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Brief article

## Assignment of reference to reflexives and pronouns in picture noun phrases: evidence from eye movements

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### Abstract

Most structural Binding Theories predict a complementary distribution between reflexives and pronouns in picture noun phrases containing possessors (e.g. “Ken’s picture of himself/him”). In two head-mounted eye-tracking experiments, listeners frequently violated Binding Theory predictions for reflexives, often interpreting the reflexives as taking an antecedent outside of the binding domain, and violating complementarity assumptions. Moreover, the pattern and timing of the eye movements showed Binding Theory violations for reflexives during the earliest moments of reference resolution. The results demonstrate that either binding constraints must be reformulated to decouple pronouns and reflexives or all reflexives in picture noun phrases must be treated as logophors, and thus exempt from structural Binding Theory.

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### 1. Introduction

The “binding” conditions that determine the referential domain for the interpretation of pronouns and reflexives have played an important role in syntactic theory since the 1960s, when structural conditions on pronouns and reflexives were first studied (e.g. [Langacker, 1969](#); [Ross, 1969](#)). Binding Theory is currently used to explain the referential domains for

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pronouns and reflexives, as a tool for diagnosing syntactic structure, and as a constraint affecting the real-time interpretation of pronouns and reflexives.

Structural Binding Theories predict that reflexives and pronouns are in complementary distribution, with reflexives required to find an antecedent within a local domain and pronouns required to find an antecedent outside of that domain. Thus, in example (1), ‘himself’ and ‘John’ must co-refer, whereas ‘him’ and ‘John’ must not.

- (1) John was impressed with himself/him.

Structural Binding Theories predict a similar pattern for “picture” noun phrases (NPs) containing possessors (e.g. [Chomsky, 1981](#); [Pollard & Sag, 1992](#); [Reinhart & Reuland, 1993](#)):

- (2) Joe saw Ken’s picture of himself/him.

Ken is predicted to be the antecedent of ‘himself’ and Joe is predicted to be the antecedent of ‘him’.

We tested this prediction using the head-mounted eye-tracking paradigm ([Tanenhaus, Spivey-Knowlton, Eberhard, & Sedivy, 1995](#)) in which participants followed spoken instructions to pick up a doll, e.g. “Joe”, and use it to touch one of another doll’s pictures (e.g. Ken’s picture of himself). The participants’ choice of referent and the timing and pattern of looks to potential referents provided information about which alternative referents were considered as participants processed instructions containing reflexives and pronouns.

## **2. Experiment 1**

Participants were seated in front of the display pictured in [Fig. 1](#). The display contained three male dolls, Ken, Joe, and Harry, each with distinct facial features. Digitized pictures of the dolls’ faces were mounted on a board in a column directly above each doll, which the participant was told “belonged” to that doll, i.e. the three pictures in the column above Joe were Joe’s pictures. Each trial contained a lead-in phrase instructing the participant to look at one of the dolls (e.g. “Look at Ken”), followed by an action sentence containing either a reflexive or a pronoun.

This experiment tested the predictions of Binding Theory in picture NPs with possessors. Consider the instruction, “Look at Ken. Have Joe touch Harry’s picture of him.”. The Binding Theory condition on pronouns predicts that participants should have the doll performing the action (e.g. Joe) touch either the picture of Joe or the picture of Ken above Harry, but never the picture of Harry. If participants instead heard, “Look at Ken. Have Joe touch Harry’s picture of himself.”, the Binding Theory condition on reflexives predicts that participants will choose Harry’s picture of Harry as the correct referent.

