Children's Representation of Verbs: Evidence from Priming during Online Sentence Comprehension

Malathi Thothathiri

Jesse Snedeker

Harvard University

Word count: 2987

Abstract

This study explores the grammatical representations employed by preschoolers during language comprehension. Tomasello and colleagues have argued that young children, unlike adults, are limited to structural representations organized around individual lexical items (*Trends in Cognitive Sciences 4* (2000) 156). Evidence for broader syntactic representations in adults comes from, among other things, studies showing syntactic priming during production, which persists in the absence of lexical overlap. Studies of production priming in children have produced mixed results. The present study uses the visual-world paradigm to look for comprehension-to-comprehension priming in 4-year-old children. In two experiments, we find structural priming for datives which persists even when the prime and target sentences do not share any content words. These results demonstrate that four-year-olds have abstract structural representations that are not solely based on individual lexical items.

Keywords: Syntax; Comprehension; Syntactic Priming; Datives; Language Acquisition

1. Introduction

The grammar of a natural language consists of generalized structures (or rules) defined over syntactic categories. To creatively produce sentences, a speaker needs to know which words in the language can instantiate which categories. An important question in language acquisition is how categorization unfolds over development. One influential proposal is that children gradually merge their representations of individual verbs to form abstract categories (the Verb Island hypothesis; see Tomasello, 2000). Early evidence for this view came from children's spontaneous production. For example, Tomasello (1992) found that his one-year-old daughter restricted most verbs to a single construction type, failing to use them in alternate permissible constructions which she had used with other verbs. For example, while *draw* was used with locative and benefactive prepositional phrases, *cut* appeared only in simple transitive sentences. Observational studies, however, cannot tell us whether restricted usage reflects the input that the child receives, differences in the meanings of the verbs, or the limited range of situations that the child wishes to discuss. These issues have been addressed in production experiments with novel words (see Tomasello, 2000 for a review). For example, Tomasello & Brooks (1998) exposed children to a novel verb in an intransitive construction while modeling an action (e.g., *The sock is tamming*). Subsequently, they modeled the same action and tried to elicit transitive constructions from the children (e.g., *He's tamming the car*). While older children extended novel verbs to new constructions, 2-to-3-year-olds primarily used them in the constructions they were exposed to during training. The authors concluded

that abstract representations of verbs and their thematic roles are generalizations over narrow lexical patterns that begin emerging around three to four years of age.

Fisher (2002) pointed out some problematic assumptions behind this interpretation. First, the constructions in which a verb can occur depend on a complex set of semantic constraints. Consider *drop* and *fall*. They have similar meanings and both can occur intransitively. *Drop* can also occur in transitive sentences (e.g., *Alice dropped the ball*), but *fall* cannot (e.g., **Alice fell the ball*). Thus, children's reluctance to extend verbs to transitive constructions may be due to their limited knowledge of these semantic constraints rather than the absence of abstract syntactic representations. Second, extracting the meaning of a novel verb from a visual scene is difficult even for adults (Gillette, Gleitman, Gleitman, & Lederer, 1999). Children in the above experiment may have failed to infer that the novel verb referred to the manner of a caused motion (rather than the object's path or position) and could therefore be used transitively (Levin, 1993).

In sum, this debate has brought to the fore methodological problems with both observational studies of spontaneous speech and experimental studies of production with novel words. Recently, structural priming has been used to investigate the abstractness of children's syntactic representations. Adult studies have found robust evidence for structural priming using a variety of tasks (Bock & Loebell, 1990; Pickering & Branigan, 1998) and constructions (Chang, Bock, & Goldberg, 2003; Scheepers; 2003). For example, speakers are more likely to produce a passive sentence after hearing a passive sentence than after hearing an active one. This facilitation is *structural* in that it occurs even when the two consecutive sentences have no content words in common. The presence or absence of structural priming in children could shed light on the nature of the

representations that underlie their linguistic behavior. But the work to date has produced mixed results. While some researchers find structural priming in 4- and 5-year-old children (Huttenlocher, Vasilyeva, & Shimpi, 2004), others find structural priming only after age 6 (Savage, Lieven, Theakston, & Tomasello, 2003).

