

Pronoun interpretation reveals the robustness and flexibility of perspective reasoning

The understanding of perspective is recognized as an essential component of semantic and pragmatic processing, influencing a wide range of processes including the interpretation of nominal expressions [e.g., 1,2], adjectives [3,4,5], and appositives and epithets [6,7], among others. In studies of language processing, it has often been claimed that the computation of perspective is challenging, entailing that perspective cues might not be used effectively during natural listening or reading [2,8]. In the present study, we explore both the robustness and complexity of perspective taking from a new angle, focusing on dramatic changes in interpretation that result from comprehenders' grasp of the felicity conditions of speech acts and epistemic authority [9,10]. This work builds on the assumption that pronoun interpretation is a by-product of understanding the overall discourse [11,12], and in turn can provide important insights into perspective-taking processes.

Consider the assertion "Jane told Annie that she likes spaghetti". Intuitively, the grammatically-ambiguous pronoun refers to Jane, as a report of "liking spaghetti" is best understood as reflecting Jane's intention to tell Annie something that Annie did not already know (cf. the pragmatic convention to "be informative" [13,14]). This reasoning explains why intuitions reverse with a *question* (cf. [15], "Jane asked Annie if she likes spaghetti", where "she" is now preferentially interpreted as referring to Annie). The latter case contrasts with the notion that pronoun interpretation is heavily guided by a bias toward subjects/first-mentioned entities [16,17]. We tested materials of this kind in antecedent judgment and self-paced reading tasks to validate and further understand how perspective reasoning influences pronoun resolution.

Experiments 1a-b (each: $n_{subs}=54$, $n_{trials}=24$) were offline antecedent judgment tasks.

Experiment 1a assessed judgments of ambiguous *subject* pronouns in sentences like "Madeline [asked/told] Anna [if/that] she remembers when the lecture starts." Intuitively, a character *asking* an interlocutor about the information expressed in the subordinate clause should lead readers to interpret the pronoun as coreferring with the main-clause object, whereas *telling* should entail main-clause subject selections. The results overwhelmingly supported this intuition: Participants picked the antecedent we expected to be "perspectivally-congruent" 99.8% of the time, and there was no order-of-mention bias. In **Experiment 1b**, we tested *object* pronouns like "Nina [asked/told] Mary [if/that] modern art interests her more than classics." The results followed the same pattern, with the "congruent" antecedent selected 99.4% of the time.

Experiments 2a-b (each: $n_{subs}=60$, $n_{trials}=24$) used self-paced reading to clarify the scope of information used in the judgments. The critical sentences used in **Experiment 2a** were identical to Experiment 1a, but now contained unambiguous pronouns, where gender marking compelled coreference with either the "perspectivally-congruent" (1a-b) or "incongruent" (1c-d) antecedent:

- (1a) Madeline asked Oscar if he remembers when the lecture starts.
- (1b) Madeline told Oscar that she remembers when the lecture starts.
- (1c) Madeline asked Oscar if she remembers when the lecture starts.
- (1d) Madeline told Oscar that he remembers when the lecture starts.

Cases (1c-d) should entail processing costs relative to (1a-b) because of the forced link with the perspectivally-incongruent character. The critical question was whether the interpretive patterns arise from (i) shallow lexical cues (e.g., the verbs *ask/tell* signal which character possesses at-issue knowledge, making the effects emerge at the pronoun) or (ii) deeper/more rational forms of linguistic reasoning drawing on global sentence information. On the latter account, referential decisions would reflect a consideration of the complete or nearly-complete subordinate clause (i.e., downstream of the pronoun). Reading time was measured at the pronoun, subordinate verb, and sentence-final regions. Mean reading times are shown in Fig. 1. Consistent with a deep reasoning account, the effect of congruency (slower reading times in the incongruent condition) was not apparent until the sentence-final region, confirmed with linear mixed-effects

modelling ($\beta=7.70$, $SE=1.78$, $t=4.32$, $p<.001$). **Experiment 2b** used the object pronoun sentences from Experiment 1b, where, e.g., the perspectively-incongruent sentences were:

- (2a) Nina asked Isaac if modern art interests her more than classics.
- (2b) Nina told Isaac that modern art interests him more than classics.

The results corroborated Experiment 2a (Fig. 2), where the location of the incongruity effect suggests readers use global sentence information ($\beta=4.60$, $SE=1.79$, $t=2.57$, $p<.05$).