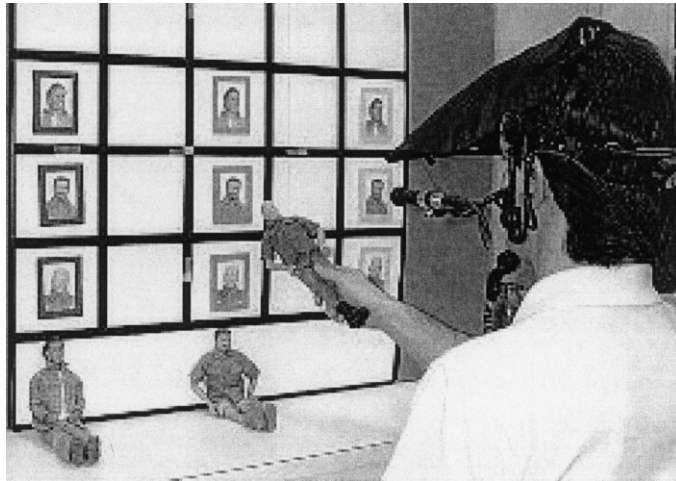


Fig. 1. Display.

## *2.1. Method*

### *2.1.1. Participants*

The participants were 16 members of the University of Rochester community, all of whom were native speakers of English.

### *2.1.2. Materials*

Two variables were manipulated: anaphor type (pronoun or reflexive) and lead-in type (different or same as doll performing the action) (see [Table 1](#)).

Three versions of each instruction were constructed, varying which of the dolls was mentioned in the lead-in and action sentences, resulting in 24 trials. Experiment 1 had embedded within it a sub-experiment including six other instructions for a total of 30 trials.<sup>1</sup> Instructions were counterbalanced and organized into three blocks. Placement of the dolls on the table was randomized between subjects so that each order was equally represented across all of the subjects.

### *2.1.3. Procedure*

Instructions were recorded and digitized for presentation using PsyScope experimental-control software ([Cohen, MacWhinney, Flatt, & Provost, 1993](#)). We used neutral prosody

<sup>1</sup> Experiments 1 and 2 each contained a “control” sub-experiment with simple unambiguous instructions containing reflexives and pronouns (e.g. Look at Joe. Have Ken touch (a picture of) him/himself). The predictions of Binding Theory were borne out in 95–100% of the trials, with no asymmetry between pronouns and reflexives, thus validating the methodology.

Table 1  
Experiment 1 materials

Lead-in	Subject	Possessor		Anaphor
Look at Ken	Have Joe touch	Harry's	picture of	him
Look at Joe				himself

with no unusual pitch accents or stress on the pronouns and reflexives.<sup>2</sup> Participants were first familiarized with the dolls and the display by following instructions containing full NPs. They performed the task by picking up the relevant doll and using it to touch a picture. Eye movements were monitored using an ASL head-mounted eye-tracker (Series 5000). The system software superimposed the fixations on a video recorded from a scene camera mounted on the tracker headband. The instructions and the scene were recorded for analysis with a Sony Hi8 videocassette recorder EVO-9650.

## 2.2. Results

The data were coded manually by the experimenters and trained research assistants. On 94.9% of the pronoun trials, participants chose the relevant picture of the subject or lead-in of the sentence, whereas on 74.8% of the reflexive trials, participants chose the relevant picture of the possessor of the picture NP (see Fig. 2), resulting in a main effect of Binding Theory compatibility ( $F(1, 13) = 54.33$ ,  $MSE = 6.81$ ,  $P < 0.01$ ;  $F(1, 5) = 739.79$ ,  $MSE = 5.40$ ,  $P < 0.01$ ). A significant interaction with type of anaphor ( $F(1, 13) = 5.28$ ,  $MSE = 0.56$ ,  $P < 0.04$ ;  $F(1, 5) = 38.01$ ,  $MSE = 0.54$ ,  $P < 0.01$ ) reflected the fact that participants violated Binding Theory more often for reflexives. Table 2 displays the total proportion of looks to the pictures of the dolls mentioned in the instructions, which also shows a main effect of compatibility ( $F(1, 12) = 43.55$ ,  $MSE = 0.60$ ,  $P < 0.01$ ;  $F(1, 5) = 127.01$ ,  $MSE = 0.25$ ,  $P < 0.01$ ) and a marginal interaction with type of anaphor ( $F(1, 12) = 3.74$ ,  $MSE = 0.06$ ,  $P < 0.08$ ;  $F(1, 5) = 3.75$ ,  $MSE = 0.13$ ,  $P = 0.11$ ).