Thus, the nature of 4-year-olds' verb representations is still an open question. The current study uses structural priming, but differs from previous studies in two important ways. First, our experiments examine priming during language comprehension rather than production. Since production tasks are often more difficult for children than comprehension tasks, this may provide a more sensitive measure of children's linguistic knowledge. Indeed, studies that use preferential looking to measure comprehension (e.g., Fisher, 2000) typically find evidence for argument structure abstractions at an earlier age than studies using production measures. Second, the current study uses a visual-world paradigm that taps online sentence processing. We measure participants' eye movements while they listen to instructions and manipulate objects. Under these circumstances, eye movements to the objects are tightly linked to the unfolding utterances and are sensitive to lexical and structural processing in both adults (e.g., Allopenna, Magnuson, & Tanenhaus, 1998; Tanenhaus, Spivey-Knowlton, Eberhard, & Sedivy, 1995) and children (Snedeker & Trueswell, 2004; Trueswell, Sekerina, Hill, & Logrip, 1999). By using a technique with good temporal resolution, we can explore whether structural priming affects children's initial interpretation of the arguments following a verb.

In two experiments, we investigate within- and across-verb priming in 4-year-olds. While within-verb priming can result from either verb-specific or more abstract representations, across-verb priming can only result from the latter.

2. Experiment I

In Experiment I, we asked whether 4-year-olds show *within-verb* priming. Critical instructions were double-object (DO) or prepositional-object (PO) dative sentences with the verb "give". We chose to use the dative alternation because a number of studies have concluded that by three years of age, children comprehend and produce both kinds of dative constructions (Campbell & Tomasello, 2001; Gropen, Pinker, Hollander, Goldberg, & Wilson, 1989).

2.1. Participants

Twenty 4-year-olds from the Boston area participated (4;0 to 4;6. Mean age = 4;1. 11 female). All were native speakers of English.

2.2. Methods

Instructions were recorded by a female native English speaker. Each participant listened to four blocks of instructions. Within a block, the first two sentences were filler sentences that were not datives. The third and fourth were prime sentences that were either DO or PO datives (e.g., DO: *Give the elephant the ball*; PO: *Give the ball to the elephant*). The fifth and final sentence was the target sentence, also a DO or PO dative (e.g., DO: *Give the bird the dog bone*; PO: *Give the birdhouse to the sheep*). Prime type was crossed with target type such that each child was randomly assigned to one of four possible conditions (DO prime-DO target; DO prime-PO target; PO prime-DO target; PO prime-PO target). See Appendix for a complete list of dative sentences.

Eye movements were recorded by a camera centered behind the display, following the procedure employed by Snedeker & Trueswell (2004). They found that gaze direction

coded from the hidden camera correlated highly with fixations that were simultaneously recorded using head-mounted eye-tracking. Eye movements were coded as being to the center, away or to one of the four quadrants. If the eyes were not visible the frame was coded as track loss and excluded from the analysis. All eye-coding was done with the audio turned off, by coders who were blind to the positions of objects in the visual scene. For 10% of the trials, eye movements were coded by a second blind coder. Intercoder reliability was 91.2% (Cohen's Kappa = 0.89).

In dative sentences, the animacy of each noun phrase typically depends on its thematic role. In DO sentences, the first NP refers to the recipient, which is usually animate. In PO sentences, the first NP refers to the theme, which is usually inanimate. On target trials, the set of toys that accompanied the utterance contained two items that were phonological matches to the *initial* part of the first NP (e.g. "bird…"). See Figure 1. One was a possible *animate recipient* (e.g., bird). The other was a possible *inanimate theme* (e.g., birdhouse). We predicted that in response to the ambiguous part of the first NP, participants primed with DO sentences would look more at the animate match (e.g., bird) while those primed with PO sentences would look more at the inanimate match (e.g., birdhouse).

