

# Sentential focus affects visual attention toward potential verb arguments



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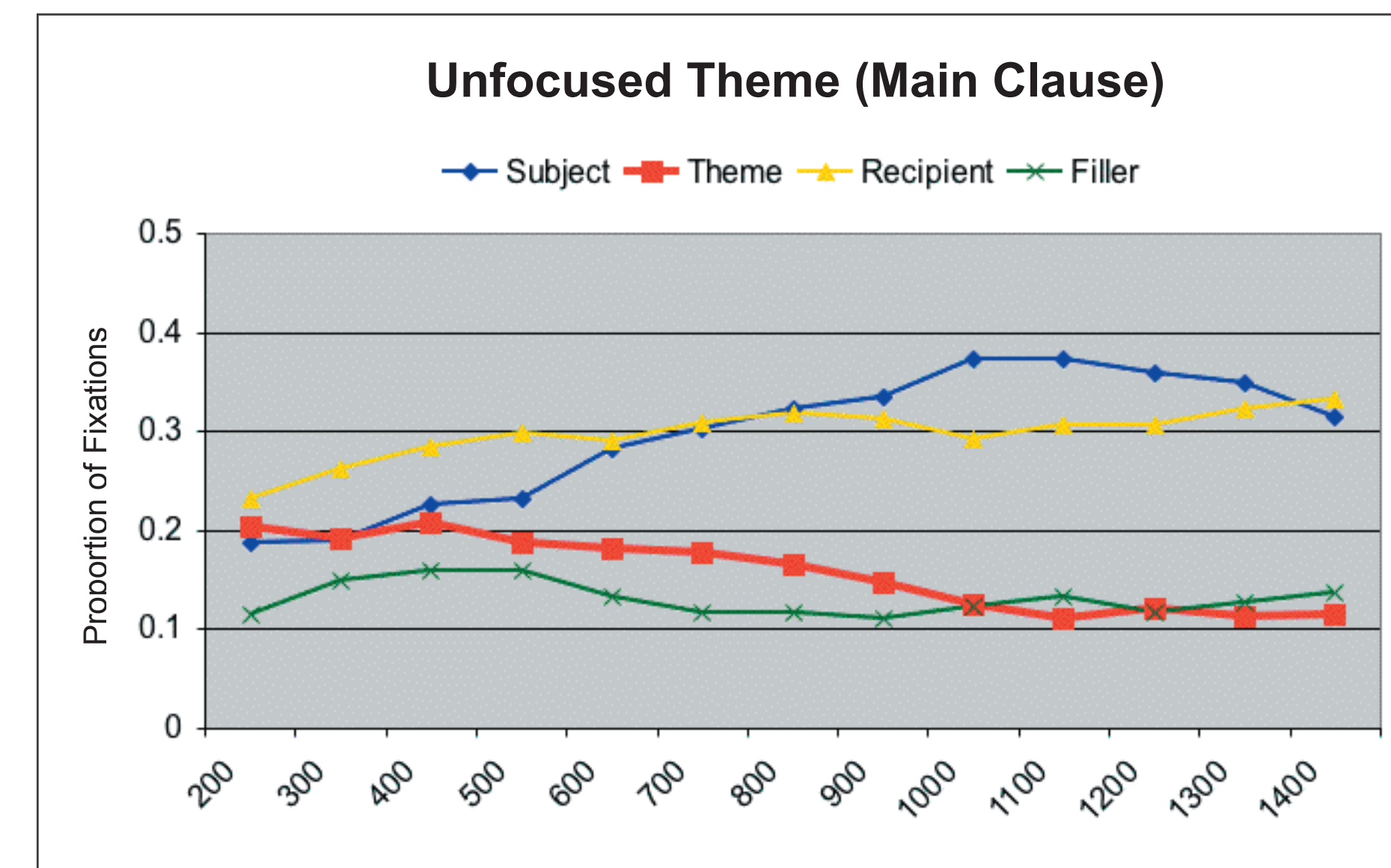
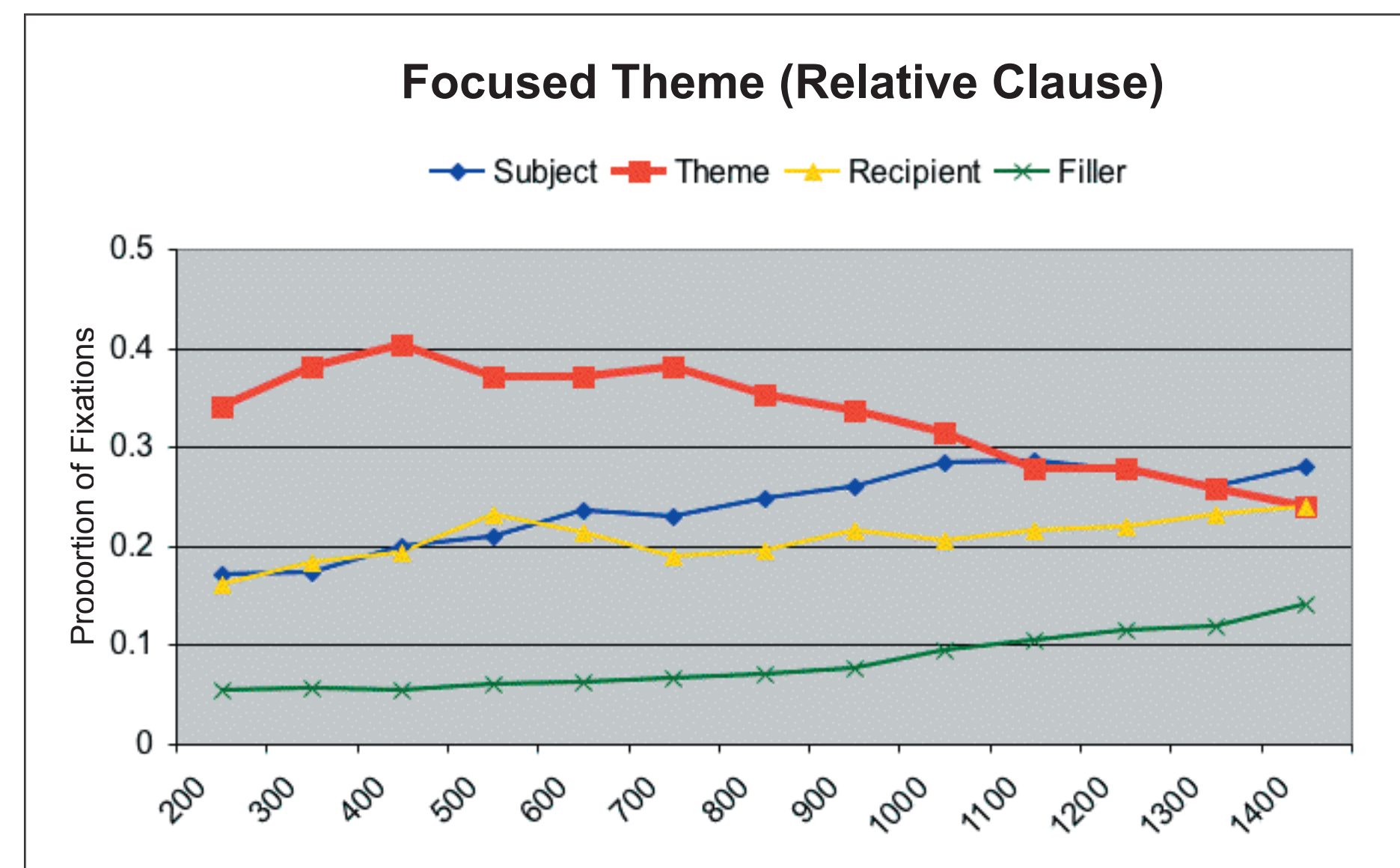
## Introduction