On trials with a distinct lead-in and subject, participants chose the subject of the sentence as the antecedent on 21.9% of the pronoun trials and on 23.8% of the reflexive trials. Under standard assumptions of complementarity, two elements in complementary distribution should not exhibit such similar behavior in the same syntactic environment.

<sup>2</sup> An anonymous reviewer suggested that although the instructions were pre-recorded with neutral prosody, some feature of the prosody might nonetheless have encouraged participants to violate Binding Theory. We tested for this possibility by having three naive participants generate the instructions after we first modeled the desired interpretation. For example, before the participant read the instruction, "Have Joe touch Harry's picture of himself", she was shown Joe touching Harry's picture of Harry. All instructions were preceded by actions that were consistent with Binding Theory. These instructions were recorded and then used with a group of 12 naive participants using the same procedure as in Experiments 1 and 2. The results replicated the pattern observed in Experiments 1 and 2. Binding Theory was followed on 95% of the trials with pronouns compared to only 79% of the trials with reflexives.

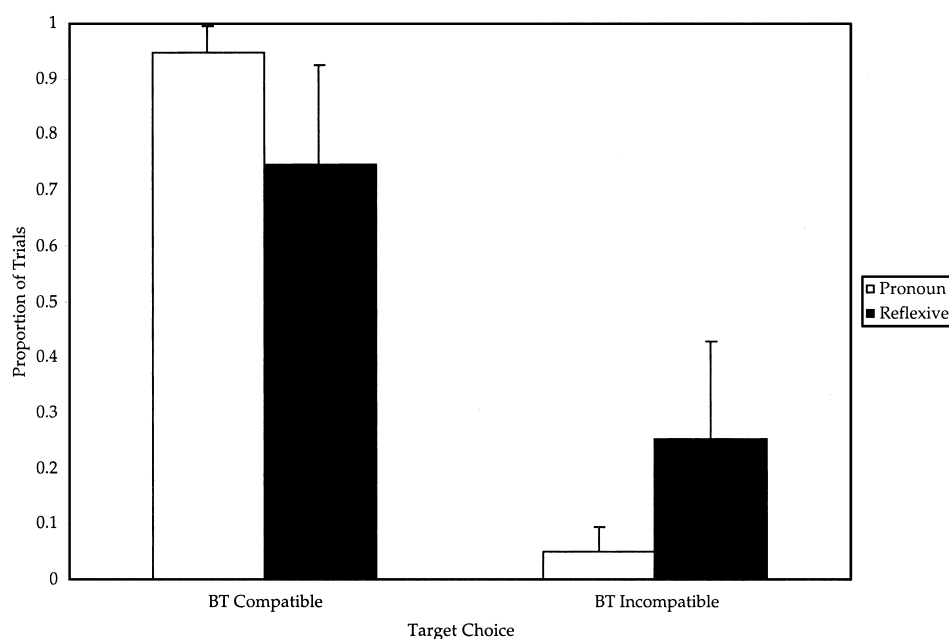


Fig. 2. Proportion of trials with target choices consistent with Binding Theory for reflexives and pronouns in Experiment 1.

### 2.3. Discussion

The pattern of results is contrary to the predictions of Binding Theory. First, reflexives frequently violated Binding Theory. Second, and perhaps more seriously, reflexives and pronouns did not have complementary referential domains.

Given the theoretical importance of complementarity for Binding Theory, we explored two possible explanations for the results that might not require abandoning or weakening the complementarity assumption. First, the choice of Binding Theory incompatible targets for reflexives might reflect pragmatic biases in a second stage of processing after an initial stage defined by structural Binding Theory (cf. Nicol & Swinney, 1989; Sturt, *in press*). If participants were initially considering the possessor as a potential referent, this should be reflected in early looks to the picture of the possessor that would precede looks to the

Table 2  
Experiment 1 proportion of Binding Theory (BT) compatible and BT incompatible looks to appropriate pictures of dolls mentioned in instructions

	Pronoun	Reflexive
BT compatible	0.41	0.31
BT incompatible	0.12	0.16

subject or lead-in. Unfortunately, the sequence of instructions resulted in poor time-locking of eye movements to the instruction; during the action instruction, e.g. “Have Harry touch Ken’s picture of himself”, participants were often still reaching for the doll at the onset of the anaphor and thus were still fixating on the doll. In Experiment 2, the instructions were modified so that the subjects always had the doll in hand before hearing the action instruction.

