Parsing sentences: Filler-gap dependencies

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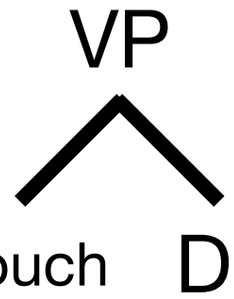
Interactivity in parsing

Today: Focus on *generation of structural candidates,* with a special focus on **filler-gap dependencies**.

Semantic [[touch]]

Syntactic



Lexical /tʌtʃ/

Phonetic

“Fillers and gaps”

→ **Long-distance dependencies (heuristic concept)** occur when it is necessary to link two terms in a sentence that are separated in the linear order, for purposes of i) semantic interpretation (e.g. assignment of a thematic role) or ii) morphosyntactic licensing (e.g. evaluating agreement features)

Which cellphone *did Juniper say that Mary wanted Rachel to* ***fix****?*

“Fillers and gaps”

→ **Long-distance dependencies (heuristic concept)** occur when it is necessary to link two terms in a sentence that are non-adjacent in the linear input, for purposes of i) semantic interpretation (e.g. assignment of a thematic role) or ii) morphosyntactic licensing (e.g. evaluating agreement features)

Which cellphone *did Juniper say that Mary wanted Rachel to fix* ***_?***

Filler: Element that has been moved from its base position due to movement.

Gap: Position in the string where the filler would normally be found

“Fillers and gaps”

→ **Filler-gap dependencies** canonically (but not uniquely) occur in many constructions that involve overt A’ movement, and which are predictable from the left edge: Examples:

Relative clause: *I met* *a man* *that Zane tried to date __ .*

Wh-movement: *Which dog* *did you walk* *__* *?*

Topicalization: *This dog*, *everyone fears* *__* .

Pseudocleft: *What* *I really hate* *__* *is broccoli.*

Comparative: *Shota is more* *Japanese* *than Brian is* *__*.

“Fillers and gaps”

→ **How we do parse filler-gap dependencies?** Prototypical example of a *generation*-level question in sentence comprehension.

One possibility: Bottom-up parsing. Process the whole sentence until you find a missing argument. Put a gap wherever there is a missing word in the sentence

Another possibility: Top-down parsing. Attempt to create a gap position as soon as is possible. Assume there is a gap before you have any evidence for it. .

Wh-movement: *Which doggo did Zelda tell Hilda that they should adopt from the pound?*

When should we create a gap position on each of these strategies? And what behavioral predictions would we make on each?

“Fillers and gaps”

→ **Active filler strategy (Frazier, 1987; anachronistic formulation):** Assign filler to base position as soon as possible.

Wh-movement: *Which doggo did Zelda tell Hilda that they should adopt from the pound?*

→ **Active filler hypothesis (Frazier, 1987; original formulation):** Empty HOLD as soon as possible.

HOLD - hypothesized memory buffer that is dedicated to the maintenance of open fillers (Wanner & Maratsos 1978).

Stowe (1986)

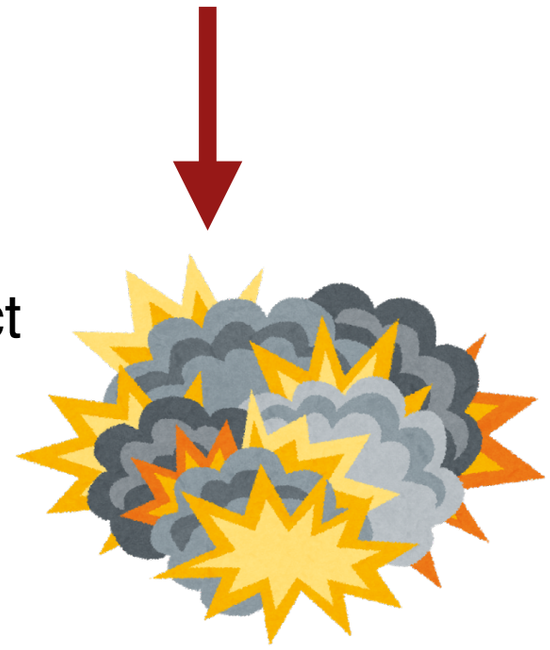
Top-down parsing via the **active filler strategy**. When we have a filler in memory, we try to put it into the first possible gap site, even before we know if there is anything in the gap site.

Prediction: The ‘parser’ should assume gaps before any bottom-up evidence.

NO FILLER: *I know that Zelda trained* ***her cat*** *with that doggo.*

FILLER: *I know which doggo Zelda trained* ***her cat*** *with.*

Filled-gap effect: Readers slow down at ‘her cat’ in examples like this (Stowe, 1986). This is called the filled-gap effect. It is thought to reflect surprise when a reader sees that a gap they had predicted is actually filled with something else.



Atkinson et al (2018)

Visual world paradigm: Listeners have their eye movements tracked while they listen to linguistic stimuli.

