What is the role of coherence (QUD) in coreference?

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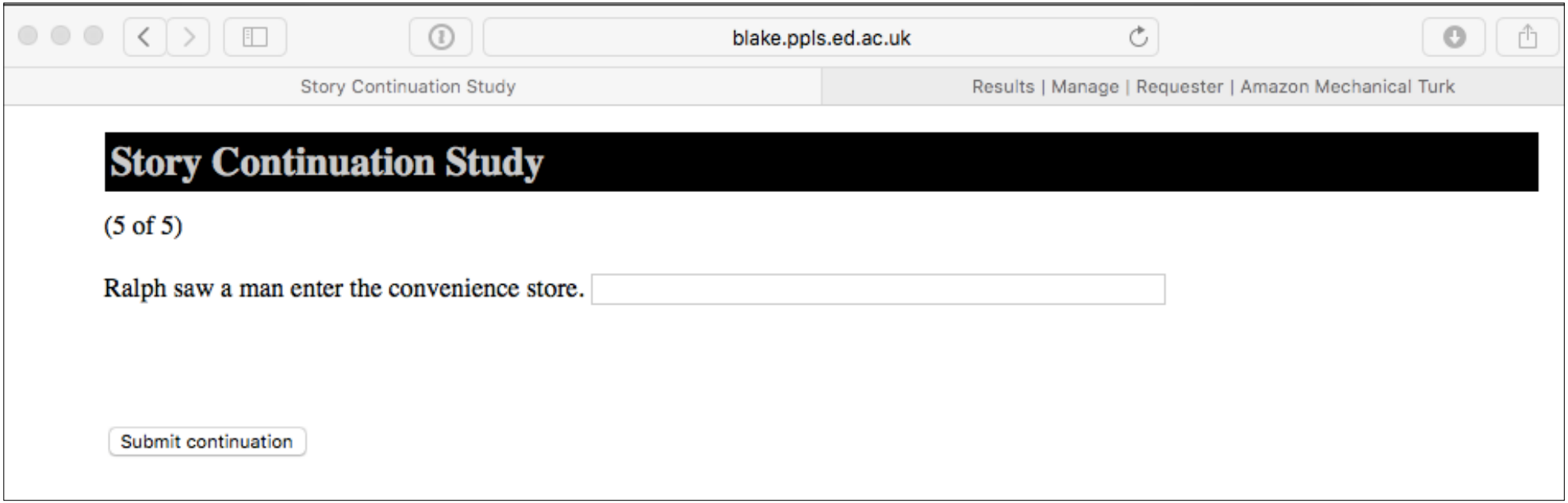
What about Ralph?

- Craige's example from Monday

(11) Ralph saw a man enter the convenience store.

- Which referent is more salient?
- How do different anaphors work in this context?



Story continuation results (N=33)

Ralph saw a man enter the convenience store.

He watched him carefully while he decided on what purchases to make.
The man was wearing very fancy clothing and had a strong presence.
…

- WHO was mentioned next?

p(referent = Ralph) = .22
p(referent = man) = .78

- HOW were they mentioned?

p("He"|referent=Ralph) = .5
p("Ralph"|referent=Ralph) = .5

p("He"|referent=man) = .14
p("The man"|referent=man) = .86

Different anaphoric expressions

Ralph saw a man enter the convenience store. ____

p(Ralph) = .22
p(man) = .78

Ralph saw a man enter the convenience store. The man ____

was wearing a mask.
was wearing a strange hat.
…

p(ref=Ralph|"The man") = 0
p(ref=man|"The man") =1.0

Ralph saw a man enter the convenience store. He ____

followed the man into the store.
was wearing a mask and proceeded to rob the store.
…

p(ref=Ralph|"He")= .5
p(ref=man|"He") = .5

→ Pronouns don't simply pick out the most salient referent!

Pronoun production & interpretation

- How to reconcile:
  - strong bias to re-mention the man
  - only half of pronouns interpreted to refer to the man
  - very few pronouns produced to refer to the man
- Problem: Thinking of pronoun interpretation as a search
- Instead: Consider how a pronoun is generated within a model of speaker production
- Bayes' Rule

$$p(\text{ref} \mid \text{pronoun}) \sim p(\text{pronoun} \mid \text{ref})\ p(\text{ref})$$

(with Andy Kehler)

Pronouns with Bayes

p(ref | pronoun) ~ p(pronoun | ref) p(ref)

- Not a model of pronoun interpretation, just a mathematical truth
- But it highlights several points:
  - Pronoun interpretation as comprehenders' expectations of what a speaker would do
  - Possibility of low p(pronoun|ref) but not low p(ref|pronoun), if big enough prior p(ref)
  - Pronoun interpretation ≠ pronoun production

Bayes' Rule

Ralph saw a man enter the convenience store. ____

$$p(\text{ref} \mid \text{pronoun}) = \frac{p(\text{pronoun} \mid \text{ref})\, p(\text{ref})}{\sum_{\textit{ref}} p(\text{pronoun} \mid \text{ref}) p(\text{ref})}$$

Bayes-derived values

$$p(\text{Ralph} \mid \text{“He”}) = \frac{.5 * .22}{.5*.22+.14*.78} = .501$$

$$p(\text{man} \mid \text{“He”}) = \frac{.14 * .78}{.5*.22+.14*.78} = .498$$

Observed values:

Ralph saw a man enter the convenience store. He ____

p(Ralph|”He”) = .5
p(man|”He”) = .5

Bayes

p(ref | pronoun) ~ p(pronoun | ref) p(ref)

- What factors influence which probability?

?

-named “Ralph”?
-subject “Ralph”?
-topic “Ralph”?