Second, the referential domains for pronouns and reflexives might be complementary, but only probabilistically. On this view, the subject is a possible, but dispreferred antecedent for both pronouns and reflexives, with the subject’s availability as a reflexive antecedent being inversely linked to its availability as a pronoun antecedent. Thus, factors affecting the preferred interpretation of the pronoun should also affect the referential domain for the reflexive. In Experiment 2 we manipulated the availability of the subject as the antecedent for the pronoun to see if this would affect its likelihood of being chosen as the antecedent for the reflexive.

### **3. Experiment 2**

The accessibility of the subject as a potential referent for a subsequent pronoun was manipulated by using two lead-in instructions. One instructed participants to look at one doll (e.g. “Look at Ken”). The other told them to pick up another doll (e.g. “Pick up Joe”). These lead-in sentences were then followed by the same sort of action sentences as in Experiment 1 (e.g. “Have Joe touch Harry’s picture of him/himself”). The doll mentioned in the “pick up” lead-in was always the doll doing the action. Thus, participants would have the correct doll in hand when the instruction with the anaphor began, increasing the likelihood that eye movements to the referent would be closely time-locked to the anaphor. The timing and patterns of fixations should be informative about what entities are being considered as potential referents in the earliest moments of reference resolution. Support for a two-stage model of reference resolution would come from evidence that participants initially consider a picture of the possessor as a potential referent for reflexives, as indexed by looks to that picture, or delayed looks to the Binding Theory incompatible target.

The order in which participants heard the two lead-in sentences varied across trials. Changing the order of mention should affect reference choice for pronouns, with the preferred referent being the doll mentioned in the second (most recent) lead-in sentence (Garnham, 2001). The crucial issue was whether these manipulations would have a complementary effect on the interpretation of reflexives. Binding Theory predicts that for pronouns, any referent other than the possessor of the picture NP should be available, and for reflexives, only the possessor should be available. Given the results of Experiment 1, however, we expected that for a proportion of the trials the subject would be available as the antecedent for the reflexive. The logic behind the manipulation is this: we expect pronouns to prefer the sentence-external NP that is less remote, i.e. the second lead-in (due to “recency”, cf., Arnold, Eisenbaand, Brown-Schmidt, & Trueswell, 2000). On trials where the second lead-in was also the subject of the sentence, the pronoun should prefer that referent as its antecedent. If the probabilistic complementarity hypothesis is correct, as

Table 3  
Experiment 2 materials

First lead-in	Second lead-in		Anaphor
Pick up Joe	Look at Ken	Have Joe touch Harry's picture of	him
Look at Ken	Pick up Joe		himself

the subject becomes a better pronoun antecedent, it should become a poorer reflexive antecedent, and vice versa.

*3.1. Method*

*3.1.1. Participants*

The participants were 18 members of the University of Rochester community.

*3.1.2. Materials*

Two variables were manipulated (see Table 3): anaphor type (pronoun or reflexive) and lead-in order (whether the lead-in containing the doll referring to the subject came first or second).

Instructions and displays were constructed and counterbalanced as in Experiment 1. Experiment 2 contained a sub-experiment including six trials (see footnote 1) and also included another 30 filler trials containing sentences with full NPs, for a total of 60 trials.

*3.1.3. Procedure*

The procedure was identical to that of Experiment 1 except we used an ISCAN EC-501 head-mounted eye-tracker. Data were recorded onto digital tapes again using neutral prosody, and analyzed using a digital editing VCR with synchronized audio and video (Sony DSR-30).