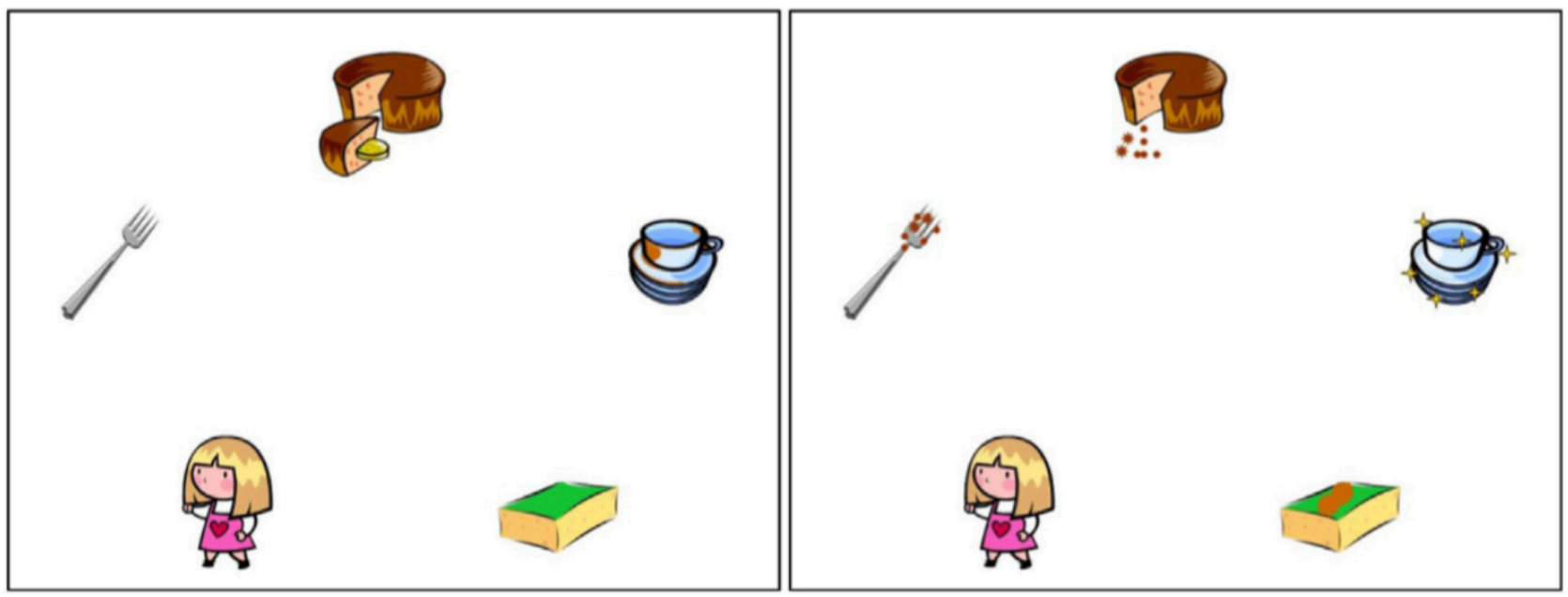
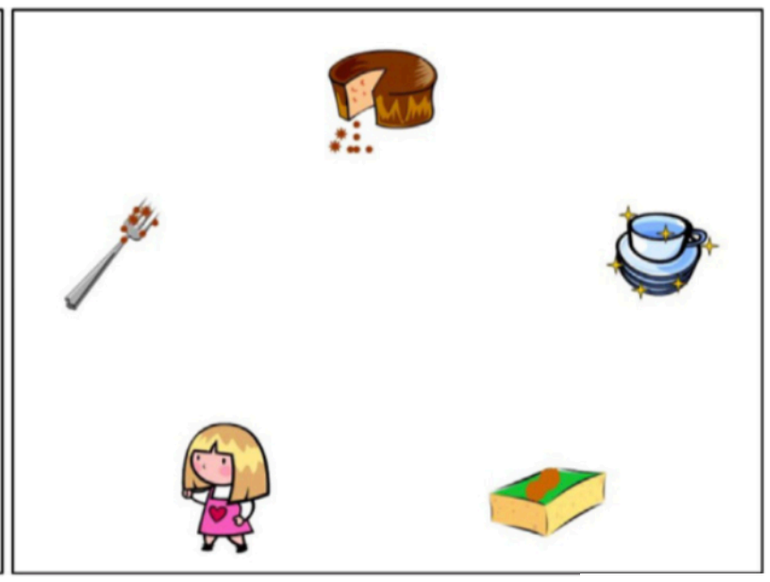


Fig. 1. A sample story display. The initial phase is on the left, and the final phase is on the right. For a question like "Can you tell me what Emily was eating the cake with _ ?", the following image labels were used (from the top, clockwise): target patient (cake), distractor patient (dishes), distractor instrument (sponge), agent (Emily), target instrument (fork).

