

The Influence of Binding Theory on the On-line Reference Resolution of Pronouns

Jeffrey T. Runner, Rachel S. Sussman and Michael K. Tanenhaus

University of Rochester

1. Introduction

1.1. Binding Theory and Sentence Processing

This paper addresses the following main question: How do the structural constraints of Binding Theory interact with on-line sentence processing? There have been two types of answers to this question hypothesized in the literature: (1) the Initial Filter hypothesis, which claims that Binding Theory constrains the sentence processing system from the earliest moments of reference resolution (Nicol & Swinney, 1989; Sturt, 2003); and (2) the Multiple Constraints hypothesis, which claims that Binding Theory constraints are among a larger set of constraints applying simultaneously during sentence processing (Badecker & Straub, 2002).

We present the results of a study using eye-movements to investigate the role of Binding Theory during sentence processing. Our results show that from the very earliest moments participants consider both Binding Theory-compatible and Binding Theory-incompatible referents, which is inconsistent with the initial filter hypothesis, but consistent with the multiple constraints hypothesis.

1.2 Background

In Runner, Sussman & Tanenhaus (2003) we examined the role of Binding Theory on pronouns and reflexives in “picture” noun phrases (NPs) containing possessors (e.g., ‘Harry’s picture of him/himself’). Our participants were seated in front of display containing three male dolls (Joe, Ken, Harry); behind each doll was a column of digitized photos of all three dolls (Figure 1).



Figure 1

Participants listened to pre-recorded instructions (see (1)) containing two “lead-in” phrases asking them to pick up one doll and look at another. The lead-ins were followed by an “action” sentence instructing the participant to touch one of the photos with the doll she has just picked up. The lead-in phrases varied in order:

- (1) $\left\{ \begin{array}{l} \text{Pick up Joe. Look at Ken.} \\ \text{Look at Ken. Pick up Joe.} \end{array} \right\}$ Have Joe touch Harry’s picture of him/himself

The study yielded two types of results: target choices and eye movement data. For target choice (which doll’s picture the participant had the actor doll (here Joe) touch), Binding Theory (BT) correctly predicted the targets of pronoun trials, with fewer than 10% of trials violating BT; however, Binding Theory did significantly worse predicting the target choice for reflexives, with almost 30% of trials violating BT (Figure 2).

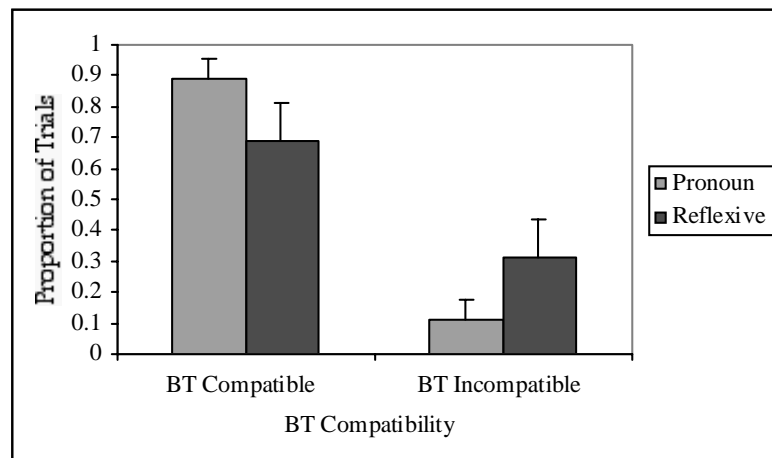


Figure 2

The second type of result we reported was the proportion of looks to the relevant pictures over time. Focusing on the reflexive trials in which participants followed BT (i.e., where they chose the picture of the possessor as target choice), Figure 3 graphs the

proportion of looks over time to the picture of the doll mentioned in the lead-in phrase, the picture of the subject doll, and the picture of the possessor. What this graph illustrates is that the picture of the BT-incompatible subject doll is being considered from the earliest moments of sentence processing, even on trials in which the participants actually chose the BT-compatible interpretation. If these reflexives are constrained by Binding Theory, this is strong evidence that BT is *not* acting as an initial filter.