*3.2. Results and discussion*

The data were coded as in Experiment 1. On 88.9% of pronoun trials, participants chose the relevant picture of the subject or lead-in, whereas they chose the possessor on only 68.9% of the reflexive trials, resulting in a main effect of Binding Theory compatibility

Table 4  
Experiment 2 proportion of BT compatible and BT incompatible looks to appropriate pictures of dolls mentioned in instructions

	Pronoun	Reflexive
BT compatible	0.44	0.33
BT incompatible	0.15	0.23

( $F(1, 17) = 32.87$ ,  $MSE = 12.04$ ,  $P < 0.01$ ;  $F(1, 5) = 276.25$ ,  $MSE = 4.23$ ,  $P < 0.01$ ) and an interaction with type of anaphor ( $F(1, 17) = 5.33$ ,  $MSE = 1.45$ ,  $P = 0.03$ ;  $F(1, 5) = 17.75$ ,  $MSE = 0.50$ ,  $P < 0.01$ ). Analyses of total proportion of looks to the appropriate pictures of the mentioned referents (see Table 4) also yielded a main effect of Binding Theory compatibility ( $F(1, 17) = 22.41$ ,  $MSE = 1.37$ ,  $P < 0.01$ ;  $F(1, 5) = 145.38$ ,  $MSE = 0.30$ ,  $P < 0.01$ ) and an interaction with type of anaphor ( $F(1, 17) = 12.83$ ,  $MSE = 0.31$ ,  $P < 0.01$ ;  $F(1, 5) = 4.32$ ,  $MSE = 0.16$ ,  $P = 0.09$ ), replicating the results from Experiment 1.

Lead-in order affected pronoun responses more than reflexive responses (see Table 5), resulting in an anaphor by lead-in order interaction ( $F(1, 17) = 17.77$ ,  $MSE = 0.50$ ,  $P < 0.01$ ;  $F(1, 5) = 25.29$ ,  $MSE = 0.16$ ,  $P < 0.01$ ). Planned comparisons demonstrated that the lead-in manipulation affected the proportion of subject choices for the pronouns, but not for the reflexives. A similar analysis on the total proportion of looks to the relevant picture of the subject (see Table 6) also revealed a main effect of type of anaphor ( $F(1, 17) = 6.41$ ,  $MSE = 0.19$ ,  $P = 0.02$ ;  $F(1, 5) = 9.61$ ,  $MSE = 0.02$ ,  $P < 0.03$ ), and of lead-in order ( $F(1, 17) = 23.59$ ,  $MSE = 0.09$ ,  $P < 0.01$ ;  $F(1, 5) = 18.69$ ,  $MSE = 0.03$ ,  $P < 0.01$ ), and an interaction between the two ( $F(1, 17) = 7.56$ ,  $MSE = 0.03$ ,  $P = 0.01$ ;  $F(1, 5) = 6.72$ ,  $MSE = 0.01$ ,  $P < 0.05$ ). Again, planned comparisons showed that the lead-in manipulation affected the proportion of looks to the subject for pronouns but not for reflexives.