The referent mentioned next is the one who is

~~As in Roberts (2003, 2004), the antecedent of a pronominal anaphoric trigger must be~~ maximally salient. ~~Hence, it must lie~~ on the Right Frontier ~~for the node in which the trigger is introduced.~~

Other story continuation data in this vein

[Expt1: Implicit Causality]

Semantic bias of the verb influences coherence expectations and, in turn, patterns of coreference

[IC1] **Mary annoyed Sue. _____**

[IC2] **Mary scolded Sue. _____**

[nonIC] **Mary babysat Sue. _____**

estimate who gets mentioned and how: p(ref), p(pro | ref)

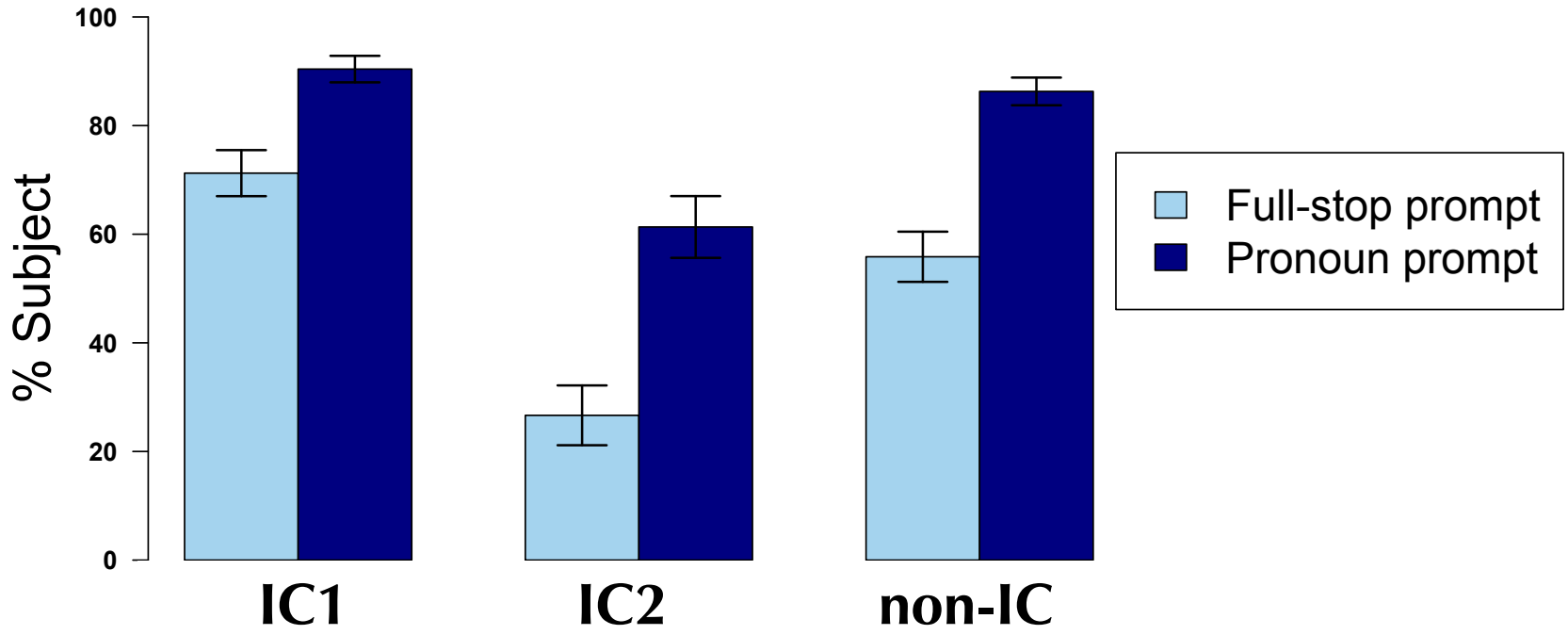
[IC1] **Mary annoyed Sue. She _____**

[IC2] **Mary scolded Sue. She _____**

[nonIC] **Mary babysat Sue. She _____**

compare to observed interpretation: p(ref | pro)

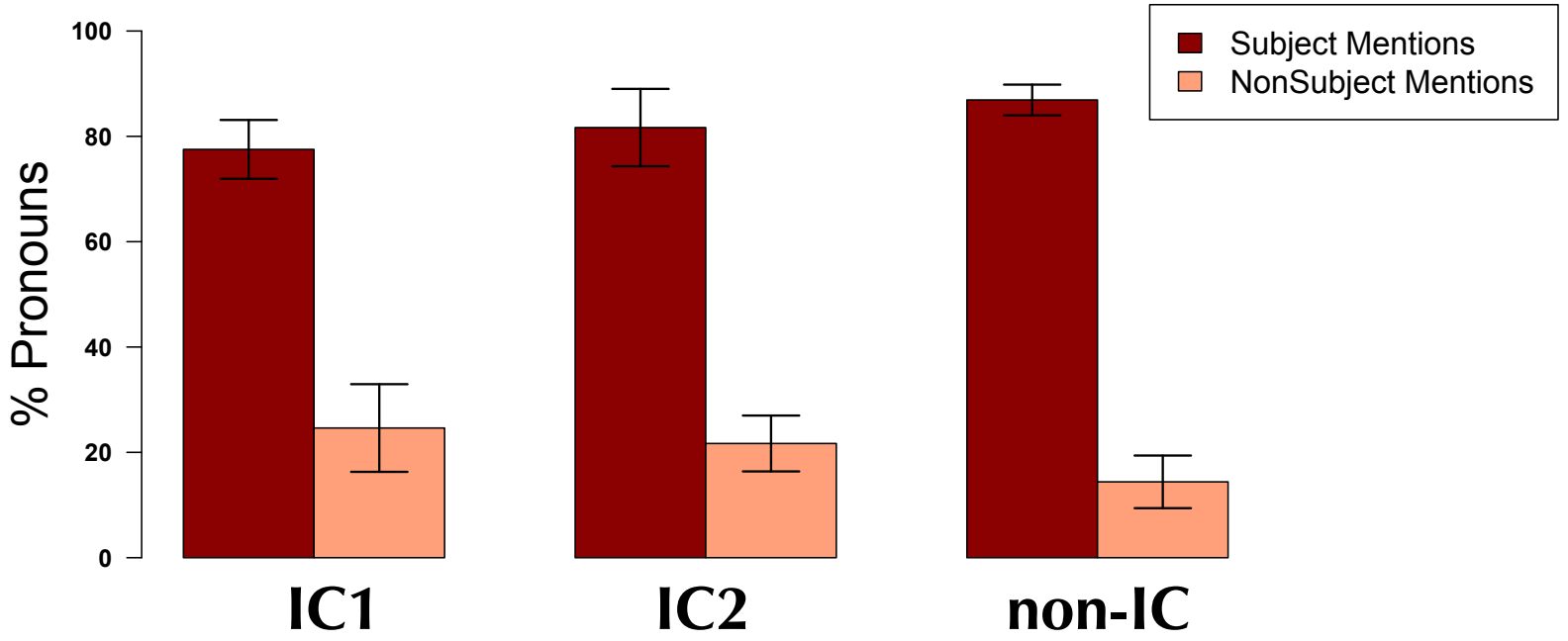
p(ref | pronoun) ~ p(pronoun | ref) p(ref)