Atkinson et al (2018)



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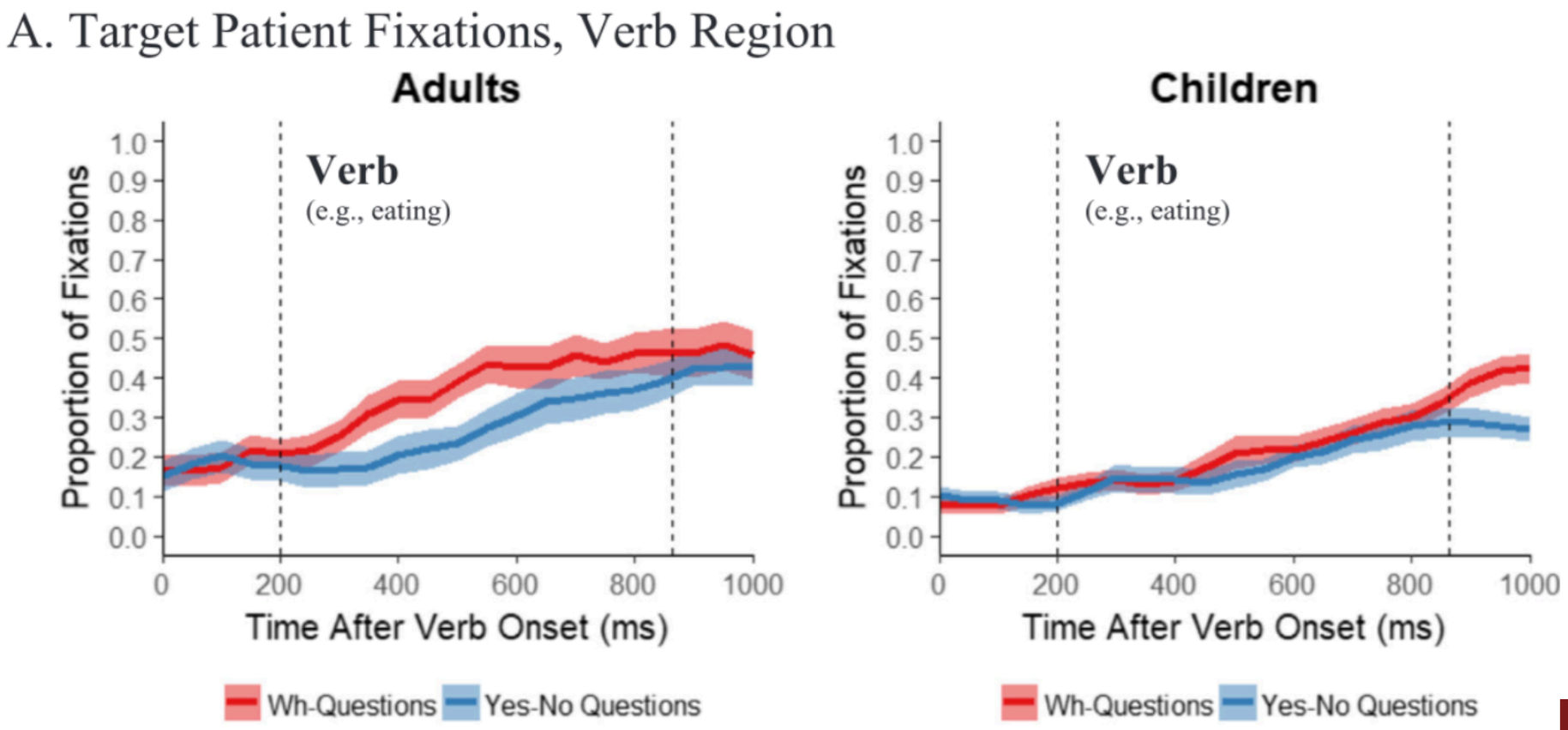


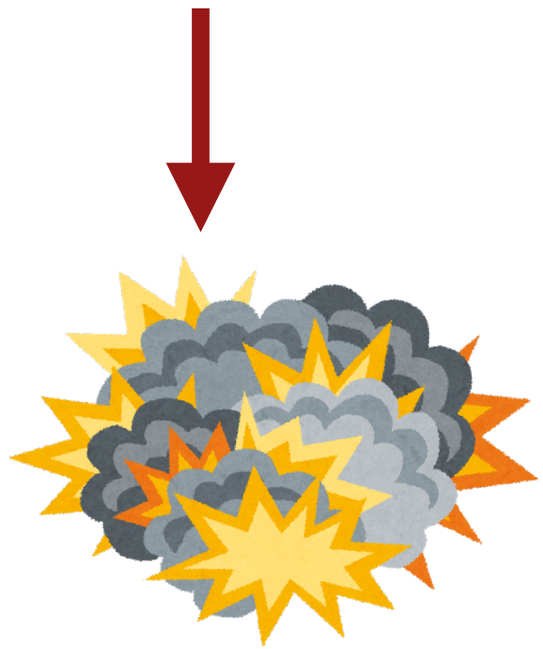
Minimal Chain Principle (de Vincenzi, 1991)

Minimal chain principle (original formulation): Avoid positing unnecessary chain members at S-structure, but do not delay necessary chain members.

Minimal chain principle (anachronistic formulation): In situations of temporary ambiguity, avoid adopting a syntactic analysis that requires movement if you can. If you have to posit movement, make it as short***** a dependency as possible.