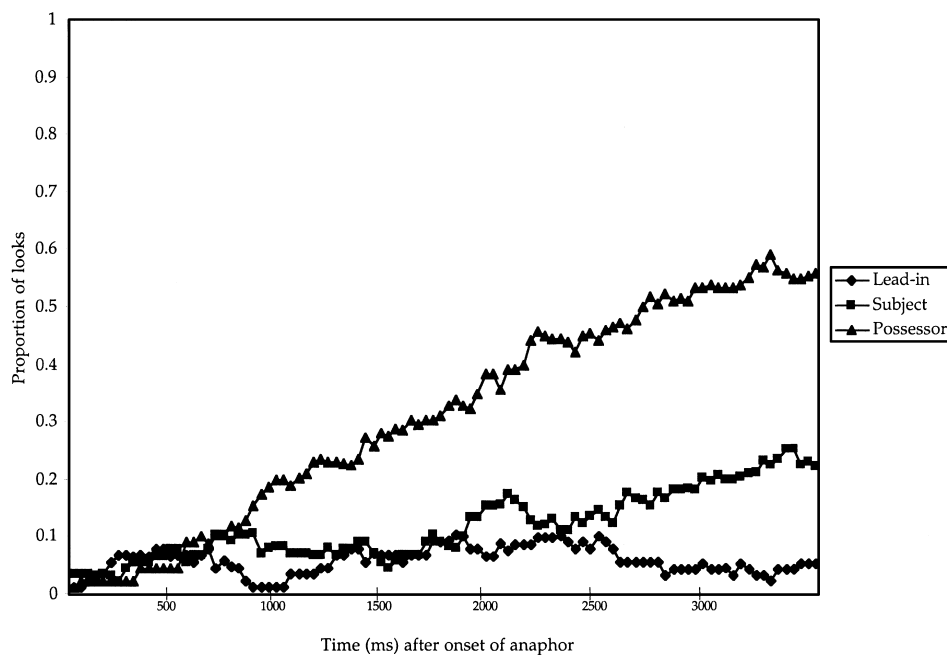


Fig. 3. Proportion of looks to the lead-in, subject and possessor in 33 ms time slices beginning with the onset of the anaphor for the reflexives in the subject-first condition in Experiment 2.

Table 5  
Experiment 2 proportions of target choices

	Pronoun			Reflexive		
	Lead-in	Subject	Possessor	Lead-in	Subject	Possessor
Subject pick up first	0.51	0.44	0.05	0.00	0.35	0.65
Subject pick up second	0.17	0.68	0.15	0.01	0.27	0.72

Table 6  
Experiment 2 proportion of looks to appropriate pictures of subjects on subject-first and subject-second conditions

	Pronoun	Reflexive
Subject-first	0.20	0.14
Subject-second	0.31	0.17

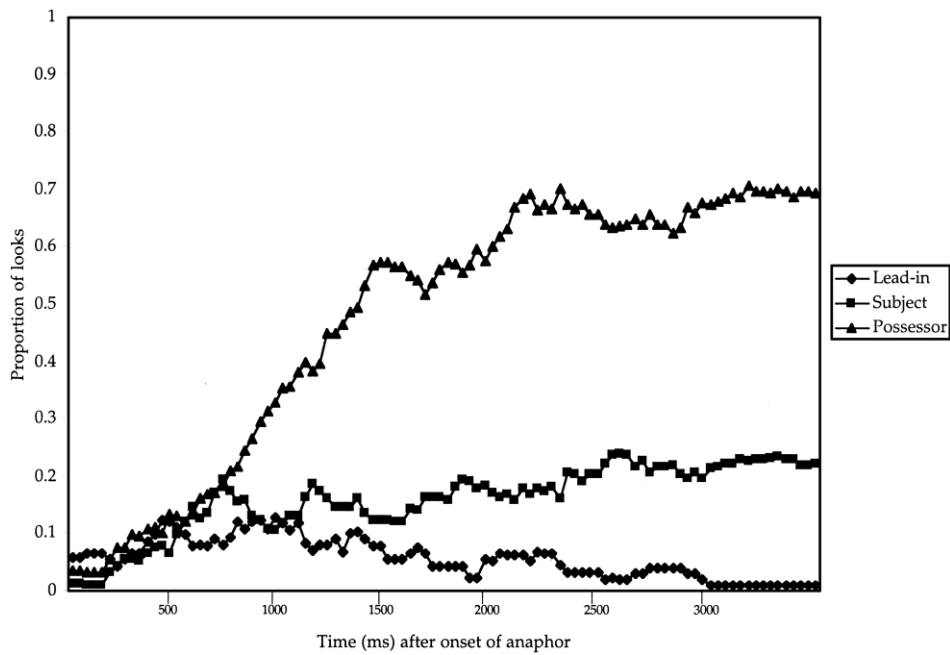


Fig. 4. Proportion of looks to the lead-in, subject and possessor in 33 ms time slices beginning with the onset of the anaphor for the reflexives in the subject-second condition in Experiment 2.