We coded eye movements on target trials only. It takes about 200 ms to program an eye movement (Matin, Shao, & Boff, 1993). Thus, our critical time interval began 200 ms after the onset of the first NP (e.g., "bird…") and ended 200 ms after the onset of the disambiguating information (e.g., *the* in "Give the bird *the* dog bone"; *house* in "Give the bird*house* to the sheep"). The total interval of interest was 400 ms. Our dependent measure was the proportion of looks to the inanimate match (e.g., birdhouse) during the

ambiguous interval. For each target trial, we calculated looking time to the inanimate match as a proportion of looking time to all four items and the center. For each participant, we calculated the looking time to the inanimate match averaged over all target trials.[1]

2.3. Results and Discussion

Unsurprisingly, children performed the right action on 90% of the target trials, correctly interpreting utterances which were lexically, syntactically and pragmatically unambiguous. Our primary interest was in how they interpreted the direct-object noun during the brief ambiguous interval. A 2x2 ANOVA (Prime Type x Target Type) of the eye movement data revealed a significant effect of prime type [$F(1,16) = 12.157$; $p<0.01$]. As predicted, participants primed with PO sentences looked more at the inanimate match compared to those primed with DO sentences (Figure 2). There was no effect of target type [$F(1,16) = 2.66$; $p > 0.1$] or interaction [$F(1, 16) < 1$; $p > 0.1$]. These results demonstrate within-verb comprehension-to-comprehension priming in 4-year-olds. This priming unfolds rapidly during the online processing of the utterance, influencing the initial interpretation the direct-object noun.

Within-verb priming results are compatible with both verb-specific and abstract representations. Therefore, in Experiment II, we asked whether priming would occur when the prime and target verbs are different.

[1] We excluded trials in which participants were looking at the center or away (i.e., not at any of the four items) for more than 2/3rd of the interval.

3. Experiment II

In this experiment, we asked whether 4-year-olds show *across-verb* priming. Prime dative sentences used *show* or *bring*. Target dative sentences used *give*. Production studies with adults typically find weaker priming across verbs than with the same verbs (Pickering & Branigan, 1998). Therefore, we anticipated smaller effects and tested more participants in this experiment than in Experiment I.

3.1. Participants

Thirty eight 4-year-olds participated (3;11 to 4;11.[2] Mean age = 4;0. 23 female). All were native speakers of English. None had participated in Experiment I.

3.2. Methods

Methods were identical to Experiment I, except for the fact that prime sentences used *show* or *bring* instead of *give* (see Appendix). Intercoder reliability for the coding of eye movements was 92.8% (Cohen's Kappa = 0.89).

3.3. Results and Discussion

The children performed the correct action on 92% of the target trials, indicating that they had little difficulty with the sentences regardless of whether the primes and targets matched. Their eye movements, however, indicated that the primes did influence their interpretation of the direct-object noun during the critical ambiguous region. For each participant, the proportion of fixations to the inanimate match was submitted to a 2x2 ANOVA (Prime Type x Target Type). There was a reliable effect of prime type [F(1,34)

[2] Only 5 participants were older than 4;6. Results were not different when these participants were excluded.

= 7.046; p<0.02]. As predicted, participants primed with PO sentences looked more at the inanimate match compared to those primed with DO sentences (Figure 3). There was no effect of target type or interaction (both F's < 1; p's > 0.1). These results demonstrate across-verb comprehension-to-comprehension priming in 4-year-olds. We conducted a 2x2x2 ANOVA (Prime Type x Target Type x Experiment) by combining data from the two experiments. This analysis revealed a significant effect of prime type [F(1, 50) = 11.957; p<0.01], but no effect of target type or experiment and no interactions (all F's < 2; p's > 0.1).

4. General Discussion

In two experiments, we have demonstrated both within- and across-verb comprehension-to-comprehension priming in 4-year-old children. Under the Verb Island Hypothesis, structural representations are specific to individual verbs. Thus, activation of a construction that contains one verb may influence the comprehension of subsequent utterances with the *same* verb but there should be no effect on comprehension of subsequent utterances with a different verb. In contrast, abstract structural representations defined over a category of verbs would lead to priming between different verbs. Thus, our across-verb priming results in Experiment II demonstrate that 4-year-olds have abstract representations.