→ verb semantics influence mention and interpretation

[IC1] Mary annoyed Sue. (She) _____
[IC2] Mary scolded Sue. (She) _____
[non-IC] Mary babysat Sue. (She) _____

p(ref | pronoun) ~ p(pronoun | ref) p(ref)



→ Verb semantics does not influence pronominalization

(Fukumura & van Gompel, 2010; Kehler et al., 2008; Miltsakaki 2007; Rohde 2008; Stevenson et al., 1994)

[IC1] Mary annoyed Sue. _____
[IC2] Mary scolded Sue. _____
[non-IC] Mary babysat Sue. _____

Bayesian approach

p(ref | pronoun) ~ p(pronoun | ref) p(ref)

- Verb semantics influence salience of mention (p(ref)) but not the likelihood of pronominalization (p(pronoun|ref)).
- As with Ralph example, we find a tight fit between observed pronoun interpretation biases and Bayes-derived estimates.
- But how does coherence/QUD influence p(ref)?

Annotating coherence relations

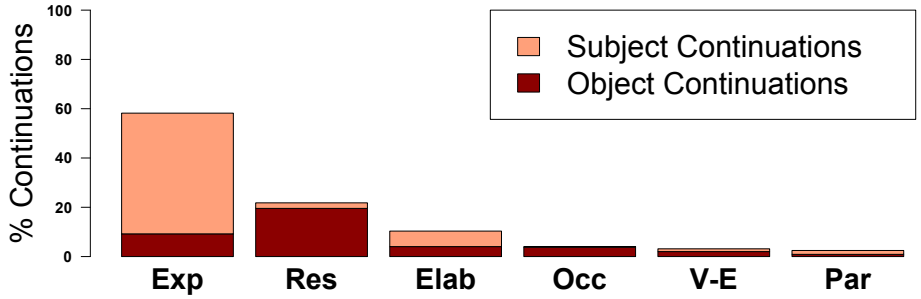
[Expt1: Implicit Causality]

Ryan hates Amy. <u>She cheated on him</u> .	Explanation
Greg corrected Sally. <u>Sally got mad</u> .	Result
Elizabeth scolded Alan. <u>She did so loudly</u> .	Elaboration
Scott thanked Jessica. <u>He then proceeded to travel home and went to bed</u> .	Occasion
Jared congratulated Debbie. <u>She didn't seem to appreciate his congratulations</u> .	Violated Expectation
Stephanie annoyed David. <u>David annoyed everyone else</u> .	Parallel

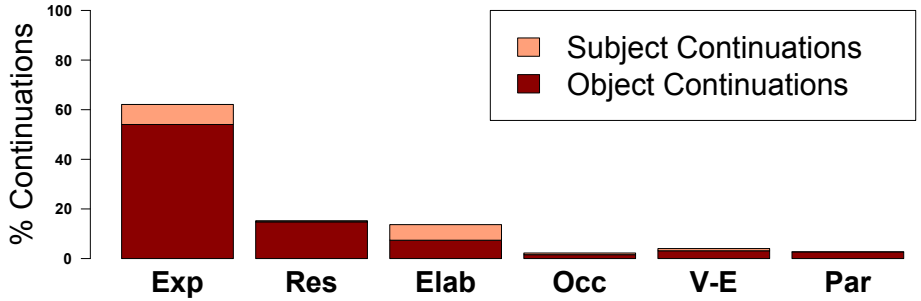
Same annotation scheme for Non-IC passages

Verbs -> coherence -> coreference

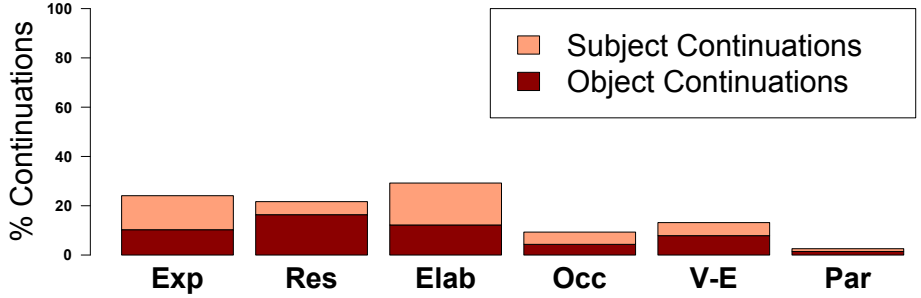
IC1
(e.g. *annoy*)



IC2
(e.g. *scold*)



Non-IC
(e.g. *babysit*)



→ IC verbs generate expectations for upcoming Explanation (if none preceding, see Simner & Pickering 2005)

→ Analogous to coherence expectations, are there also expectations about upcoming questions?

Coherence relations and QUDs

- Coherence Relations (Mann & Thompson, 1988; Webber & Joshi, 1998; Hobbs,1990; Kehler, 2002; Asher & Lascarides, 2003; Webber, 2006; reviews in Knott, 1996 and Hutchinson, 2005)

  Comprehenders use general inferencing to identify the relationship between two propositions

Mary scolded John. She did so loudly.	Elaboration
Mary scolded John. He was late again.	Explanation

- Question-Under-Discussion models (Roberts, 1996; Van Kuppevelt, 1995; Büring, 2003; Larsson, 1998; Ginzburg & Sag, 2000)

  An utterance is coherent insofar as it answers a question relevant to the proceeding discourse

Mary scolded John. She did so loudly.	How?
Mary scolded John. He was late again.	Why?

"An implicit question is a question which the speaker anticipates will arise in the listener's mind on interpreting preceding utterances (or some non-linguistic events occurring in the discourse).

... In this paper, however, we will largely leave undiscussed the way in which these questions arise as the result of the interaction of given contextual information and a given model of the addressee."

(van Kuppevelt, 1995, p. 117)

Verbs -> coherence/QUD?

[Expt2: IC in monologue and dialog]

- Task: imagine a phone conversation, write either

Monologue continuation
Friend: Mary scolded/babysat John. _____.

Dialog continuation
Friend: Mary scolded/babysat John.
You: _____?

