

Are both syntactically and semantically-based pronoun dependencies stored in memory?

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What representations are activated during language use? To answer this core question about the language system, one method is to test whether a structure can be primed. E.g., we know that both syntactic and semantic structures can be primed during language comprehension (e.g., Ziegler & Snedeker, 2018). Here we ask whether comprehension also stores long-distance dependencies, such as referential connections. E.g., in *Biden criticized Trump. He won the election*, do people store the connection between “he” and “Biden”, and use that structure to guide future pronoun processing? If yes, at what level of generalization is this link stored? Priming naturally involves some generalization, because it requires encoding a structure in such a way that it can apply to new instances. Perhaps people remember that a third-person pronoun was used to refer to the subject of the previous sentence (a syntactic generalization). Or perhaps they specifically represent a link between the pronoun and the agent of a judgment verb (a semantic generalization).

We test whether people store a representation of long-distance dependencies between a pronoun and its referent, and whether the type of referent is encoded at a syntactic level, a semantic level, or both. We examine pronoun interpretation in the context of transfer verbs, e.g. *Will took the popcorn from Matt and then he...* (Table 1). People tend to assign an ambiguous pronoun to the subject character (Will), following the well-known subject bias (e.g., Jarvikivi et al., 2005). But this bias is stronger with the verb “took” than “passed”, revealing a simultaneous bias toward the semantic role of “goal” (Langlois & Arnold, 2020).

We ask whether pronoun interpretation in these contexts is influenced by recent exposure to unambiguous pronouns, and if so, how. For example, in *Matt got the ketchup from Ana and then he....*, Matt is both the subject and the semantic goal of the transfer event. Do people remember this as a link between the pronoun and the prior subject (a syntactic generalization), or as a link between the pronoun and the prior goal (a semantic generalization)?

Methods. Both experiments tested pronoun interpretation in 12 critical stories about a transfer event with two same-gender characters, followed by an ambiguous pronoun (Table 1). Verb type was manipulated: 6 goal-source and 6 source-goal items. A question probed interpretation of the pronoun. As a control manipulation, the question either asked about the first or second character. In a heavy-handed priming manipulation, all 24 fillers had the same unambiguous pronoun structure, half in each verbytype. In Exp. 1 (118 participants), fillers used pronouns that were either subject-linked (Table 2 A&B) or non-subject-linked (Table 2 C&D'). In Exp. 2 (120 participants) filler pronouns were either Goal-linked (Table 2 A&D) or Source-linked (Table 2 B&C). Thus, both experiment used the same materials, but the fillers were re-combined to encourage either a syntactic (Exp. 1) or a semantic generalization (Exp. 2). We asked whether pronoun interpretation would follow the priming pattern of the filler sentences.

Results. Priming modulated results in both experiments (see Fig. 1). Exp. 1 categorized responses in terms of % selection of the subject character; subject selection was higher in the subject-prime than nonsubject-prime condition. Exp. 2 categorized responses in terms of % selection of the goal character; goal selection was higher in the goal-prime than source-prime condition. Verbytype effects revealed that for Exp. 1, there were more subject responses when the subject was the goal than when it was the source; for Exp. 2 there were more goal responses when the goal was the subject than when it was the nonsubject. An effect of question type showed a Yes bias (not pictured in Fig. 1). There were no interactions.

Conclusions. Results provide strong evidence that long-distance dependencies are activated and stored, and people tend to follow recently-encountered patterns when comprehending ambiguous pronouns (see also Author & Author, 2019). People can learn generalizations at both syntactic and semantic levels when recent input is strongly biased toward one level of generalization. Findings point to a role for the statistical frequency of structures at the discourse level in models of language comprehension.