NO FILLER: *I know that Zelda trained* ***her cat*** *with that doggo.*

FILLER: *I know which doggo Zelda trained* ***her cat*** *with.*



Relative clauses (English)

***SUBJECT RELATIVE CLAUSE**:*

*I know **the cat** that __ attacked the terrier.*

***OBJECT RELATIVE CLAUSE**:*

*I know **the cat** that the terrier attacked __ .*

→ **Subject relative clauses:** relative clause formed when the subject position of the embedded clause is extracted. The **head** of the relative clause (**the cat**) corresponds to the subject of the embedded clause.

→ **Object relative clauses:** relative clause formed when the object position of the embedded clause is extracted. The **head** of the relative clause (**the cat**) corresponds to the object of the embedded clause.

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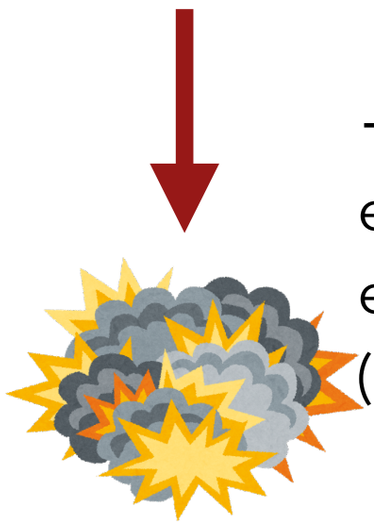
→ **Many languages** show greater difficulty for ORCs over SRCs: English, Dutch, German, French, Spanish, Korean.

→ **In some languages** this is more controversial (and often is quite nuanced): Mandarin Chinese, Russian, Nieuan, Basque, Chamorro, Tagalog.

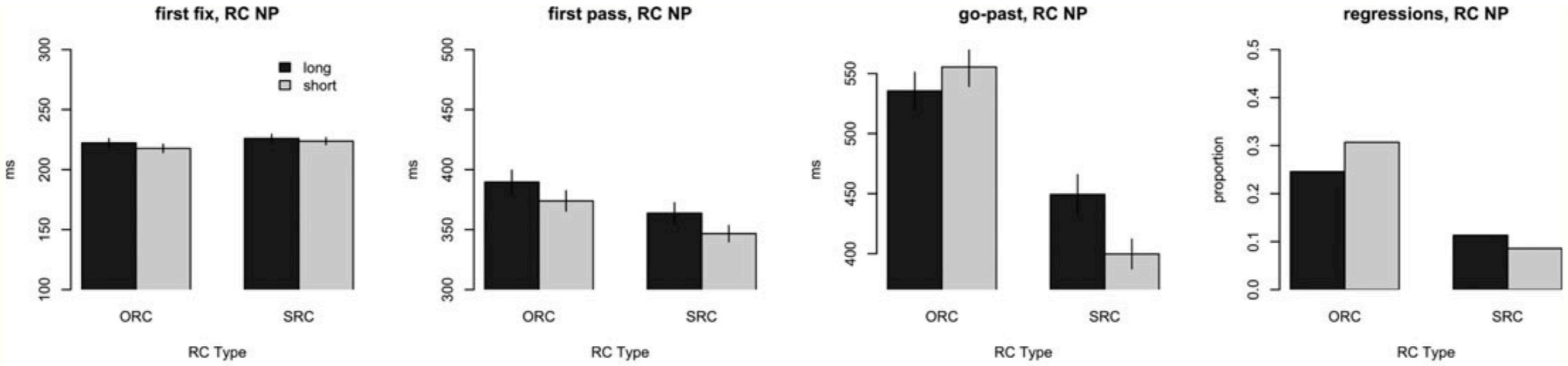
Relative clauses (English)

OBJECT RELATIVE CLAUSE :

I know ***the cat*** *that* ***the terrier*** *attacked* __ .



→ **Object relative clauses:** readers already encounter difficulty when they see the embedded subject in an object relative clause (data from Staub et al. 2017)



Questions for us to ruminate on

→ What is relative contribution of frequency / predictability and structural factors to resolving open filler-gap dependencies?

→ Do indirect wh-questions and relative clauses form a natural class with respect to resolution of filler-gap dependencies?

→ What are the structural factors that push comprehenders to prefer shorter chain lengths? What makes a chain 'short' - structural, or linear distance? Can this be overcome by other factors?

Staub et al (2018)

→ **RC/CC ambiguity:** Where does the incremental ambiguity arise? What predictions does MCP make here?

(9) a. The claim that the cop who the mobster attacked ignored the informant might have affected the jury.
b. The claim that the cop who the mobster attacked ignored might have affected the jury.