- Participants: 75 monolingual English speakers
- Materials: 40 IC verbs and 40 non-IC verbs
- Evaluation: judges annotated relation & question

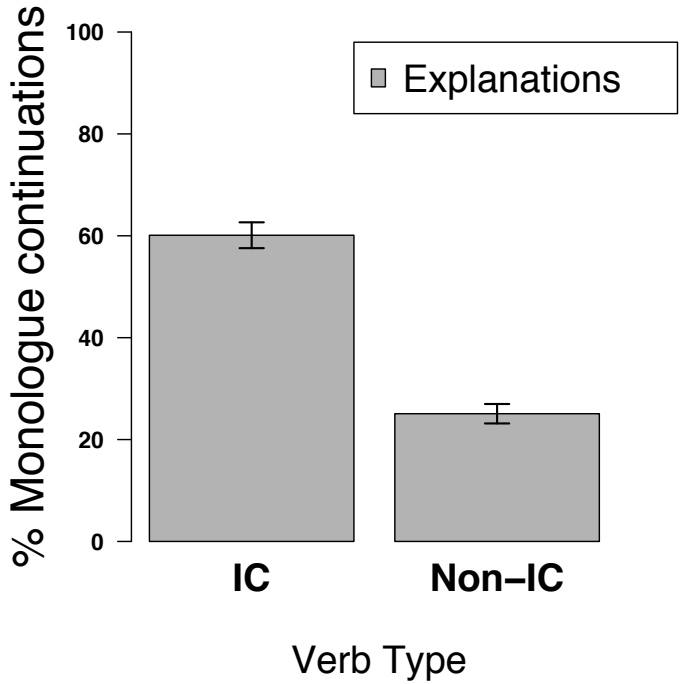
Dialog annotation

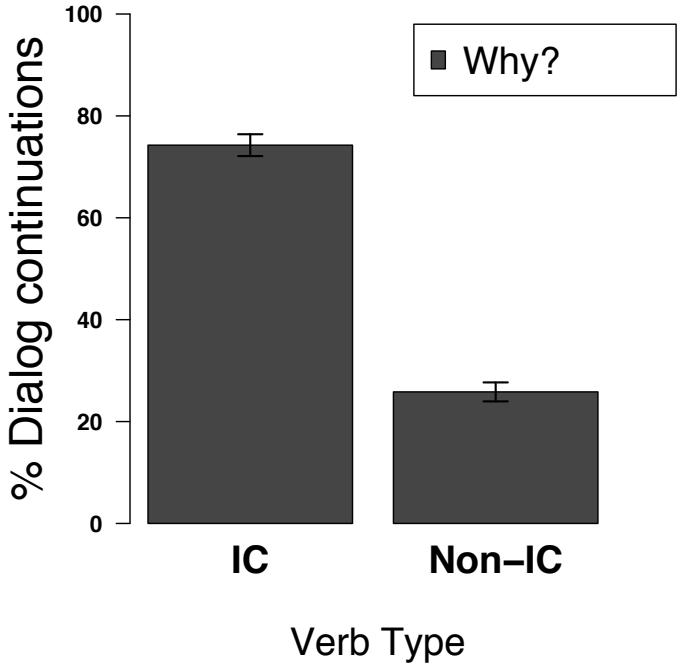
[Expt2: IC in monologue and dialog]

Friend: Ryan hates Amy. **You: What has she done ?**	Explanation
Friend: James charmed Amber. **You: Did she blush ?**	Result
Friend: Greg corrected Sally. **You: When did this happen ?**	Elaboration
Friend: Laura values Luis. **You: Does Luis value Laura ?**	Parallel
Friend: Craig reproached Kate. **You: What happened next ?**	Occasion

Note: no violated expectation questions
(see Hunter & Abrusán, forthcoming)

Results: Explanation ~ Why





→ IC verbs: bias to Explanations and to the question Why

→ Beyond Explanations?

verb aspect -> coherence/QUD?

- Moens & Steedman 1988
  - Perfective describes an event as completed
  - Imperfective describes an event as ongoing
- Predictions:
  - Relations/QUDs that require an end state favored following perfective (e.g., Occasion, What next?)
  - Other relations/QUDs favored following imperfective

verb aspect -> coherence/QUD?

Exp3: aspect in monologue and dialog

- Task: imagine a phone conversation, write either

Monologue continuation
Friend: John handed/was handing a book to Bob. __.

Dialog continuation
Friend: John handed/was handing a book to Bob.
You: _____?

- Participants: 75 monolingual English speakers
- Materials: 40 transfer verbs (perfective/imperfective)
- Evaluation: judges annotated relation & question

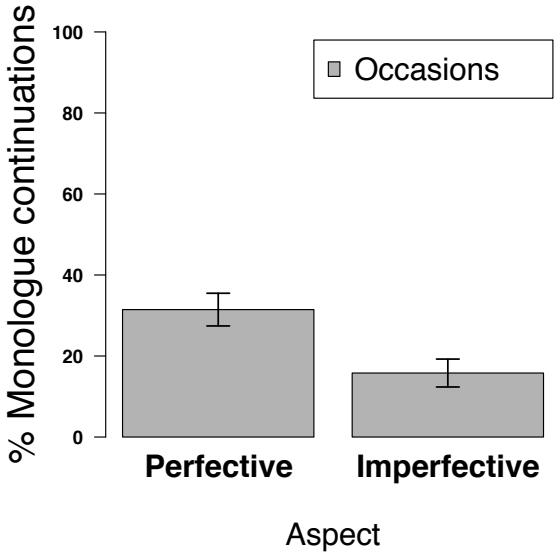
Dialog annotation

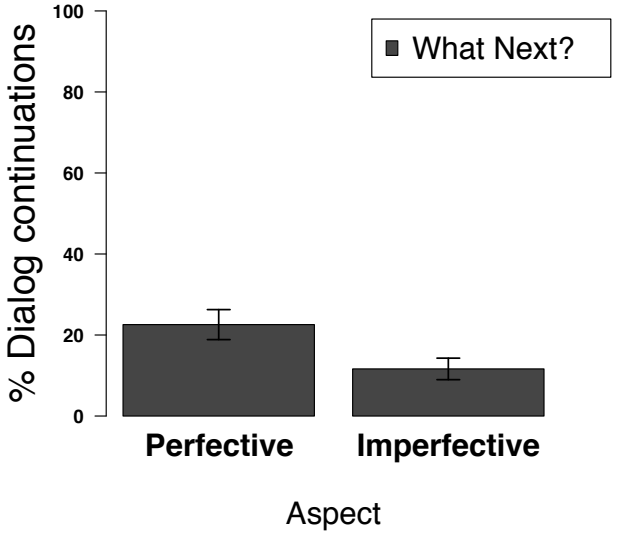
Exp3: aspect in monologue and dialog

Friend: Heather refunded $30 to Roger. **You: Why did she owe him money ?**	Explanation
Friend: Amanda shifted some poker chips to Scott. **You: How did Scott react ?**	Result
Friend: Tim was floating a life vest to Jessica. **You: Where were they ?**	Elaboration
Friend: George was slapping a beachball to Sarah. **You: Did she hit it back ?**	Parallel
Friend: Keith mailed a fruitcake to Barbara. **You: Did she throw it away ?**	Occasion