To further assess the richness and flexibility of perspective reasoning, **Experiment 3** ($n_{subs}=60$, $n_{trials}=20$) assessed the potential for a preceding context sentence to “switch” the default patterns in the *ask* vs. *tell* sentences seen in Expt. 1, with materials like the following:

- (3a) Molly, who is unfamiliar with Japanese currency, was talking to her tour guide, Hana. Molly asked Hana if she had enough cash to buy a sandwich.
- (3b) Molly, a tour guide, was talking to Hana, who is unfamiliar with Japanese currency. Molly told Hana that she had enough cash to buy a sandwich.

Readers’ judgements reflected a preference for subject antecedents 68% of the time for *ask* and 23% for *tell*, overriding **Experiment 1a-b’s** near-categorical object selections for *ask* and subject selections for *tell*. Readers significantly changed their antecedent selection preference when presented with context sentences (relative to neutral baseline sentences, where the context sentence was not presented: $\beta=-2.48$, $SE=0.25$, $z=-10.1$, $p<.001$, via generalized linear mixed-effects modelling). Thus, the context sentences readily shift the understood subject of the embedded clause despite the “cues” stemming from the main verb. This outcome provides even more compelling evidence that the interpretive patterns reflect full-blown perspective reasoning.

In summary, Experiments 1a-b show extremely robust effects of perspective on pronoun resolution. Experiments 2a-b confirm that interpretation is not driven by lexical cues but instead involves a consideration of global sentence content, which we argue is a rational processing strategy considering the different ways that subsequent sentence information can influence interpretation. Experiment 3 further demonstrates that shallow lexical cues are insufficient as an explanation and highlights the flexibility of linguistic perspective taking. Together, the findings underscore the robustness of perspective reasoning in language understanding.

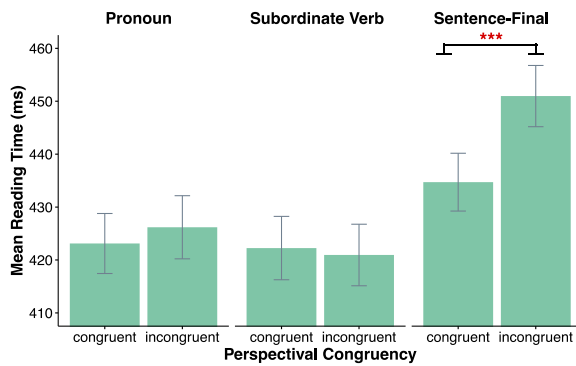


Figure 1: Mean RTs per condition by region, subject pronouns.

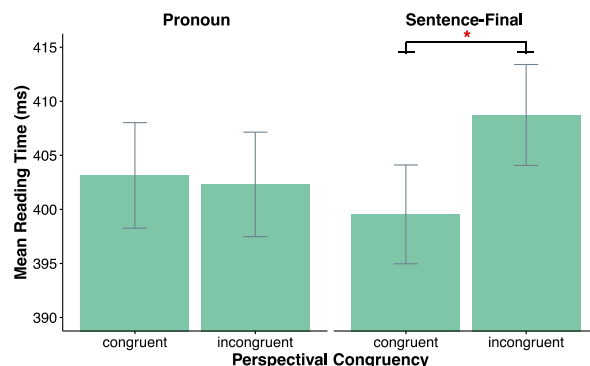


Figure 2: Mean RTs per condition by region, object pronouns.

References: [1] Clark & Marshall (1981). In *Elements of discourse understanding*. [2] Keysar et al. (2000). *Psych. Sci.* [3] Lasersohn (2005). *Ling. & Phil.* [4] Nadig & Sedivy (2002). *Psych. Sci.* [5] Heller et al. (2008). *Cognition*. [6] Harris & Potts (2009). *Ling. & Phil.* [7] Kaiser (2015). *Sem. & Ling. Theory*. [8] Weingartner & Klin (2005). *Mem. & Cognition*. [9] Searle (1969). *Speech Acts*. [10] Westra & Nagel (2021). *Cognition*. [11] Hobbs (1979). *Cog. Sci.* [12] Kehler (2002). *Coherence, reference, and the theory of grammar*. [13] Grice (1975). In *Syntax & Semantics Vol. 3*. [14] Smyth (1995). *J. Child Lang.* [15] Brown-Schmidt et al. (2008). *Cognition*. [16] Gordon et al. (1993). *Cog. Sci.* [17] Arnold et al. (2000). *Cognition*.