Staub et al (2018)

→ Not all head nouns occur equally often with a complement clause, and not all clauses are equally plausible as RC or CC:

(19) a. The information that the health department provided
b. The information that Bob released

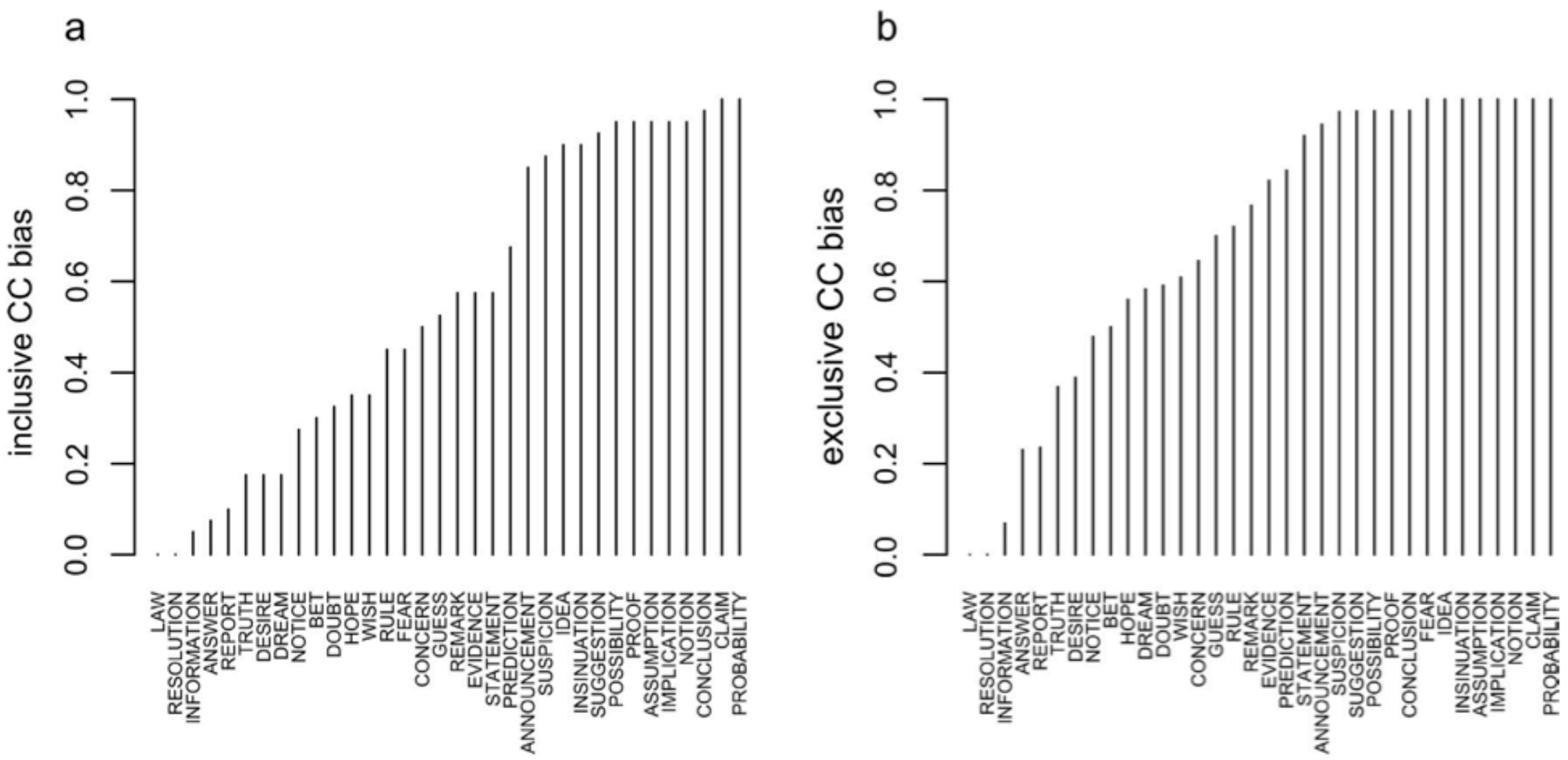
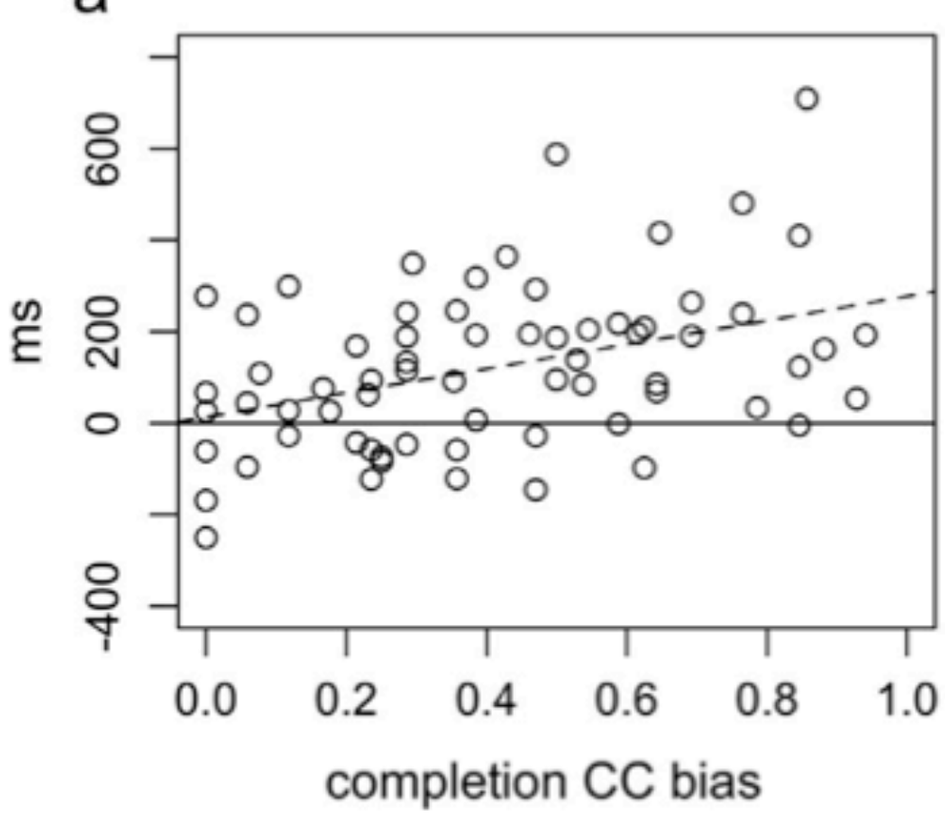