Results: coherence~QUD

Occasion
~
What next





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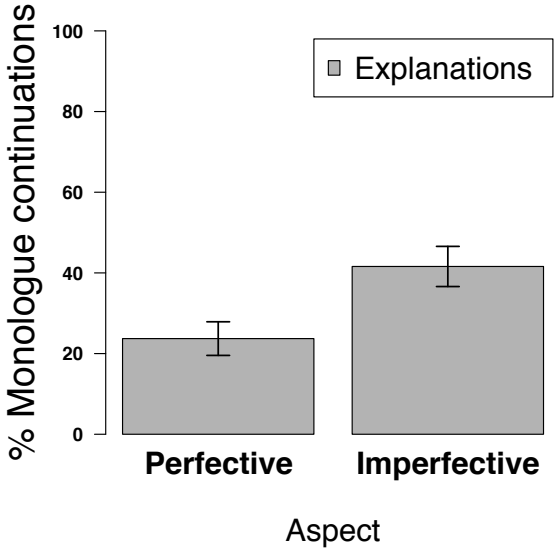
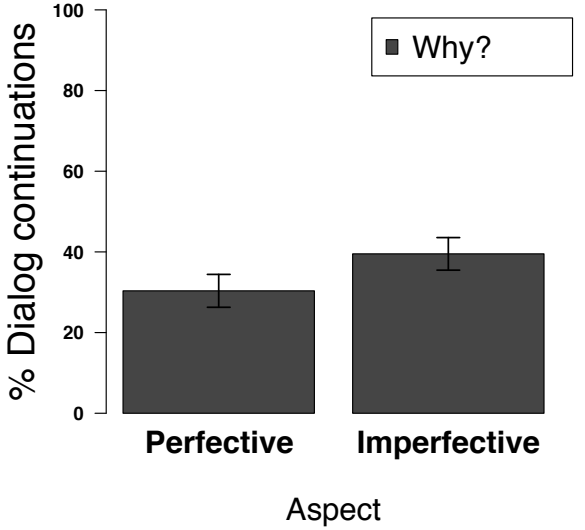
Explanation
~
Why





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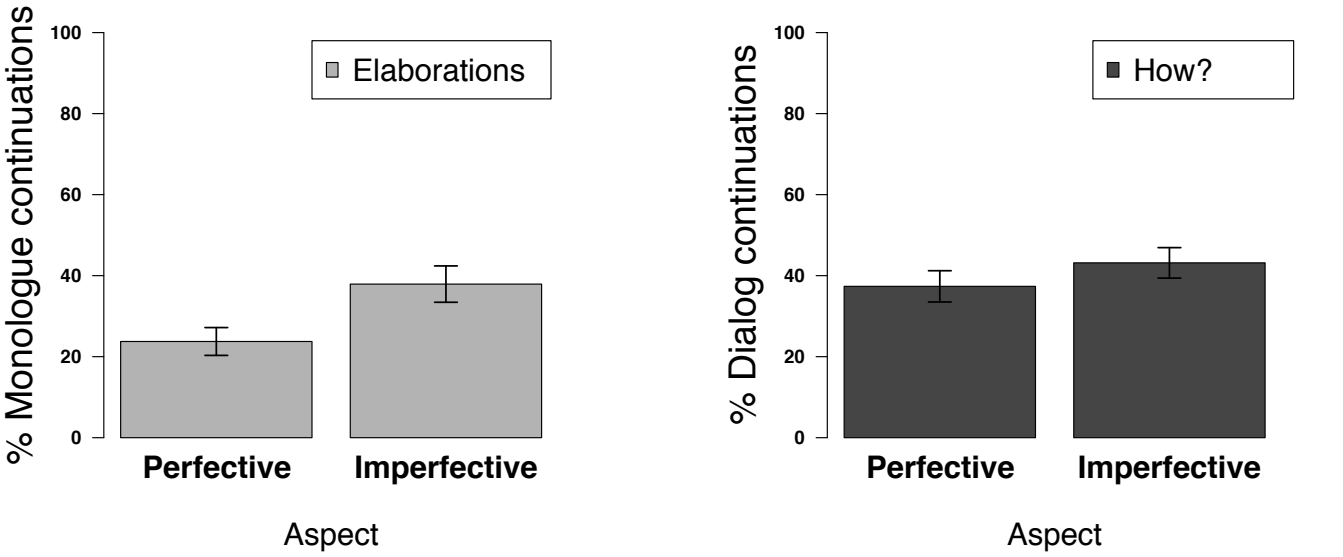
Results: coherence~QUD

Elaborations
~
when/where/how



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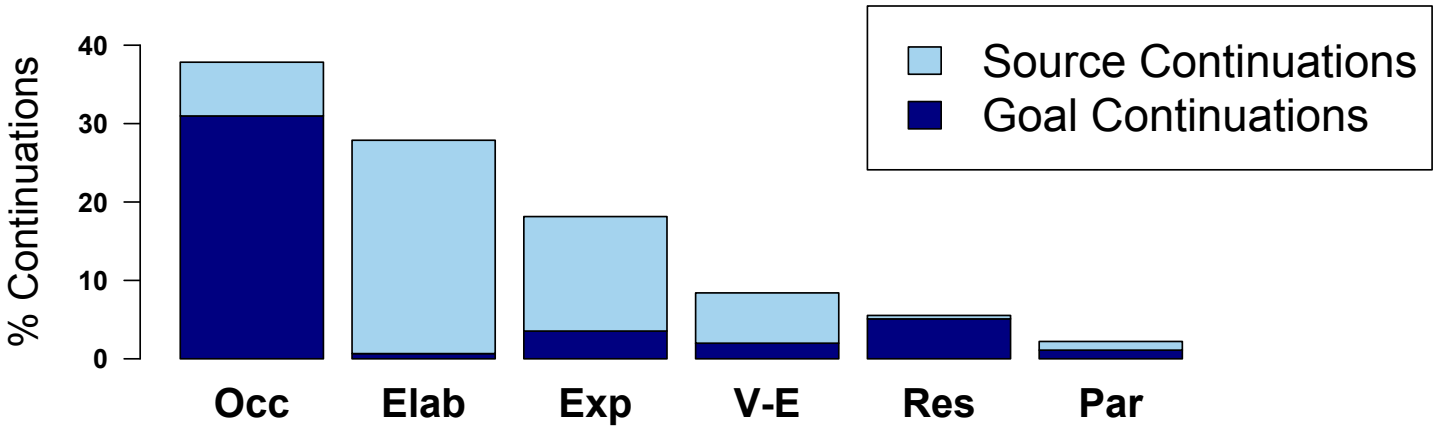
→ Targeted manipulation of verb aspect shifts distributions of coherence relations and QUDs in similar ways.