Previous eye-tracking research using sentences like (1) suggested that a dative verb introduces an indirect object (recipient) into the discourse (Boland, 2005).

(1) *The house was dirty inside, but the realtor swept/sold it easily for/to some newlyweds.*

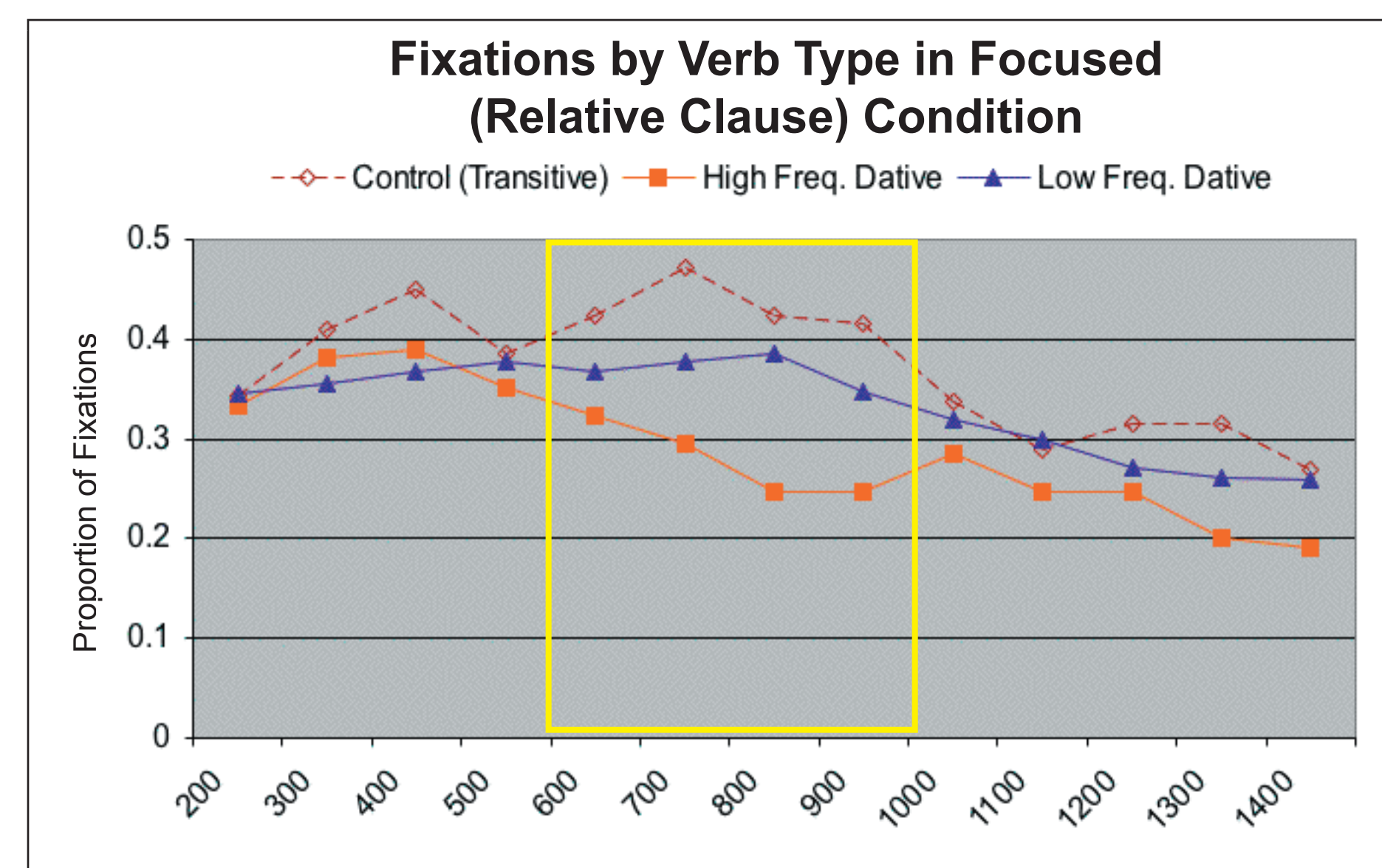
Boland found anticipatory fixations on photographs depicting potential recipients following dative (but not transitive) verbs. Datives also require a direct object (theme), but there were relatively few fixations on photographs depicting themes, even after the pronoun. In the current study, the theme attracts a high proportion of fixations when it is prominent (i.e., focused, Selkirk, 1984) in a sentence's information structure. This research demonstrates that sentential focus strongly influences visual attention toward event participants, at times minimizing effects of argument structure. In a related experiment, using nearly identical materials in an auditory change-detection paradigm, listeners were less sensitive to dative/transitive verb substitutions when the theme was focused. Taken together, these findings suggest that verb meaning (or perhaps argument structure) is processed more deeply or more completely