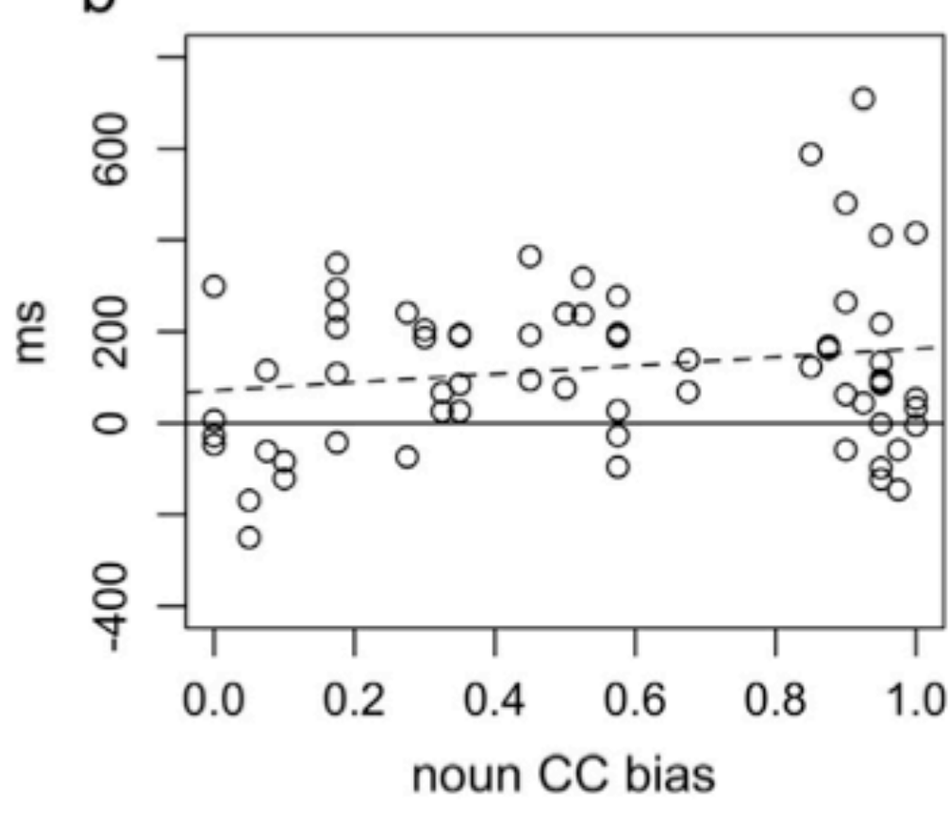
Fig. 1. Distribution of inclusive (a) and exclusive (b) CC noun bias, as defined in the text.

Staub et al (2018)

→ **E1: Eyetracking while reading**

(21) a. The information that Bob released the secret was surprising to me.
b. The information that Bob released was surprising to me.





Staub et al (2018)

→ **E2: Eyetracking while reading**

(22) a. The vaccination that the health department provided reassured the tour operators.
b. The information that the health department provided reassured the tour operators.