What is the nature of these representations? In the adult priming literature, proposals for primed representations include thematic roles, animacy features, context-free rules and hierarchical syntactic relations (Bock, Loebell, & Morey, 1992; Chang, et al., 2003; Pickering & Branigan, 1998; Scheepers, 2003). While our measure was transparently related to animacy features (looks to the object reflect the expectation that the direct-

object noun will be inanimate), the priming itself need not have occurred at this level. Animacy is systematically related to thematic roles (Dowty, 1991), which are in turn tightly linked to grammatical structure (Baker, 1988). The priming of syntactic structures or rules could support robust inferences about thematic-role assignment, which in turn support predictions about animacy. Thus our results are compatible with all the proposals listed above and uniquely support none of them. For current purposes the crucial point is that the primed representations span across verbs and thus are more abstract than item-specific generalizations or Verb Islands.

This study rules out two alternate explanations for prior evidence of structural-priming in children. First, because the paired constructions used in priming studies are distinguished by the presence or absence of closed-class words (e.g., *to*), many of the production effects could reflect the priming of closed-class words rather than grammatical structures. By measuring priming prior to the point at which this morpheme occurs, we avoided this possibility. Second, because the alternate forms of these constructions vary in their length, which in turn influences their prosodic structure, production priming effects could reflect speeded access to recently-used prosodic templates. In comprehension tasks this confound never arises because participants in different prime conditions are given prosodically identical target utterances.

Our results are consistent with several lines of research indicating that young children have abstract structural representations. Fisher and colleagues have demonstrated that even 18-month-olds can use word order to interpret transitive utterances with novel verbs (Gertner & Fisher, 2004). By four, even advocates of the Verb Island Hypothesis agree that children employ structural generalizations in novel-verb production tasks

(Tomasello, 2000). Nevertheless we believe that priming studies in preschoolers uniquely constrain this debate. Productivity in novel-verb tasks can always be attributed to ad hoc strategies that are employed only when the necessary item-based representation is missing. For example, an infant who interprets the preverbal argument of a novel verb as its agent could be drawing an analogy from a single known verb rather than using a stable abstract representation of transitivity. Priming studies with common verbs provide no footholds for this kind of explanation. Item-based representations are perfectly adequate for understanding the utterances in the current study. The fact that children spontaneously employed abstract structural knowledge demonstrates that these representations are an integral part of everyday language comprehension.

The paradigm reported here can be used to answer two important questions that remain. First, do younger children use abstract structural priming? As with 4-year-olds, recent studies of production priming in 3-year-olds have produced mixed results. Using the dative alternation and a sentence-imitation task, Song & Fisher (2004) found structural priming in 3-year-olds. In contrast, Gamez, Shimpi, & Huttenlocher (2005) did not find structural priming using a picture description task with 3.5-to-4.5-year-olds. Exploring comprehension priming in 3-year-olds could help us interpret this discrepancy. A second important issue is how different verbs are clustered together in abstract representations. In other words, how abstract are the abstract representations? Dative verbs fall into several semantic classes (Gropen, et al., 1989). For example, some signify physical transfer (e.g., *give*) while others signify metaphorical transfer or communication (e.g., *show*). Is comprehension-to-comprehension priming in young children limited to verbs with closely similar meanings or does it encompass all verbs that participate in the

dative alternation? [3] By looking for priming within and across semantic classes, we hope to discover how dative verbs are organized in young children's minds.

[3] The current study contained verbs from different semantic classes but lacked the statistical power to detect differences.

Acknowledgements

This work was funded by a Harvard University McMaster's grant to Malathi Thothathiri. We thank Cindy Fisher for helpful discussions, Steven Pinker for comments on the manuscript, and Sneha Rao and Jane Sung for their assistance in collecting and coding data.

