Grammatical and Coherence-Driven Biases in Pronoun Interpretation

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Interpreting ambiguous pronouns

- Morphosyntactic factors: grammatical-role biases influence interpretation (e.g., Kameyama 1996)

  (1) John kicked Bill. Mary told him to go home.

  (2) Bill was kicked by John. Mary told him to go home.

- Coherence-driven factors: interpretation is a side effect of general inferencing used in establishing a coherent discourse (Hobbs 1979, Kehler 2002)

  (3) The city council denied the demonstrators a permit...
  a. ... because they feared violence
  b. ... because they advocated violence

  (Winograd 1972)

This talk

Puzzle: Evidence that pronoun interpretation is sensitive to grammatical role biases and coherence-driven factors

The question: What type of model can capture these facts?

Outline

- Evidence for coherence-driven biases (Rohde et al. 2006, 2007)
- Evidence for grammatical-role biases (Stevenson et al. 1994)
- Story continuation experiment
- Bayesian model of pronoun interpretation
- Conclusions

Evidence for coherence-driven biases (Rohde et al. 2006, 2007)

(4) John handed a book to Bill. He _____.

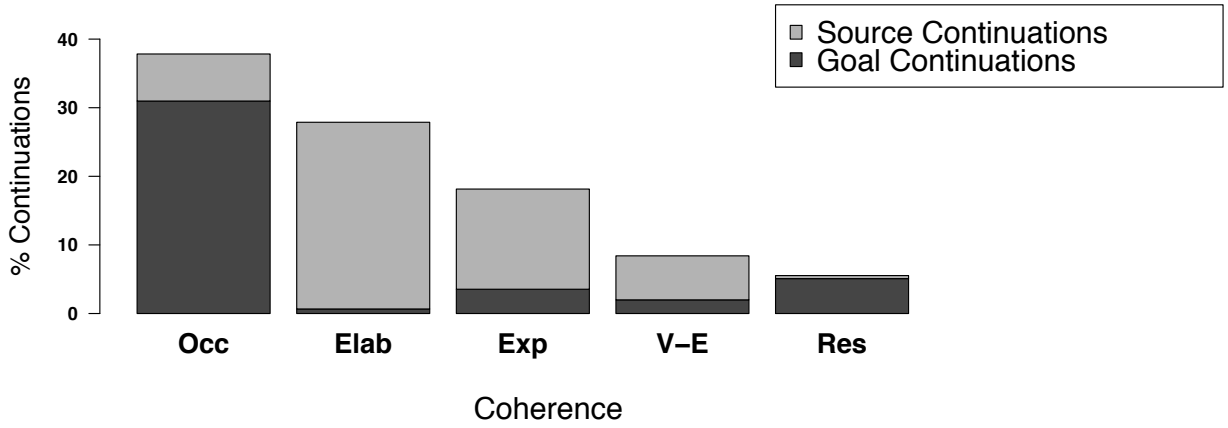
SOURCE (SUBJECT) — TRANSFER VERB — GOAL (TO-PHRASE) — AMBIGUOUS PRONOUN PROMPT

- Pronoun interpretation biases vary across coherence relations

(5) John passed the comic to Bill. He *took it and opened it*.	Occasion: event sequence
(6) John passed the comic to Bill. He *did so carefully*.	Elaboration: P from S_1, S_2
(7) John passed the comic to Bill. He *wanted Bill to read it*.	Explanation: $S_2 \rightarrow S_1$
(8) John passed the comic to Bill. He *accidentally hit Bill*.	Violated-Expectation: $S_1 \rightarrow \neg S_2$
(9) John passed the comic to Bill. He *thanked John*.	Result: $S_1 \rightarrow S_2$

Coherence breakdown (Rohde et al. 2006, 2007)

John passed the comic to Bill. He _____.



$$p(ref) = \sum_{coh} p(ref \mid coh) * p(coh)$$

→ Results show role of coherence establishment in interpretation

Interpretation/production asymmetry

- Story continuations (Stevenson et al. 1994)

  (10) John passed the comic to Bill. He _____ read it .

  (11) John passed the comic to Bill. _____ read it .