Figs. 3 and 4 show the proportion of fixations to pictures of the lead-in, the subject and the possessor for reflexives in the subject-first and subject-second lead-in conditions, respectively. The figures reveal tight time-locking between the onset of the reflexive and looks to potential antecedents. Crucially there is no hint of an early point in processing in which looks to the possessor preceded looks to the subject as would be expected if binding—as defined by classical Binding Theory—were operating as an early first-stage filter. Fig. 5 shows that the same pattern of results held even on those trials where participants chose the possessor as the referent.

The time course of the looks allowed us to evaluate another hypothesis for why looks to the subject were so frequent shortly after the onset of the reflexive. Despite phonetic differences between ‘him’ and the ‘him’ in ‘himself’, one might argue that participants could have been temporarily garden-pathed on some proportion of trials, briefly hearing ‘himself’ as ‘him’, and therefore initially considering the referents that Binding Theory predicts are appropriate to pronouns. Such a word-internal garden path associated with the reflexive form might account for the early looks to the subject referent for reflexives in picture NPs with possessors in both Experiments 1 and 2 without assuming that Binding Theory is being violated. Fig. 6 presents the proportion of fixations to the subject for the first 400 ms of the speech stream beginning with the onset of the pronoun and reflexive. The first 200 ms of this time window should not include any fixations that are programmed in response to input from the anaphor (Allopenna, Tanenhaus, & Magnuson, 1998). Thus,

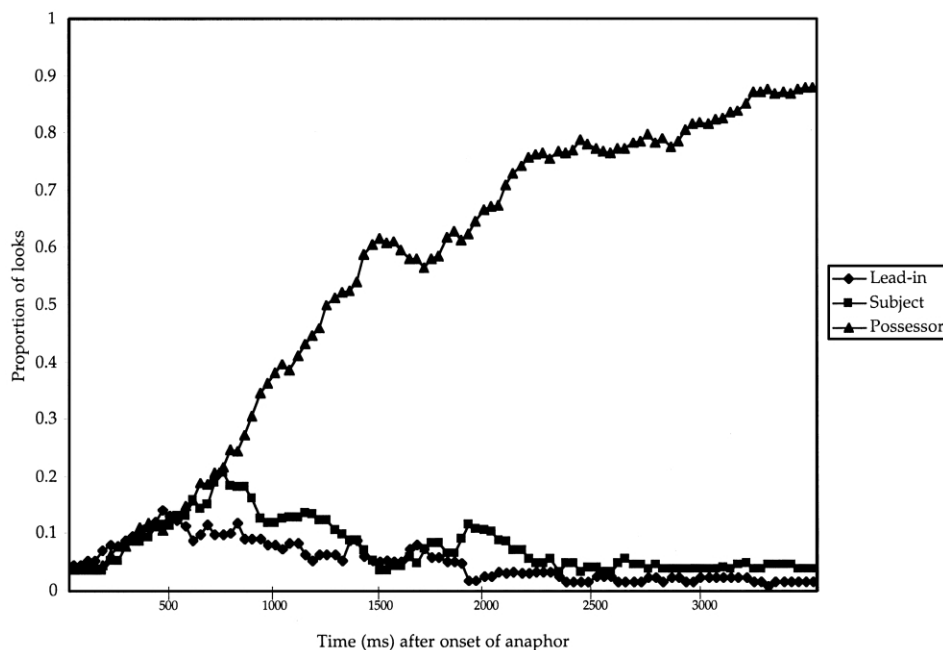


Fig. 5. Proportion of looks to the lead-in, subject and possessor in 33 ms time slices beginning with the onset of the anaphor for the reflexives when the possessor was chosen as the target in Experiment 2.