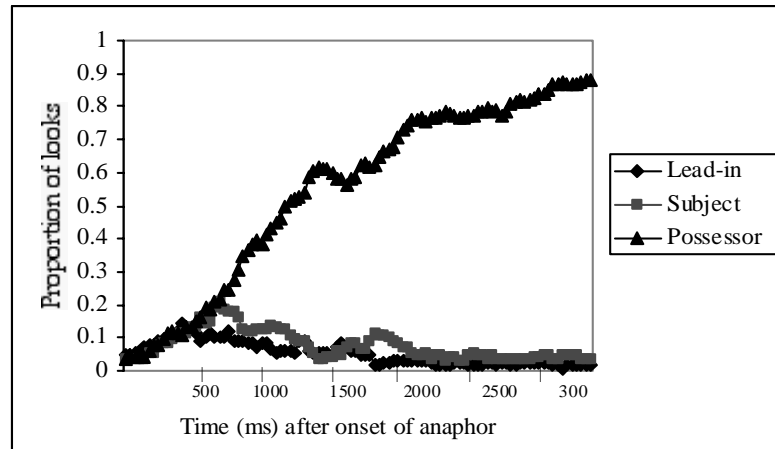


Figure 3

However, it may not be justified to reject the initial filter hypothesis based on these results. As argued by Runner, Sussman & Tanenhaus (2002) and Runner (2003), these reflexives may actually be logophors, a type of coreferential anaphor that is not constrained by Binding Theory. If this is the case, then Figure 3 does not illustrate the interaction of BT and sentence processing.

The Runner et al. (2003) study, though, did provide a candidate for testing the initial filter hypothesis. It showed that pronouns do seem to be constrained by Binding Theory. Recall the basic results presented in Figure 2, which showed that BT did a good job at predicting the target choices for pronouns. If pronouns are constrained by BT, then an analysis of the early looks on the pronoun trials should illustrate the role of BT in sentence processing.

Figures 4 and 5 show the proportion of looks over time on the pronoun trials. Figure 4 contains the trials in which the subject doll was mentioned first (the “pick up” lead-in preceded the “look at” lead-in); Figure 5 shows the trials in which the subject doll was mentioned second. What we see by examining these graphs is that there are early looks to the relevant pictures of the BT-compatible subject and lead-in dolls, but there also seem to be early looks to the picture of the BT-incompatible possessor doll.

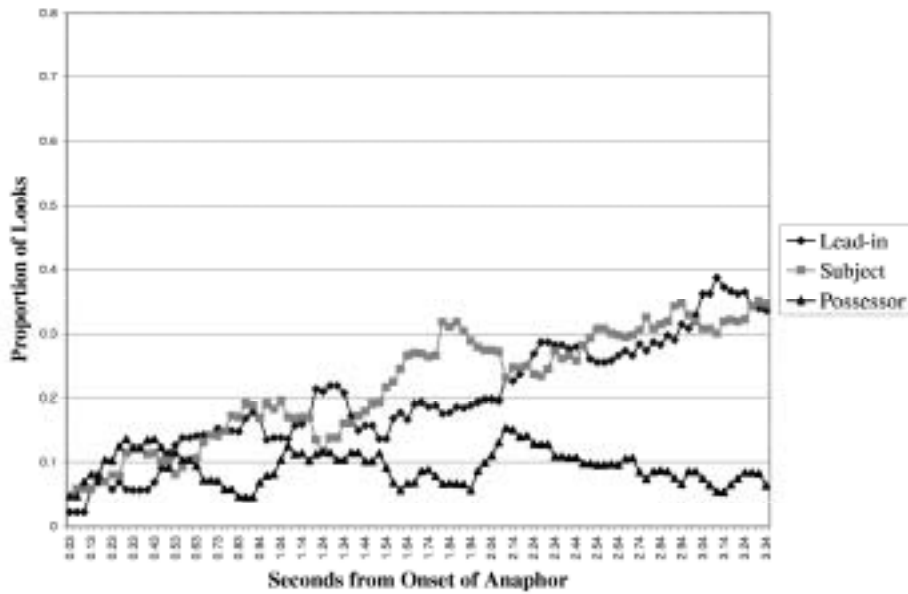


Figure 4



Figure 5

Unfortunately, because of the design of the experiment, the relevant comparison is missing. As (1) shows, every instruction began with two lead-in phrases. This provided two BT-compatible potential referents, and only one BT-incompatible one. What may have happened, then, is that the looks to the two BT-compatible referents may have been divided, providing the impression that the looks to the BT-incompatible possessor were higher than they actually were. The comparison that is needed is one in which there is only one BT-compatible potential referent and one BT-incompatible potential referent. If the looks to these two potential referents do not differ early on, then

this will show that the Binding Theory is not acting as an early filter on sentence processing.

2. Current Study

2.1. Experiment

The main question we were interested in was the following: How does the Binding Theory constraint on pronouns apply during on-line sentence processing? In particular, we wanted to do this in a way that would provide the appropriate comparisons (see above). Our secondary goal was to replicate the basic results of Runner, Sussman & Tanenhaus (2003) using instructions recorded by “naïve” speakers.

Participants were again seated in front of the display in Figure 1. They heard instructions like the following:

- (2) Pick up Joe. Have Joe touch Ken’s picture of him/himself.