Appendix

Primes (Expt. I/II)

DO	PO
Give/Show the dog the fork	Give/Show the fork to the dog.
Give/Show the lion the ball	Give/Show the ball to the lion.
Give/Show the tiger the bottle	Give/Show the bottle to the tiger.
Give/Show the horse the orange	Give/Show the orange to the horse.
Give/Bring the bear the truck	Give/Bring the truck to the bear.
Give/Bring the sheep the towel	Give/Bring the towel to the sheep.
Give/Bring the elephant the box	Give/Bring the box to the elephant.
Give/Bring the frog the brush	Give/Bring the brush to the frog.

Targets (Expts. I and II)

DO	PO
Give the doll the cat food	Give the dollhouse to the bunny.
Give the bird the dog bone	Give the birdhouse to the sheep.

Give the pig the cat food	Give the pigpen to the tiger.
Give the fish the dog bone	Give the fishbowl to the bear.

References

Allopenna, P. D., Magnuson, J. S., & Tanenhaus, M. K. (1998). Tracking the time course of spoken word recognition using eye movements: Evidence for continuous mapping models. *Journal of Memory & Language*, *38*, 419-439.

Baker, M. C. (1988). *Incorporation: A theory of grammatical function changing.* Chicago, IL: University of Chicago Press.

Bock, K., & Loebell, H. (1990). Framing sentences. *Cognition, 35*, 1-39.

Bock, K., Loebell, H., & Morey, R. (1992). From conceptual roles to structural relations: bridging the syntactic cleft. *Psychological Review*, *99*, 150–171.

Chang, F., Bock, K., & Goldberg, A. E. (2003). Can thematic roles leave traces of their places? *Cognition, 90*, 29-49.

Campbell, A. L., & Tomasello, M. (2001). The acquisition of English dative constructions. *Applied Psycholinguistics, 22*, 253-267.

Dowty, D. (1991). Thematic proto-roles and argument selection, *Language, 67*, 547–619.

Fisher, C. (2002). The role of abstract syntactic knowledge in language acquisition: a reply to Tomasello. *Cognition, 82*, 259-278.

Fisher, C. (2000). *Who's blicking whom? Word order influences toddlers' interpretations of novel verbs*. Paper presented at the 11th International Conference on Infant Studies, Brighton, UK.

Gertner, Y., & Fisher, C. (2004). *How early does word order guide sentence comprehension?* Paper presented at the 29th Annual Boston University Conference on Language Development, Boston, MA.

Gamez, P. B., Shimpi, P. M., & Huttenlocher, J. (2005). *Emerging syntactic representations as evident through priming*. Poster presented at the 2005 SRCD Biennial Meeting, Atlanta, GA.

Gillette, J., Gleitman, H., Gleitman, L., & Lederer, A. (1999). Human simulations of vocabulary learning. *Cognition, 73*, 135-176.

Gropen, J., Pinker, S., Hollander, M., Goldberg, R, & Wilson, R. (1989). The learnability and acquisition of the dative alternation in English. *Language, 65*, 203-257.

Huttenlocher, J., Vasilyeva, M., & Shimpi, P. (2004). Syntactic priming in young children. *Journal of Memory and Language, 50*, 182-195.

Levin, B. (1993). *English verb classes and alternations: A preliminary investigation,* Chicago, IL: University of Chicago Press.

Matin, E., Shao, K. C., & Boff, K. R. (1993). Saccadic overhead: Information-processing time with and without saccades. *Perception & Psychophysics, 53*, 372-380.

Pickering, M. J., & Branigan, H. P. (1998). The representation of verbs: Evidence from syntactic priming in language production. *Journal of Memory & Language, 39*, 633-651.

Savage, C., Lieven, E., Theakston, A., & Tomasello, M. (2003). Testing the abstractness of children's linguistic representations: lexical and structural priming of syntactic constructions in young children. *Developmental Science, 6*, 557-567.

Scheepers, C. (2003). Syntactic priming of relative clause attachments: Persistence of structural configuration in sentence production. *Cognition, 89*, 179-205.