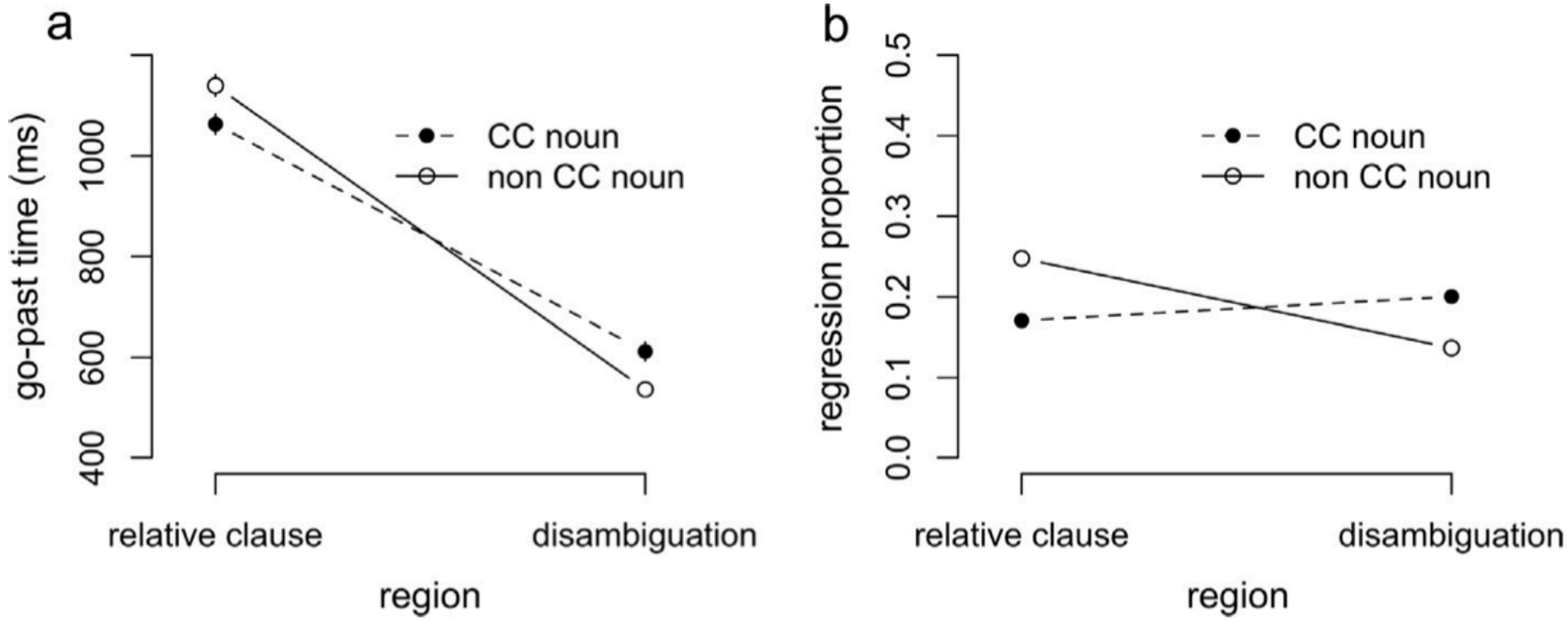


Fig. 4. Mean go-past time with standard errors (a) and regression proportions (b) on each region, by noun status as CC-permitting or not CC-permitting.

Staub et al (2018)