Table 1. Example Ambiguous test item for both Exp. 1 and Exp. 2

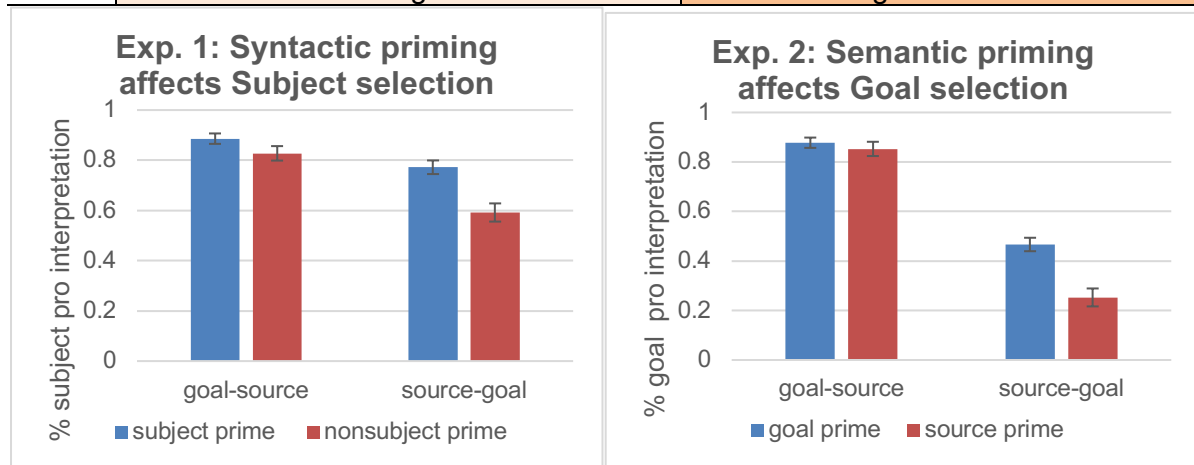
Goal-source verbs	Source-goal verbs
Will and Matt were watching a movie. Will took the popcorn from Matt and then he drank some soda.	Will and Matt were watching a movie. Will passed the popcorn to Matt and then he drank some soda.

Test questions:

- Subject question: Did Will drink some soda? (Yes / No) – Yes signals Subject interpretation
- Nonsubject Q: Did Matt drink some soda? (Yes / No) – No signals Subject interpretation

Table 2. Example priming stories (fillers with unambiguous pronouns)

A. Goal-source verbs Subject/Goal-linked pronoun fillers	B. Source-goal verbs Subject/Source-linked pronoun fillers
Will and Liz were watching TV. Will took the remote from Liz and then he changed the channel.	Will and Liz were grocery shopping. Will gave the credit card to Liz and then he browsed the magazines.
C. Goal-source verbs Nonsub./Source-linked pronoun fillers	D. Source-goal verbs Nonsub/Goal-linked pronoun fillers
Will and Liz were watching TV. Will took the remote from Liz and then she went to get a beer.	Will and Liz were grocery shopping. Will gave the credit card to Liz and then she got in line to check out.



Effect	Experiment 1 (Syntactic priming)			Experiment 2 (Semantic priming)		
	Est. (SE)	t	p	Est. (SE)	t	p
Priming	0.67 (0.23)	2.97	0.0036	0.74 (0.24)	3.12	0.0092
Verbtype	1.07 (0.19)	5.73	<.0001	3.11 (0.31)	10.19	<.0001
Question	1.26 (0.22)	5.66	<.0001	1.4 (0.29)	4.8	<.0001
Verbtype * Question	0.33 (0.34)	0.99	0.3437	0.37 (0.59)	0.63	0.5465
Priming * Question	-0.21 (0.37)	-0.58	0.5655	-0.44 (0.58)	-0.76	0.4592
Priming * Verbtype * Q	0.42 (0.87)	0.48	0.6398	0.4 (0.9)	0.44	0.668

Figure 1. Results from Exp. 1 and Exp 2. Exp. 1 uses Subject selection as the dependent measure; Exp. 2 uses Goal selection as the dependent measure.

References: Author & Author (2019). CUNY poster. ♦ Jarvikivi et al. (2005). Ambiguous pronoun ... *Psych. Science* 16, 260–4. ♦ Langlois & Arnold (2020). Print exposure explains ... *Cognition*, 197, 104155. ♦ Ziegler & Snedeker (2018). How broad... *Cognition* 179, 221-240.