→ Is anaphora sensitive to this manipulation of aspect?

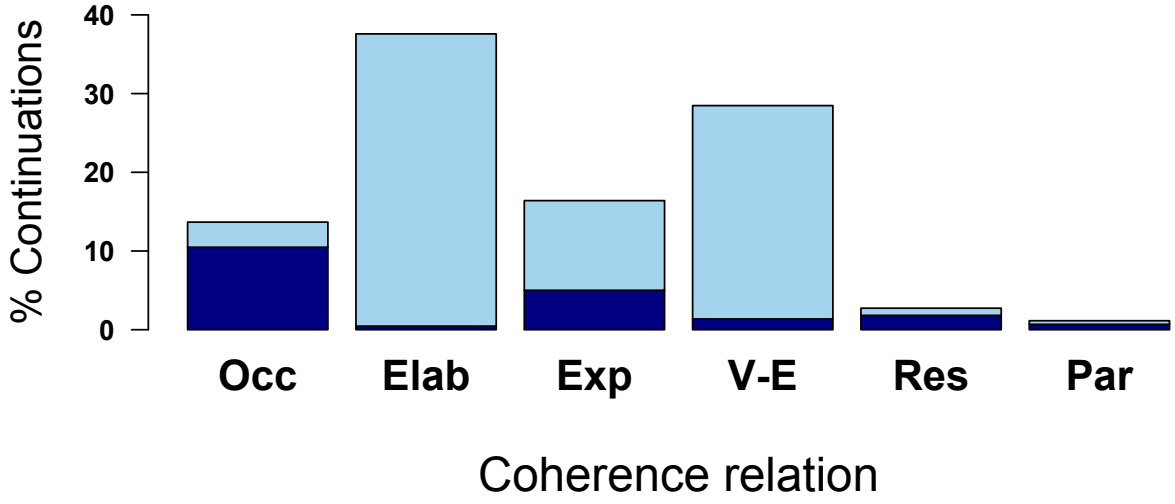
aspect -> coherence -> coreference

Exp3′: aspect manipulation (monologues)

perfective



imperfective



→ Different distributions of relations yield different coreference patterns

Manipulate coherence distribution

Expt4: story continuations with QUD

- Task: write a story continuation
- Instructions: Answer the question "why" or "what happened next?" (between subjects)

John handed a book to Bob. He _____.

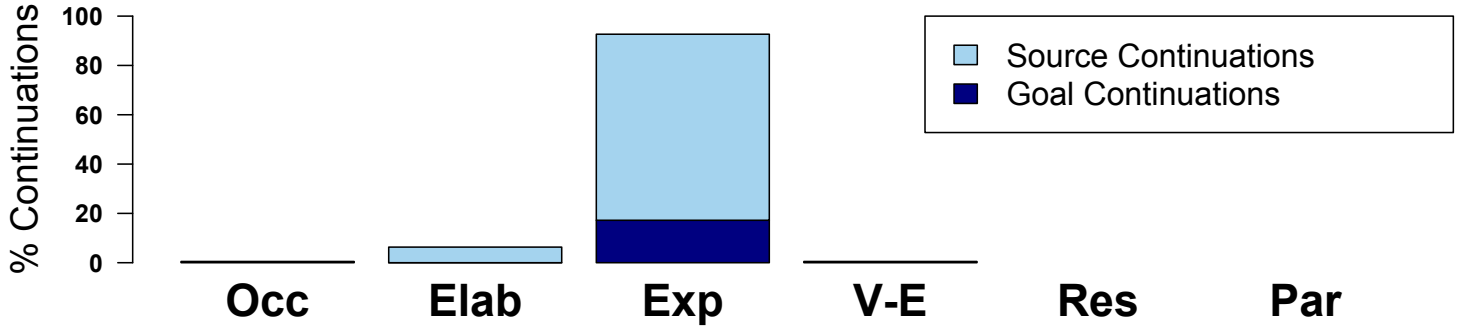
- Predictions:

  "Why?" → more Explanations → Source bias

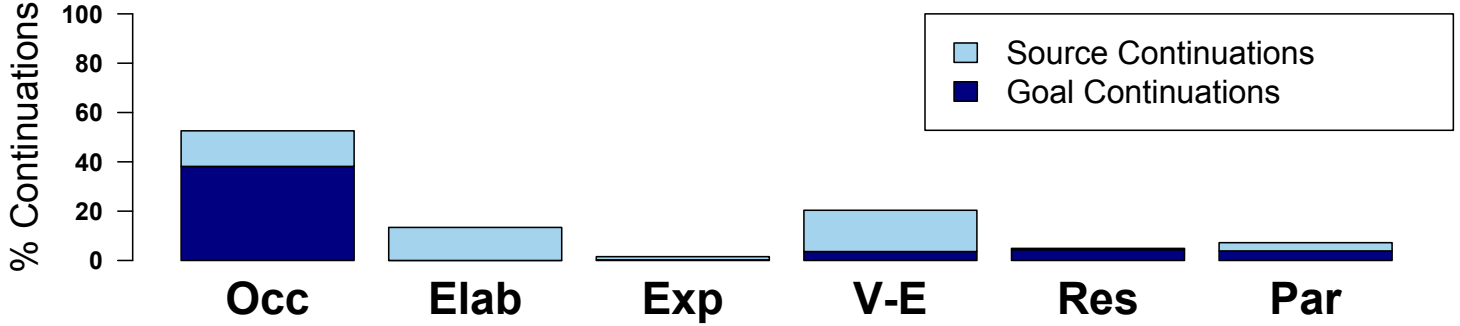
  "What happened next?" → more Occasions → Goal bias

Results: QUD -> coreference

"Why?"



"What next?"



