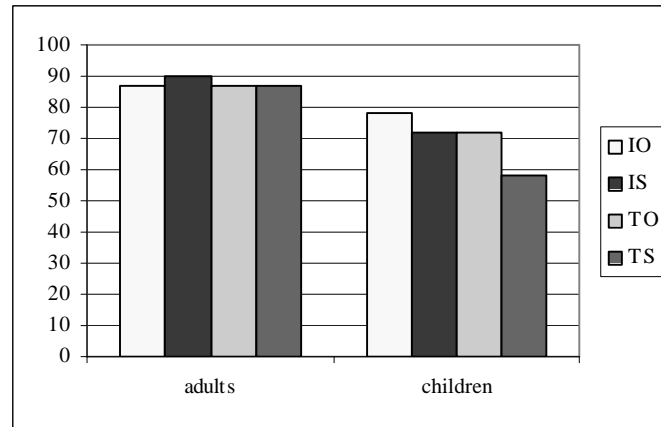
Graph 6 presents the data on accurate responses for the Agreement task for each group:



Graph 6. Agreement Experiment: Accuracy Percentages per group

There were no significant effects in either group, although overall adults were more accurate than the children.

Graph 7 depicts the accuracy data for the Case task:



Graph 7. Case Experiment: Accuracy percentages per group

No significant effects were obtained in the adult data. The child data revealed that the TS condition was responded to significantly less accurately than the TO condition ($t(25)=2,899$; $p<0,01$). Given the children's preference for the subject reading found in the RTs for both the Noun and the GJs we are presented with a speed-accuracy trade-off effect.

5. Conclusions

The results from our study suggest that in highly inflected languages morphological cues override syntactically based parsing strategies like Late Closure at the initial stage of parsing. In such languages, morphologically unmarked words might result in the generation of parallel structures, evidenced in the child and adult data from the Agreement experiment. In the Case task, we found evidence that the thematic processor operates on the Noun, i.e. a lexical category but not on the Determiner. Thus, the grammaticality effect found in the Agreement experiment on the main verb, also a lexical category, is accounted for. The difference between child and adult processing is (a) that no garden-path effects are found in the child data in either experiment and (b) that children show an early closure effect in the Case experiment which leads to a drop in their accuracy rates in the TS condition. The child findings are consistent with the claim that child processing is based on grammatical properties. In our study, children rely more on morphological cues for ambiguity resolution rather than on heuristics, like Late Closure, used by adults on the Determiner in the Case experiment.

References

- Felser, C. Marinis, Th., & Clahsen, H. 2003. Children's Processing of Ambiguous Sentences: A Study of Relative Clause Attachment. *Language Acquisition* 11(3): 127-163.
- Frazier, L. 1987. Theories of sentence processing. In J. Garfield (ed.), *Modularity in Knowledge Representation and Natural Language Understanding* (pp. 291-307). Cambridge, MA: MIT Press.
- Frazier, L., & Clifton, C. 1996. *Construal*. Cambridge, MA: MIT Press.
- Frazier, L., & Fodor, J.D. 1978. The sausage machine: a new two-stage parsing model. *Cognition* 6: 291-325.
- Frazier, L., & Rayner, K. 1982. Making and correcting errors during sentence comprehension: eye movements in the analysis of structurally ambiguous sentences. *Cognitive Psychology* 14: 178-269.
- Mitchell, D.C. 1987. Lexical guidance in human parsing: Locus and processing characteristics. In M. Coltheart (ed.), *Attention and Performance XII: The Psychology of Reading* (pp. 601-618). Hillsdale, NJ: Erlbaum.
- Pickering, M.J., & Traxler, M. J. 2003. Plausibility and recovery from garden-paths: An eye-tracking study. *Journal of Experimental Psychology: Learning, Memory and Cognition*, 24, 940-961.
- Pritchett, B.L. 1988. Garden-path phenomena and the grammatical basis of language processing. *Language* 64: 539-576.
- Pritchett, B.L. 1992. Parsing with grammar: Islands, heads, and garden paths. In H. Goodluck, & M. Rochemont (eds.), *Island Constraints: Theory, Acquisition, and Processing* (pp. 321-349). Dordrecht: Kluwer.
- Traxler, M. 2002. Plausibility and subcategorization preference in children's processing of temporarily ambiguous sentences: Evidence from self-paced reading. *Quarterly Journal of Experimental Psychology* 55A, 75-96.
- Weinberg, A. 2001. A Minimalist Theory of Human Sentence Processing. In S.D. Epstein and N. Hornstein (eds), *Working Minimalist* (pp. 283-314). Cambridge, MA: MIT Press.