Snedeker, J., & Trueswell, J. C. (2004). The developing constraints on parsing decisions: The role of lexical-biases and referential scenes in child and adult sentence processing. *Cognitive Psychology, 49*, 238-299.

Song, H.-J., & Fisher, C. (2004). *Syntactic priming in 3-year-old children*. Paper presented at the 29th Annual Boston University Conference on Language Development, Boston, MA.

Tanenhaus, M. K., Spivey-Knowlton, M. J., Eberhard, K. M., & Sedivy, J. C. (1995). Integration of visual and linguistic information in spoken language comprehension. *Science, 268*, 1632-1634.

Tomasello, M. (2000). The item-based nature of children's early syntactic development. *Trends in Cognitive Sciences, 4*, 156-163.

Tomasello, M. (1992). *First verbs: A case study in early grammatical development*, New York: Cambridge University Press.

Tomasello, M., & Brooks, P. (1998) Young children's earliest transitive and intransitive constructions. *Cognitive Linguistics, 9*, 379-395.

Trueswell, J., Sekerina, I., Hill, N. M., & Logrip, M. L. (1999). The kindergarten-path effect: Studying on-line sentence processing in young children. *Cognition, 73*, 89-134.

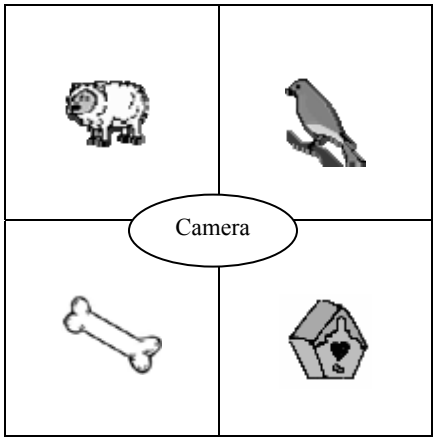

Fig. 1. Depiction of visual scene for:

DO: Give the **bird** the dog bone; PO: Give the **bird**house to the sheep.

The ambiguous interval is underlined and in bold.