These instructions contained only a single lead-in phrase, which asked the participant to pick up the doll that would be the subject of the action sentence. Thus, there is one BT-compatible potential antecedent mentioned (the subject) and one BT-incompatible potential antecedent (the possessor).

The instructions were recorded by three naïve speakers, who were told they were recording instructions for an experiment. They pronounced the instructions after having the Binding Theory-compatible action modeled by one of the researchers. These instructions were then used in the current experiment with 24 additional listeners. The intent here was to see what effect pronunciations intended to elicit a BT-compatible action would have on the actual actions of listeners.

2.2. Results

First, our results successfully replicated the basic target choice results of Runner et al. (2003): Binding Theory did a good job of predicting the pronoun choices (less than 10% BT violation) but a worse job of predicting the reflexive choices (over 20% BT violation). This result is particularly interesting given that the instructions were recorded by naïve speakers and were intended to elicit BT-compatible actions only.

To evaluate our main question of whether Binding Theory is acting as an early filter on the reference resolution of pronouns we isolated the earliest looks, the first 1000 ms after the onset of the pronoun. As Figure 6 shows, looks to the picture of the BT-compatible subject (Ken’s picture of Joe in the example) and to the picture of the BT-incompatible possessor (Ken’s picture of Ken) increase together from the earliest moments of processing. It is only later on that looks to the picture of the possessor start to decrease. This seems inconsistent with the main claim of the early filter hypothesis. It is consistent with the claim of the multiple constraints hypothesis, since the effects of

Binding Theory do gradually appear, resulting in a pattern of looks very similar to the final target choices.

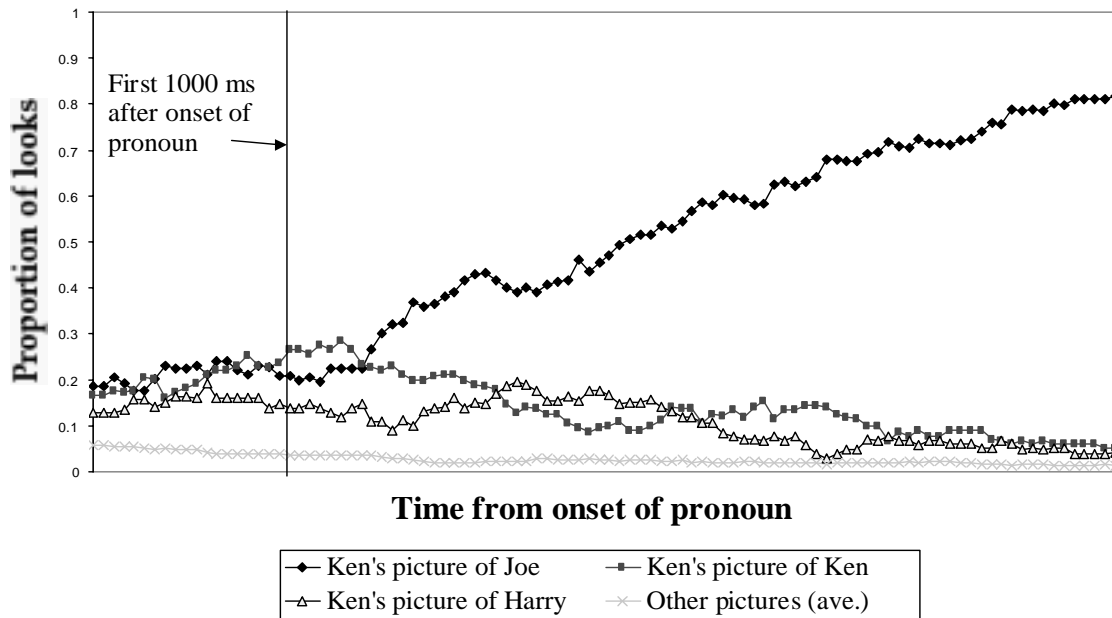


Figure 6

To help clarify the details of the time course graph we also analyzed the total proportion of looks to the objects in the display during that first 1000 ms. Figure 7 shows these results.