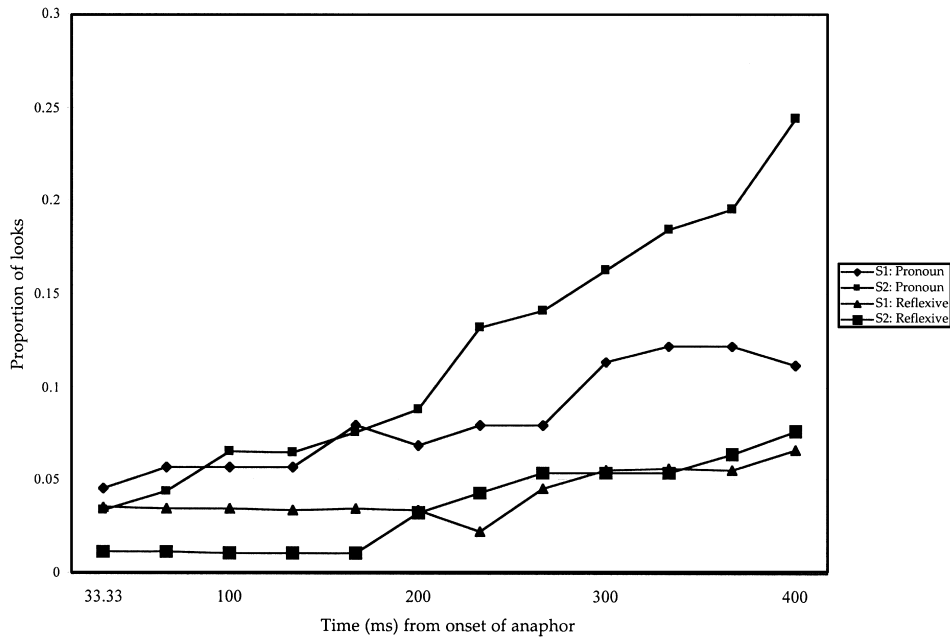


Fig. 6. Earliest looks to the subject for sentences with pronouns and reflexives in the subject-first and subject-second conditions in Experiment 2.

no differences among conditions are expected in this time window. For pronoun trials an effect of lead-in order begins to emerge shortly after 200 ms with the proportion of fixations to the subject increasing more rapidly in the subject-second condition compared to the subject-first condition. If listeners were initially processing the beginning of the reflexive ‘himself’ as if it were the pronoun ‘him’ there should be a similar pattern of fixations for reflexives. However, there is no hint of a discourse effect for the reflexives.

#### 4. Discussion and conclusions

The pattern of results from both Experiments 1 and 2 is contrary to the expectations of Binding Theory. Responses to reflexives frequently violated Binding Theory. Moreover, reflexives and pronouns did not have fully complementary referential domains. Experiment 2 ruled out two possible explanations for these results that would not require abandoning the complementarity assumption. One was that the choice of Binding Theory inconsistent targets for reflexives reflects pragmatic biases that come into play only in a second stage of processing after an initial stage of Binding Theory compatible processing. However, initial looks to Binding Theory consistent targets did not precede looks to Binding Theory inconsistent targets. The other was that the referential domains for pronouns and reflexives are complementary, but probabilistic, allowing some overlap in the distribution of the two types of anaphor. This approach predicted that as the

availability of a pronoun antecedent increases its availability as a reflexive antecedent should decrease. This prediction was not confirmed.

The results present a challenge to Binding Theory by demonstrating that it makes incorrect predictions about both the referential domain for reflexives and the complementarity of the referential domains for pronouns and reflexives. A modified form of structural Binding Theory might accommodate these results, either by revising the definition of subject for reflexives to exclude possessors, or by abandoning the complementarity assumptions that have been a hallmark of Binding Theory. Either approach would have significant implications for syntactic theory.

An alternative to pursue in future research is that reflexives in picture NPs with possessors are “logophors” and thus “exempt” from Binding Theory, as has been argued for reflexives in simple picture NPs by Pollard and Sag (1992) and Reinhart and Reuland (1993). While this approach would restrict Binding Theory to verbal NP arguments, it would allow one to maintain the claim that Binding Theory accurately predicts a complementarity between reflexives and pronouns in domains other than picture NPs (see Sturt, *in press*). Logophoric reflexives are argued to be sensitive to pragmatic factors such as “point of view”, “source”, and “awareness” (Kuno, 1987). Thus, support for this approach would come from evidence that the reflexive in picture NPs with possessors is also sensitive to these factors, whereas the reflexive in simple verb phrase constructions is not – a prediction we are currently testing.

### Acknowledgements

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