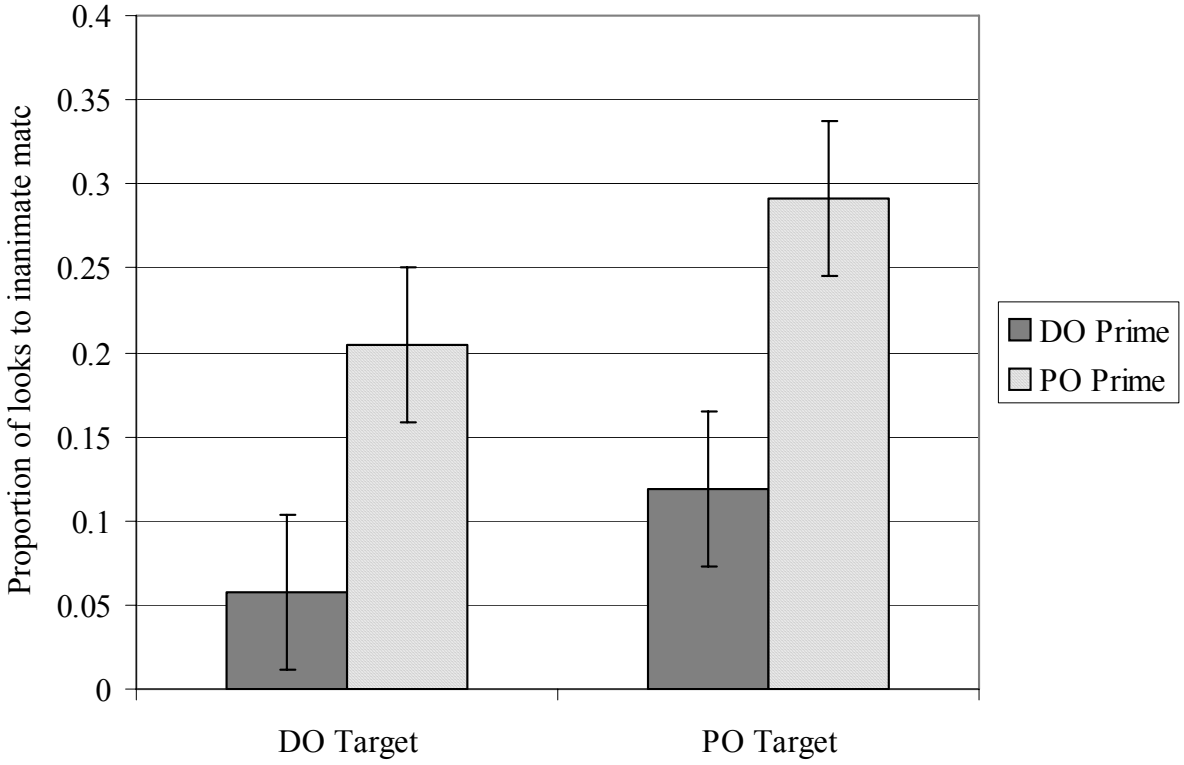

Fig. 2. Within-Verb priming: Proportion of looks to the inanimate match during the ambiguous interval.

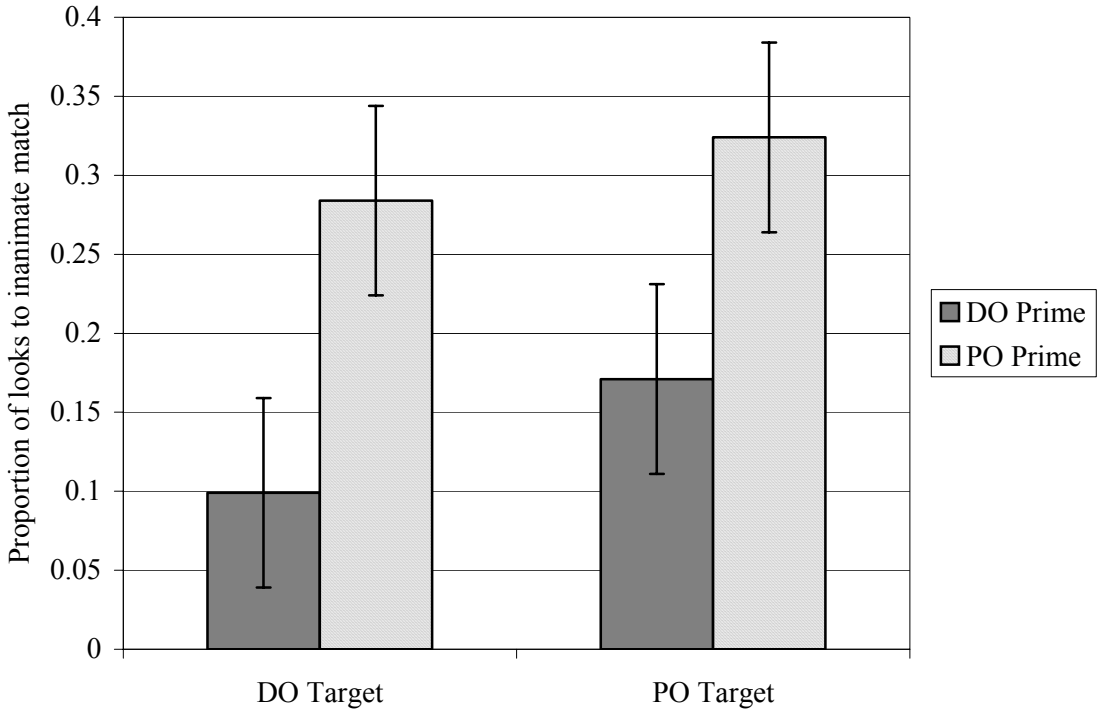

Fig. 3. Across-Verb Priming: Proportion of looks to the inanimate match during the ambiguous interval.