## Main Effect of Sentence Type on Focus

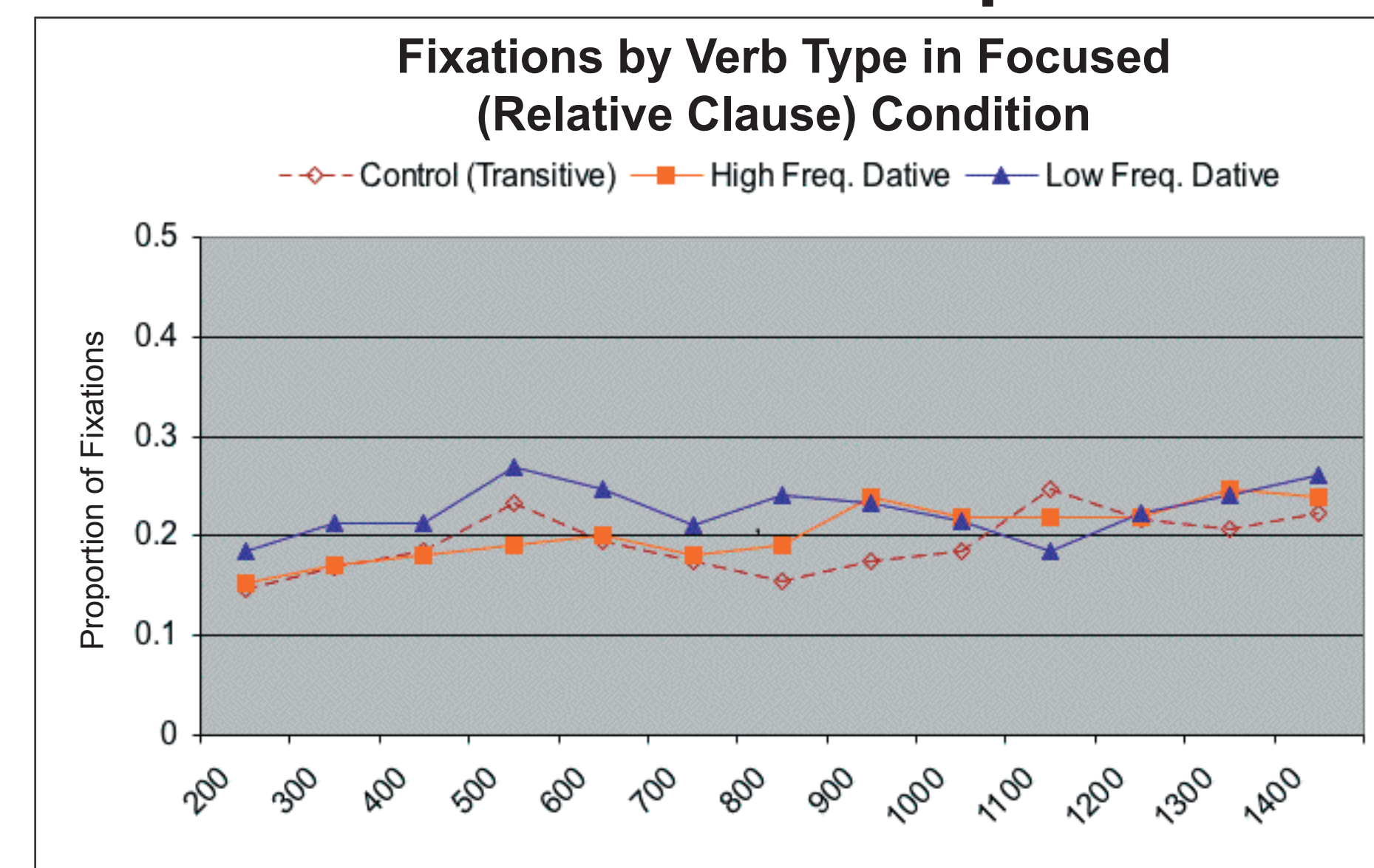


We examined gaze in 100 ms bins 200-1000 ms after the onset of dative and transitive verbs. Fixations on the theme were much more likely in the focused condition than in the unfocused condition [ $F(1,18) = 34.38, p < .01$ ;  $F(2,1,24) = 26.58, p < .01$ ].