- Results (see also Arnold 2001)
  - INTERPRETATION: Pronoun prompt in (10) yields 50/50 Source/Goal interpretation -- participants were equally likely to interpret pronoun to refer to Goal as to Source
  - PRODUCTION: No-pronoun prompt in (11) reveals subject production bias for pronouns... participants were more likely to produce a pronoun when re-mentioning subject/Source and a name when re-mentioning non-subject/Goal

→ Why is this a problem? Hobbsian coherence-driven model

- pronouns are unbound variables
- no misalignment between interpretation/production is expected

Prediction for interacting biases

- Prediction: bias to produce a pronoun when referring back to subject referent may influence coherence establishment

$$p(coh) = \sum_{ref} p(coh \mid ref) * p(ref)$$

→ **Production influences interpretation:** based on production bias in Stevenson et al., p(ref=subj) is higher when pronoun is present

→ **Which in turn influences coherence:** probability that upcoming coherence relation is subject-biased (Source-biased) is higher when pronoun is present, even one whose referent is fully ambiguous

→ Are there more Source-biased relations with pronoun prompt?

- Method: elicit story continuations, categorizing referents of referring expressions and categorizing passages for coherence

Pronoun prompt: John passed the comic to Bill. He _____.

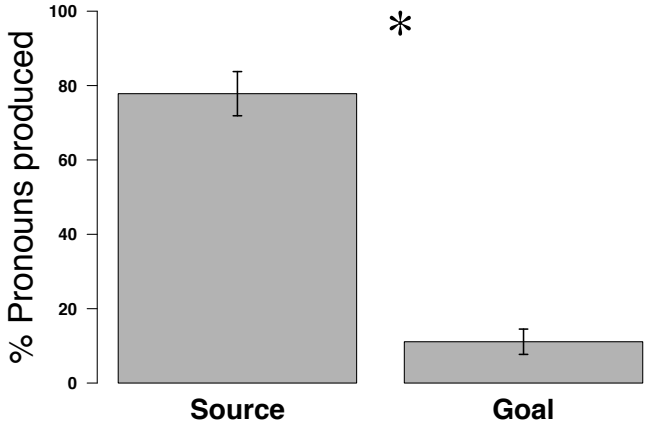
No-Pronoun prompt: John passed the comic to Bill. _____.

Story continuation experiment

- Participants: 52 monolingual English speakers
- Task: instructed to write a natural continuation
- Stimuli: vary prompt type (pronoun/no-pronoun)
- Evaluation: two judges assess coherence and coreference

Results: choice of referring expression

- Continuations elicited with no-pronoun prompt confirm subject bias in participants' production of pronouns

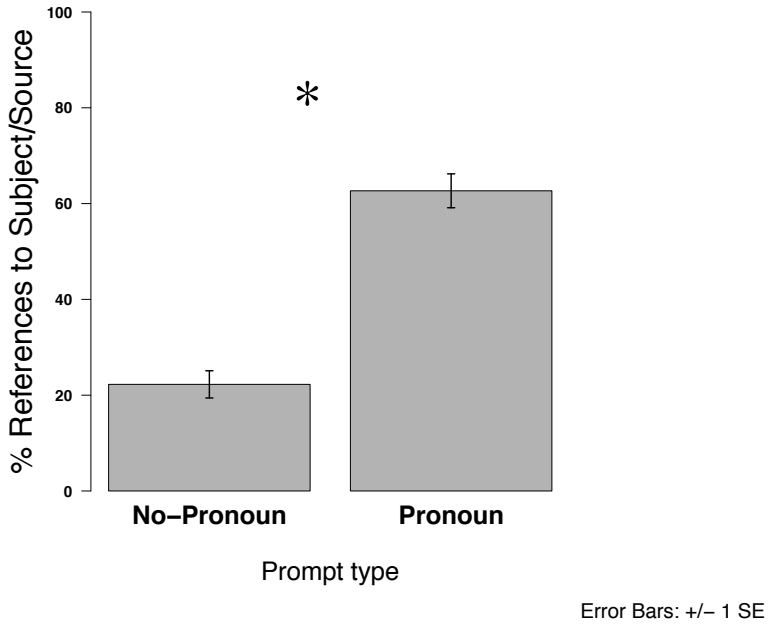


Error Bars: +/– 1 SE

No-Pronoun Prompt: John passed the comic to Bill. _____.