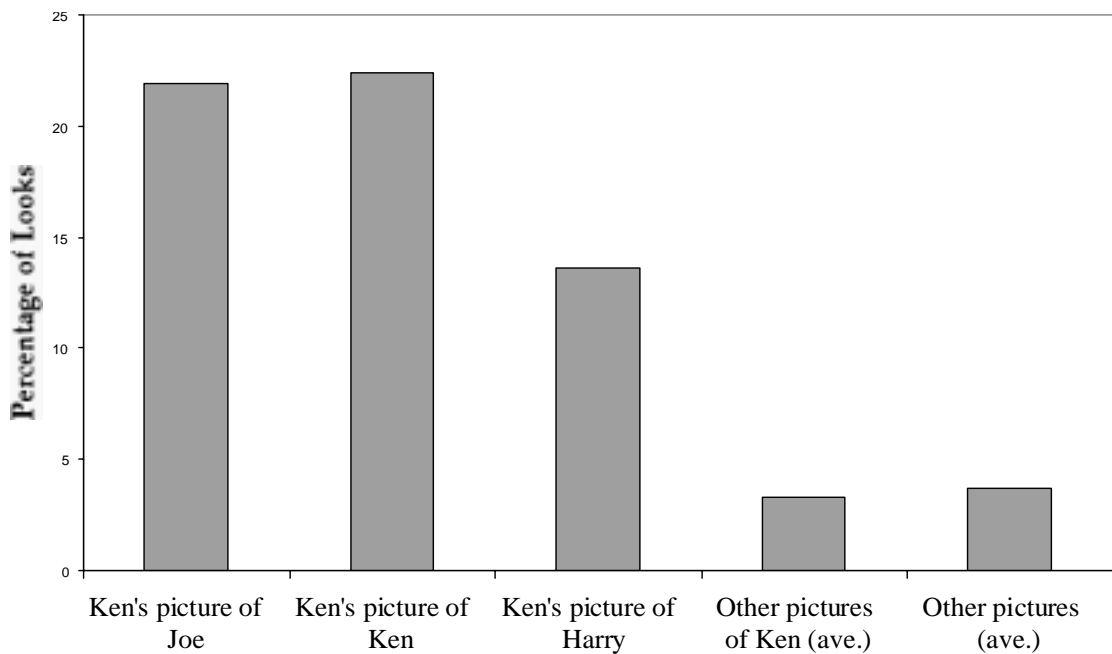


Figure 7

Looks to the picture of the BT-compatible subject (Ken's picture of Joe) and looks to the picture of the BT-incompatible possessor (Ken's picture of Ken) do not differ (unless otherwise stated, all differences mentioned are at the standard p-level of $<.05$). That means that during the earliest moments of processing, looks to these two pictures are equally likely. This is very strong evidence against the initial filter hypothesis, which would predict looks to the BT-compatible referent (the subject) to be increased in comparison with looks to BT-incompatible referents during this time period.

To rule out the possibility that the increased looks to the possessor were simply due to the fact that participants had to scan the relevant column of pictures before finding the correct photo, we compared the proportion of looks to the possessor to those of the third unmentioned doll in the same column (Ken's picture of Harry); the proportion of looks to the possessor were significantly greater than those to that third picture (Figure 7), suggesting again that participants were considering the possessor as a potential referent contra Binding Theory.

Finally, to rule out the possibility that participants were primed to look at pictures of the possessor simply because it had been mentioned, we compared looks to the other pictures of the possessor with looks to the other pictures (including those of the subject); these proportions were not different either (Figure 7), again suggesting that the prior mention of the possessor cannot alone account for the increased looks.

3. Conclusions

The results of the current experiment are inconsistent with the initial filter hypothesis. From the earliest moments of pronoun reference resolution, pictures of both the BT-compatible subject and BT-incompatible possessor were equally considered. The early looks cannot be attributed to scanning the scene or to prior mention of the possessor. What we find instead is that the effects of Binding Theory are gradual, only clearly appearing well after the first 1000 ms of processing, a result consistent with the multiple constraints hypothesis.

References

- Badecker, William and Kathleen Straub. 2002. The Processing Role of Structural Constraints on the Interpretation of Pronouns and Anaphors. *Journal of Experimental Psychology: Learning, Memory, and Cognition* 28: 748-769.
- Nicol, Janet and David Swinney. 1989. The Role of Structure in Coreference Assignment During Sentence Comprehension. *Journal of Psycholinguistic Research* 18: 5-19.
- Runner, J.T. 2003. Insights into Binding and Ellipsis from Head-mounted Eye-tracking Experiments. In *Chicago Linguistic Society 39 Proceedings*.
- Runner, Jeffrey T., Rachel S. Sussman and Michael K. Tanenhaus. 2002. Logophors in Picture Noun Phrases. In *WCCFL 21 Proceedings*, ed. L. Mikkelsen and C. Potts. Somerville, MA: Cascadilla Press.

Runner, Sussman & Tanenhaus

Runner, Jeffrey T., Rachel S. Sussman and Michael K. Tanenhaus. 2003. Assignment of Reference to Reflexives and Pronouns in Picture Noun Phrases: Evidence from Eye Movements. *Cognition* 89: B1-B13.

Sturt, Patrick 2003. The Time-Course of the Application of Binding Constraints in Reference Resolution. *Journal of Memory and Language* 48: 542-562.

Department of Linguistics
Box 270096
University of Rochester
Rochester, NY 14627

runner@ling.rochester.edu