→ Materials held constant but different coreference pattern via QUD

Real-time interpretation

[Expt5: QUD reading time]

- Task: read passages one word or phrase at a time
- Instructions: expect follow-on sentences that answer *Why?* or *What next?* (between subjects)

Source-referring pronoun

Jessica served chili to_Emily. She explained to Emily

[WHY] ... in_the_kitchen_that morning that_everyone needs_to try_chili_once.
[WHAT-NEXT] ... in_the_kitchen_that night that the_secret_to chili is_real_jalapenos.

Goal-referring pronoun

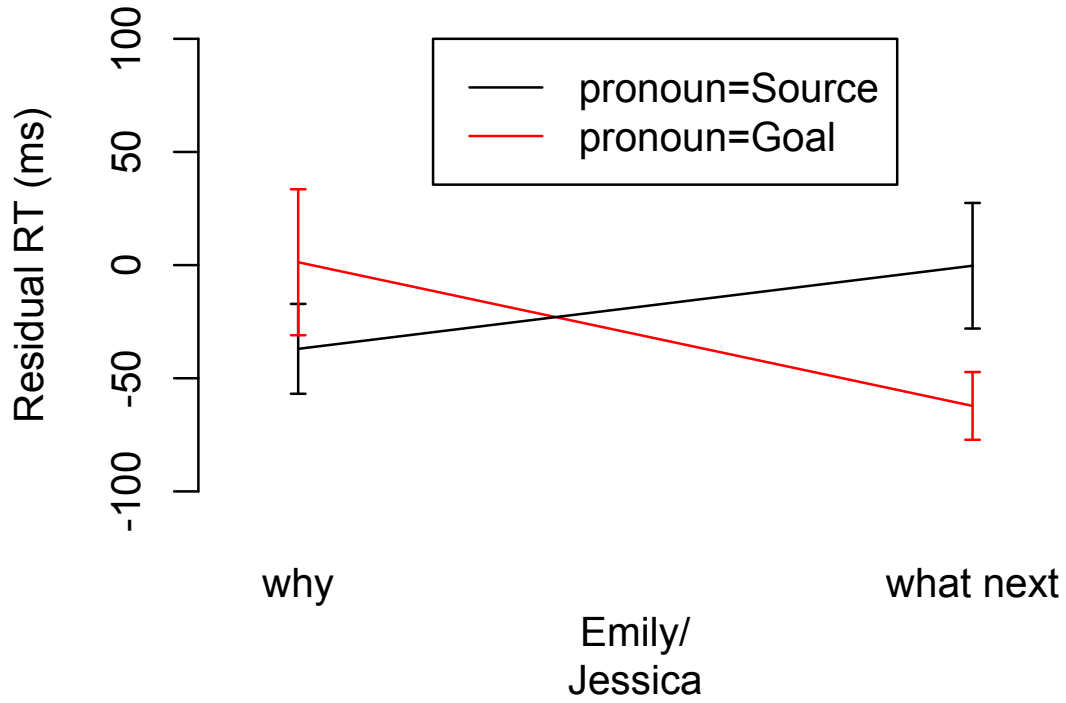
Jessica served chili to_Emily. She explained to Jessica

[WHY] ... in_the_kitchen_that morning that_she can_only eat_soft_foods.
[WHAT-NEXT] ... in_the_kitchen_that night that the_chili was_a_bit too_spicy.

→ At disambiguating name, does processing speed reflect QUD?

Results: QUD -> coreference

[pronoun=Source] Jessica served chili to_Emily. She explained to Emily …
[pronoun=Goal] Jessica served chili to_Emily. She explained to Jessica …



→ Predicted interaction between QUD and coreference

Interim summary

- Bayesian model of pronoun interpretation reconciles competing biases of WHO to mention versus HOW
- Contextual cues (verb semantics, verb aspect) that influence coherence also influence QUD
- Coreference sensitive to coherence/QUD
- Next: Is coherence/QUD sensitive to coreference?

Coreference -> coherence?

When to update p(coherence relation)?

Mary annoyed John. *Mary had been bragging too much.*

Mary annoyed John. She *had been bragging too much*

Mary annoyed John. He *avoids talking to her.*

- Subject-referring pronoun -> subject-biased relations
- Object-referring pronoun -> object-biased relations