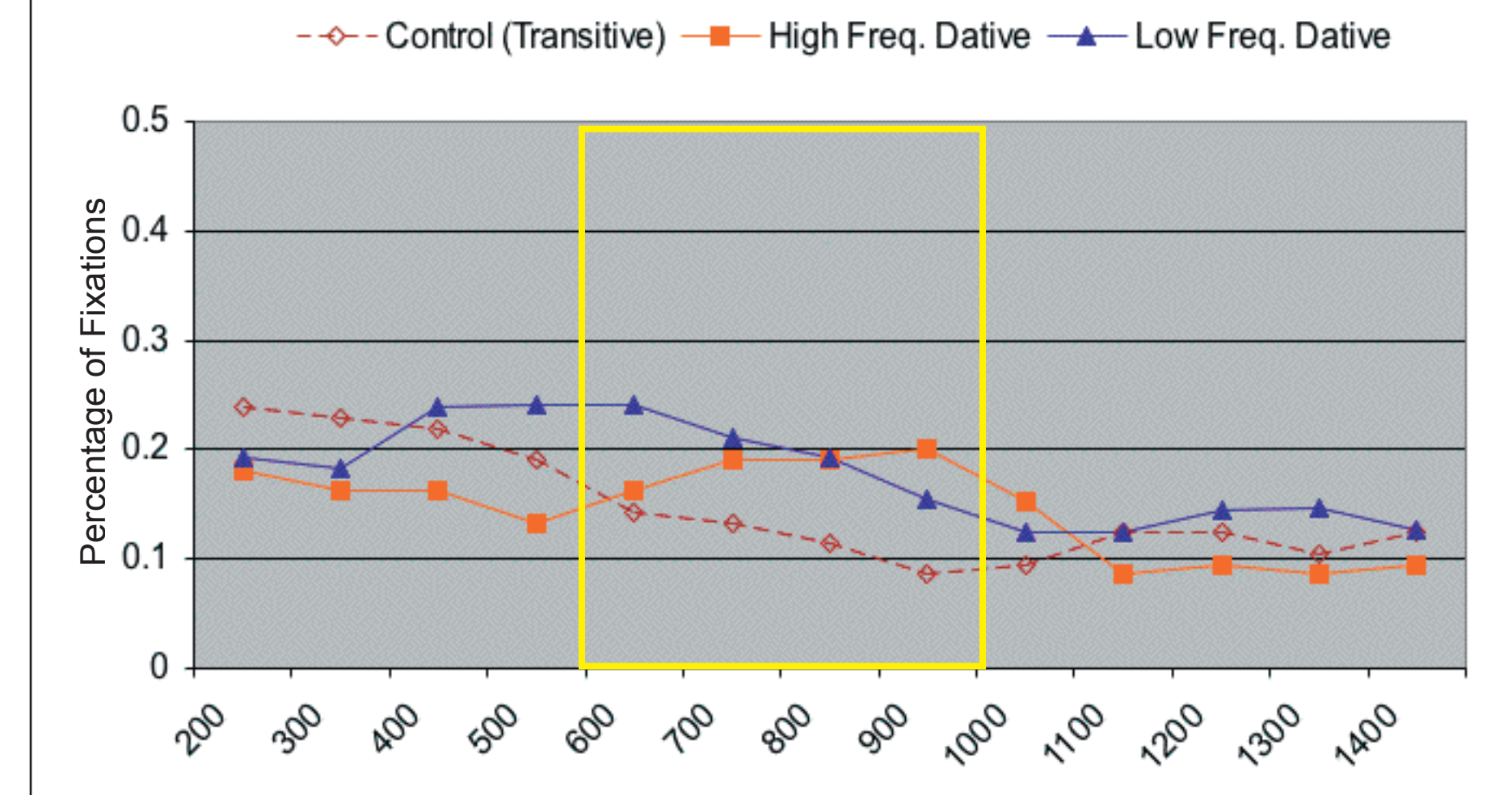
## Fixations on Theme



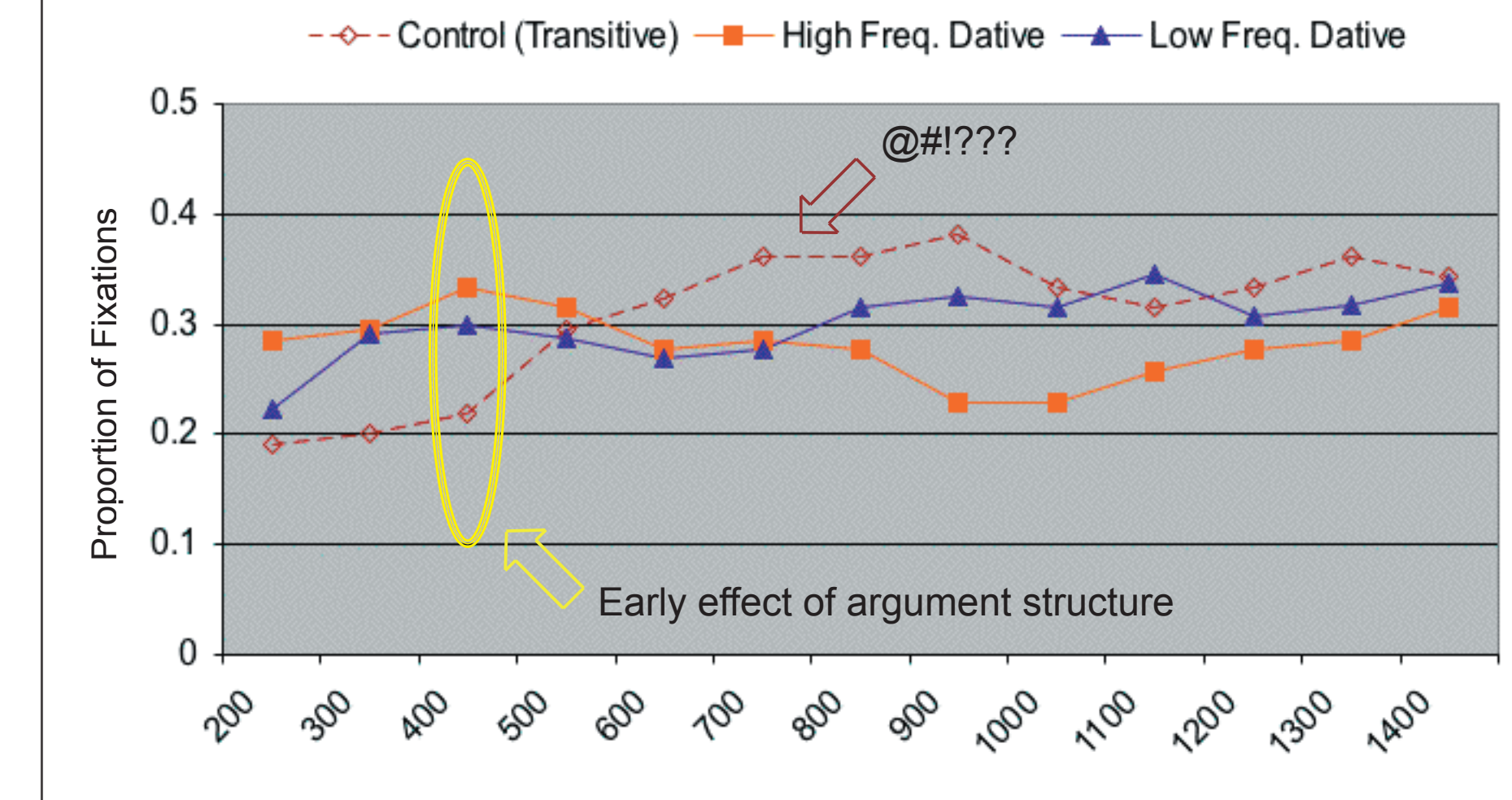
## Fixations on Recipient



## Fixations by Verb Type in Unfocused (Main Clause) Condition



## Fixations by Verb Type in Unfocused (Main Clause) Condition



The focus effect highlighted above, participated in a three-way interaction with verb type and temporal bin [ $F(14,252) = 2.49, p < .05$ ;  $F(2,14,336) = 3.50, p < .01$ ]. The three-way interaction reflects a different time course on looks to the theme across the three verb conditions. Each of the three verb conditions exhibited a main effect of focus on looks to the theme across the 200-1000 ms interval [All  $F$ 's  $> 7.5$ ]. In the control condition, the effect of focus interacted with temporal bin, with a larger focus effect in later bins [ $F(7,126) = 4.26, F(2,7,168) = 4.30, p < .05$ ]. In contrast, the effect of focus did not interact with temporal bin for the low frequency datives [ $F$ 's  $< 1.0$ ], and for high frequency datives, interacted (marginally) in the opposite direction, with fewer looks to the focused theme in later temporal bins [ $F(7,126) = 2.80, p = .06$ ;  $F(2,7,168) = 3.00, p < .05$ ]. We believe that the decrease in looks to the focused theme at later time points, after dative verbs compared to control verbs, reflect a shift in visual attention to the recipient of the dative verb.