Results: coreference

- Presence of pronoun yields more references to the subject of the previous sentence (Source references)



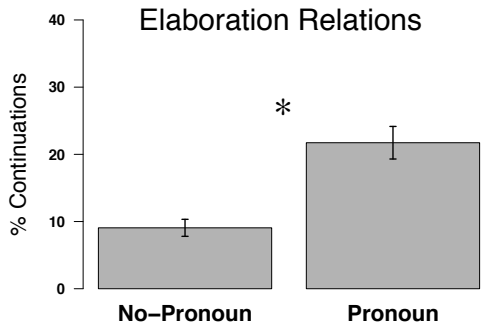
Pronoun prompt: John passed the comic to Bill. He _____.

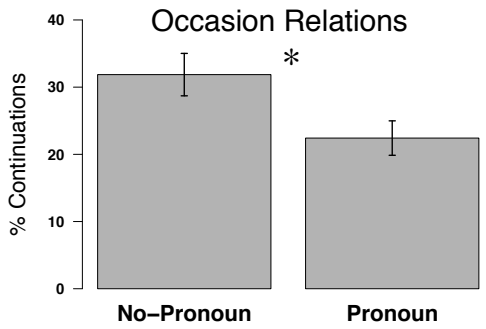
No-Pronoun prompt: John passed the comic to Bill. _____.

Results: coherence

- Compare proportions of two most frequent and opposite-biased coherence relations (Source-biased Elaborations & Goal-biased Occasions) and test for effect of prompt type

- We find more Elaborations with pronoun prompt and more Occasions with no-pronoun prompt



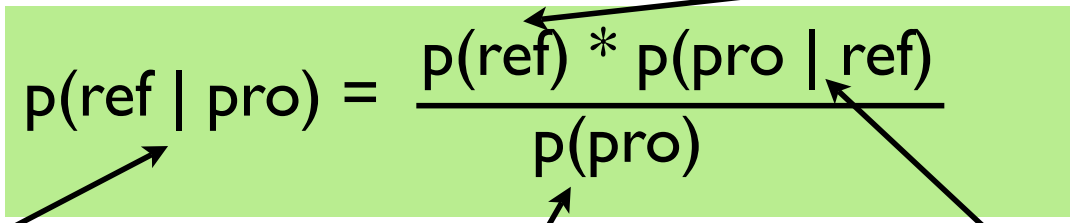


→ Presence of ambiguous pronoun shifts coherence

→ Confirms prediction regarding interaction of coherence-driven biases and grammatical-role biases

Accounting for the asymmetry

- Bayes rule for pronoun interpretation



Prior for referent in a particular context

Pronoun **interpretation**: Stevenson et al.'s result that probability is 50/50 of interpreting a pronoun as subject-referring

Overall probability of using a pronoun

Grammatical-role **production** bias: Stevenson et al.'s result that probability of producing a pronoun is high when referent is the subject

Accounting for the asymmetry

- Case study to see asymmetry: subject #14

$$p(ref \mid pro) = \frac{p(ref) * p(pro \mid ref)}{p(pro)}$$

Interpretation bias (pro prompt)	Production biases (no-pro prompt)
p(ref=Source | pro) = 0.63	p(ref=Source) = 0.33 p(pro|ref=Source) = 1.0 p(pro|ref=Goal) = 0.25
p(ref|pro) = 0.63	$\frac{p(ref) * p(pro \mid ref)}{p(pro)}$ = 0.67

- Rate of Source coreference: correlated across prompt types

R^2=0.266, F(1,100)=37.65, p<0.001; R^2=0.404, F(1,71)=49.73, p<0.001

Coherence & pronominalization

- Biases regarding upcoming coherence relations are dependent on the probability that a particular referent has been mentioned

$$p(coh) = \sum_{ref} p(coh \mid ref) * p(ref)$$

- Probability of next mention is dependent on the presence of a pronoun

$$p(ref \mid pro) = \frac{p(ref) * p(pro \mid ref)}{p(pro)}$$

Summary

- Introduced a model to capture both coherence-driven and grammatical-role biases
  → crucially without simply enumerating factors but rather showing when and how particular factors come into play
- We explain the apparent asymmetry between pronoun interpretation and production
- Our model correctly predicts that the occurrence of a pronoun -- even a fully ambiguous one -- will change expectations about how the discourse will continue

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Thank you!