$$p(coh \mid referent) \sim p(referent \mid coh)\ p(coh)$$

Pronominal form -> coreference -> coherence

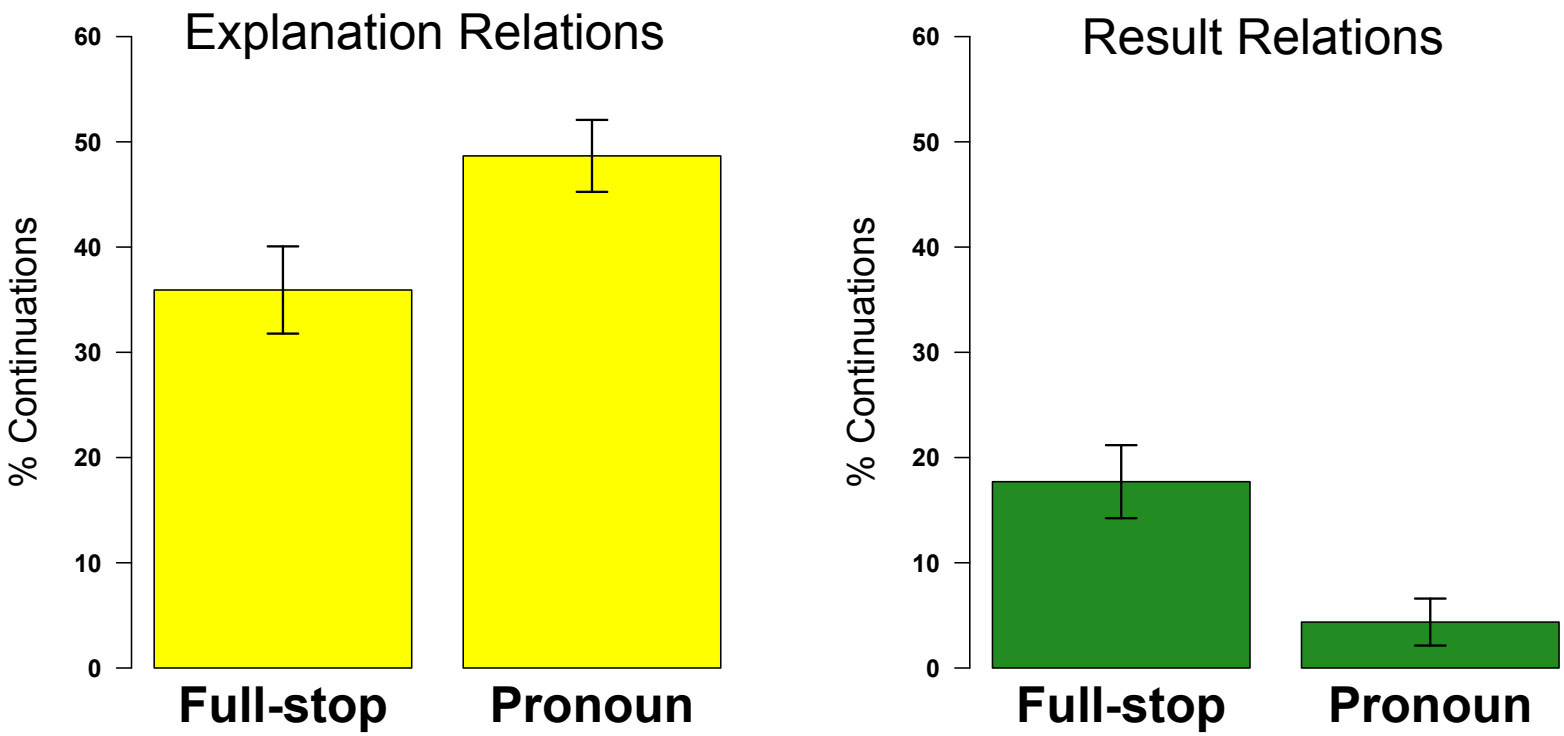
Expt6: IC & pronouns on coherence

Full-stop prompt: **John annoyed/scolded/babysat Bill. _____.**

Pronoun prompt: **John annoyed/scolded/babysat Bill. He ___.**

- Full-stop shows prior coherence distribution: **p(coh)**
- Pronoun prompt is predicted to yield more subject-biased relations & fewer object-biased relations, via a Bayesian update: **p(coh | referent)**
- Subject-biased verbs ('annoy')
  - Subject-biased relation: Explanation
  - Object-biased relation: Result

form of reference -> coreference -> coherence



Full-stop prompt: **John annoyed Bill. _____.**

Pronoun prompt: **John annoyed Bill. He ___.**

Pronominal form -> coreference -> coherence

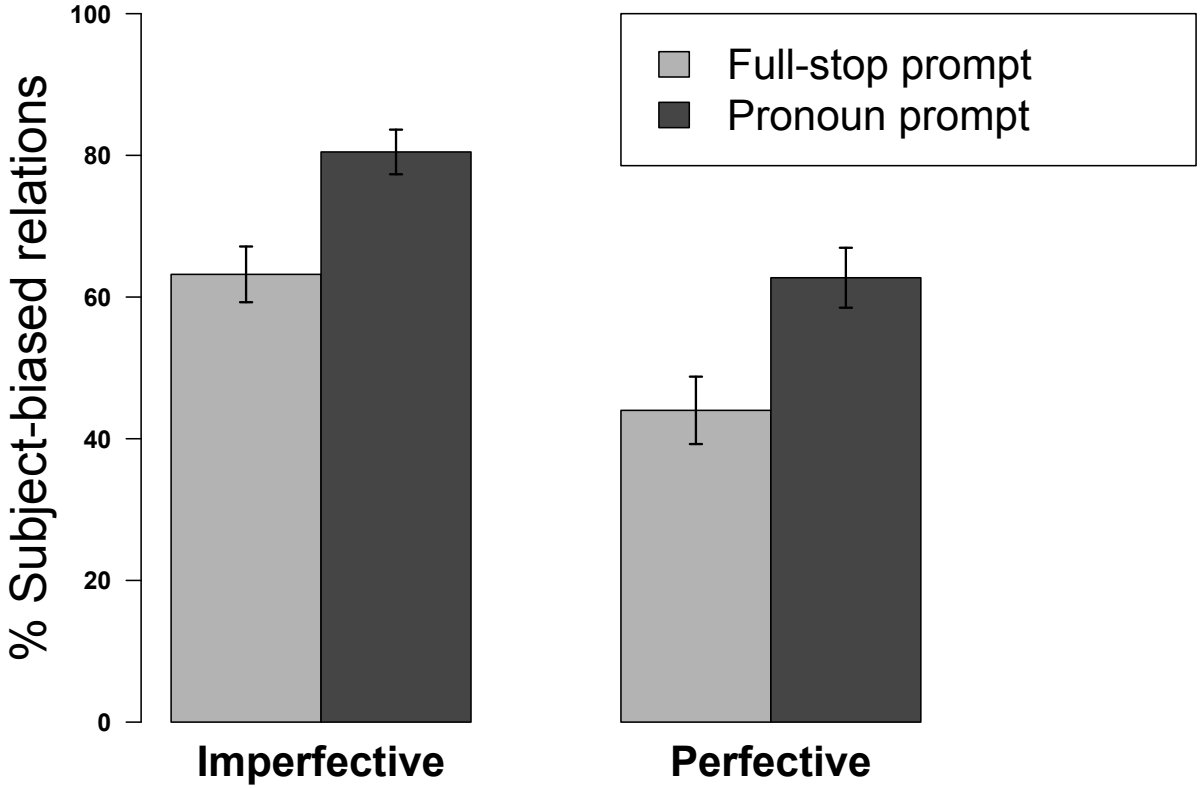
Expt7: aspect & pronouns on coherence

Full-stop: **John handed/was handing a book to Bill. _____.**

Pronoun: **John handed/was handing a book Bill. He _____.**

- Full-stop shows prior coherence distribution: **p(coh)**
- Pronoun prompt is predicted to yield more subject-biased relations & fewer object-biased relations, via a Bayesian update: **p(coh | referent)**
- For transfer-of-possession contexts
  - Subject-biased relations: Explanation, Elaboration, Violated Expectation
  - Object-biased relation: Occasion, Result

form of reference -> coreference -> coherence



→ Again, a (fully ambiguous) pronoun can influence distribution of coherence relations

What is the role of coherence (QUD) in coreference?

- Coherence and QUD similarly sensitive to cues in the context
  p(coherence | context) ~ p(QUD | context)
- Coherence and QUD influence salience of referents via the prior
  p(referent | pronoun) ~ p(pronoun | referent) p(referent)
- Bidirectional relationship between Coherence/QUD and coreference
  p(QUD | referent) ~ p(referent | QUD) p(QUD)

Thanks!