Fixations on the recipient were also influenced by the focus manipulation, though less dramatically. When the theme was focused, the critical verb was in a relative clause. When the theme was unfocused, the verb was in a more prominent position, as in Boland (2005). The current research investigated whether the anticipatory fixations on recipients found in Boland (2005) would be replicated if the verb were in a less prominent position. In fact, sentence structure interacted with both temporal bin and verb type [ $F(14,252) = 2.20, p < .05$ ;  $F(2,14,336) = 2.48, p < .05$ ]. High frequency datives prompted more fixations on recipients across the entire critical interval when the verb was in a main clause [ $F(1,18) = 4.72, p < .05$ ;  $F(2,1,24) = 4.59, p < .05$ ]. Surprisingly, the control condition also had more fixations on recipients when the verb was in a main clause [ $F(1,18) = 9.66, p < .01$ ;  $F(2,1,24) = 4.86, p < .05$ ], but this effect interacted with temporal bin [ $F(7,126) = 3.65, p < .05$ ;  $F(2,7,168) = 3.92, p < .05$ ], beginning substantially later than for datives.

## Change Detection Study

### Methods

#### Participants

Twenty-one undergraduates at the University of Michigan.

#### Materials

The sentences from the eye-tracking study (with minor changes) became the final sentence in 3-sentence paragraphs like (4) and (5). One version of each critical sentence used a dative verb and one version used the transitive control verb. We also constructed paragraphs in which the final or second to last sentence alternated between a transitive an intransitive verb (6). In sentences (4) and (6), the alternating verb was in a main clause (MC), whereas in (5) it was in a relative clause (RC). 45 critical paragraphs were mixed with 60 filler paragraphs. 5 of the fillers had a verb change in the first sentence, 25 had an alternating noun, and 30 had no alternating word. There were no picture stimuli.

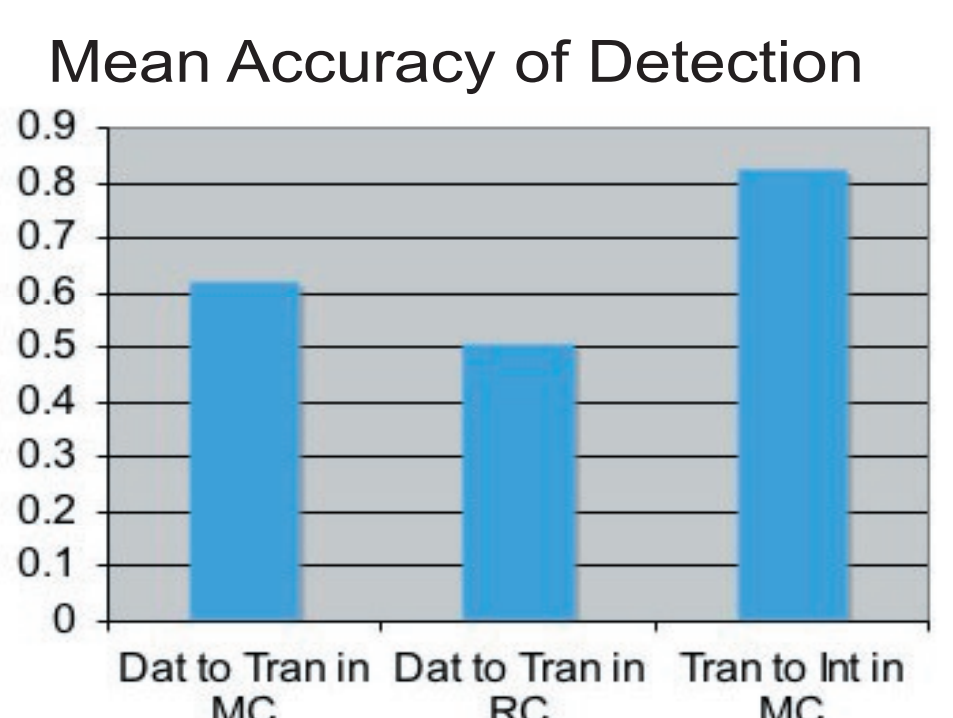
- (4) *The famous collector had a deep passion for illustrated stories. Some issues only existed in very limited numbers. Because one comic book was extremely rare, [MC he loaned/owned it in a shroud of secrecy.]*  
 (5) *Unusually large diamonds and rubies are favorites of the well-known jeweler. They could be found in nearly every case in the store. The necklace [RC that he loaned/owned was worth a million dollars.]*  
 (6) *The sweet grandmother always stayed busy with cooking and cleaning. There were constantly hungry mouths to feed and messes to clean. Whenever she could, [MC she embroidered/relaxed in her rocking chair].*

#### Procedure

We used an auditory version of Sturt et al's (2004) change detection paradigm. Stimuli were presented to participants using E-Prime software. Participants were told that for each trial they would hear a sentence set and after a brief pause they would hear the same sentence set again. During this second set of sentences, they were instructed to immediately press a key if they detected a word change. If a change was detected, participants were asked to type in the word they thought changed. Response time and mean accuracy data were collected.

#### Results

As expected there was a main effect of condition [ $F(2,38) = 58.42, p < .01$ ]. Importantly, the dative/transitive alternation was less likely to be detected in the relative clause condition than in the main clause condition [ $t(19) = 3.96, p < .01$ ].



## Eye-Tracking Study

### Methods

#### Participants

Twenty-one undergraduates at the University of Michigan participated in the experiment to fulfill a requirement for an undergraduate introductory Psychology class.

#### Materials

In 15 sets of items we manipulated sentence structure such that, at the verb, the theme was either still in focus (2) or not (3), using the same high frequency dative (e.g., loan), low frequency dative (e.g., sell), and transitive control (e.g., own) verbs in both conditions. We also manipulated the frequency with which the dative verbs occurred with recipient arguments.

- (2) *The necklace that the well-known jeweler loaned/sold/owned was worth a million dollars.*  
 (3) *Because one comic book was extremely rare, the famous collector loaned/owned/sold it in secret.*

#### Procedure

Participants engaged in a passive listening task, listening to the sentences while looking at an array of photos corresponding to the agent, theme, and potential recipient of the critical verb (see Figs. 1. and 2. for examples). A fourth photo depicted an object that was not a potential argument of either the dative or the control verb. During the listening task we tracked their eye movements on the array using a head-mounted ISCAN ETL-500 Pupil/Corneal Reflection Tracking System.



Fig. 2. Slide corresponding to sentence (3).

#### Acknowledgements

We would like to thank Monica Chin and the students in the Boland Psycholinguistics Lab at the University of Michigan, whose hard work and assistance helped make this research possible.

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## Conclusions

In Experiment 1, there were clear effects of sentence structure on looks to both the theme and the recipient. Likewise, in Experiment 2, sentence structure influenced accuracy in a change detection task. We interpret both of these sentence structure effects as reflecting differences in the information structure, or focus, of the sentence, which in turn influenced how thoroughly verb argument structure was processed and/or the degree to which argument structure was effective in shifting listener attention to unmentioned sentence participants. While focus has received some attention in the ambiguity resolution literature (e.g., Brown-Schmidt et al., 2005; Jun, 2003; Schafer et al., 2000; Sedivy, 2002), this is the first demonstration of an interaction between argument structure effects and focus.

## Open Questions

1. Is the verb-type effect on looks to focused theme an effect of argument structure? If so, why don't we see it in the recipient figure?
2. Why were the effects of argument structure on looks to the recipient so early and short-lived, compared to previous studies?
3. Why are transitive/intransitive changes easier to detect than dative/transitive changes?
4. Can focus be defined more clearly?