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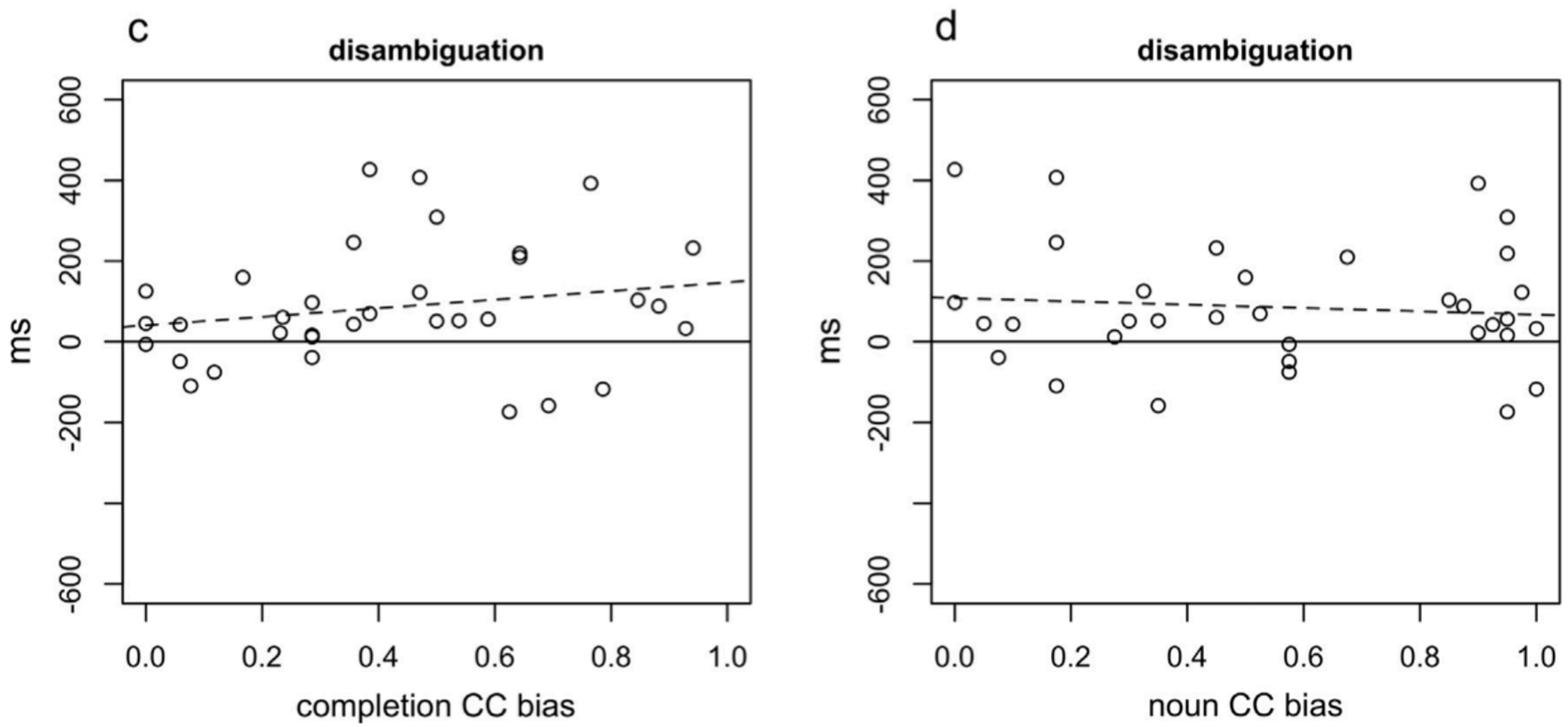
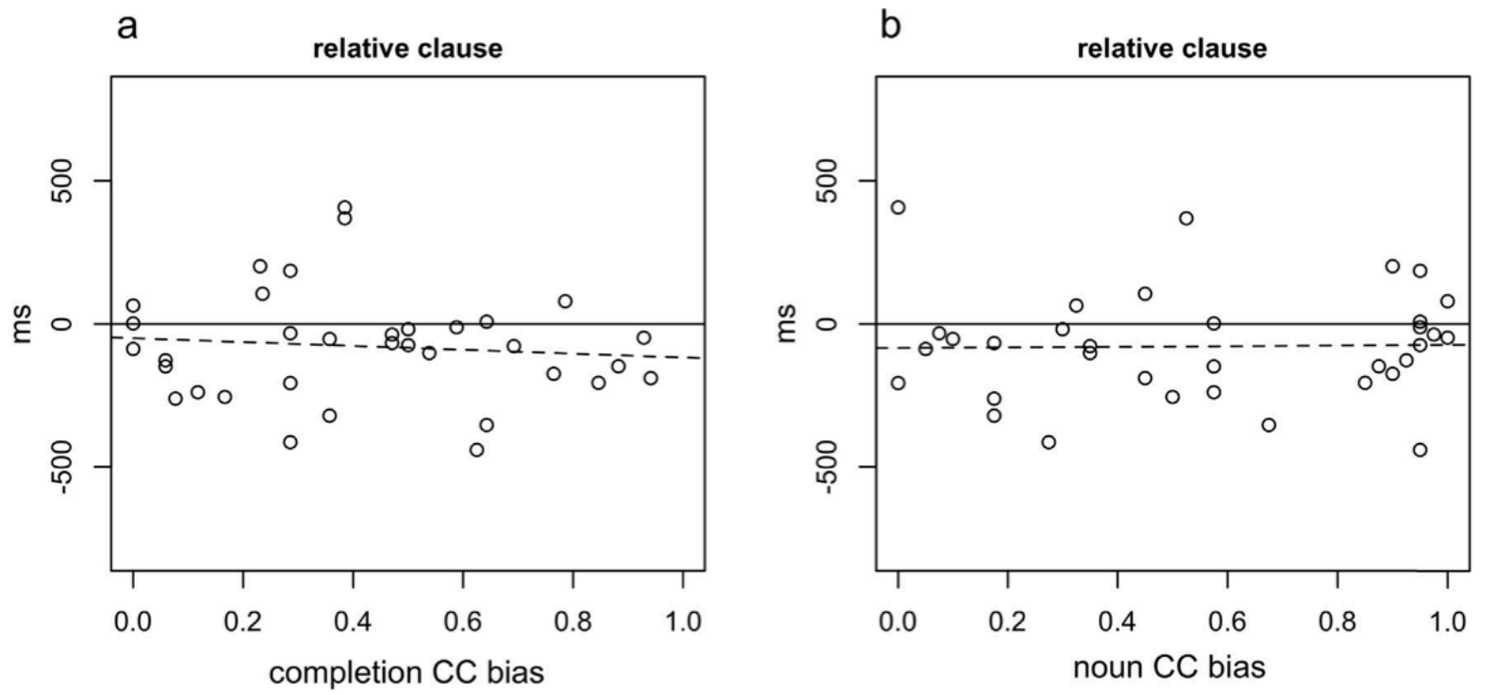


Fig. 5. Experiment 2 go-past time penalty in the CC-permitting condition, by item, on relative clause regions (panels a and b) and disambiguation region (panels c and d) as a function of completion CC bias and noun CC bias. Dashed line is linear regression line. Negative values represent an advantage in the CC-permitting condition.

Staub et al (2018)

→ **E2: Eyetracking while reading**

(22) a. The vaccination that the health department provided reassured the tour operators.
b. The information that the health department provided reassured the tour operators.



Staub et al (2018)

→ **E3: Eyetracking while reading**

(23) a. The information which the health department provided reassured the tour operators.
b. The information that the health department provided reassured the tour operators.

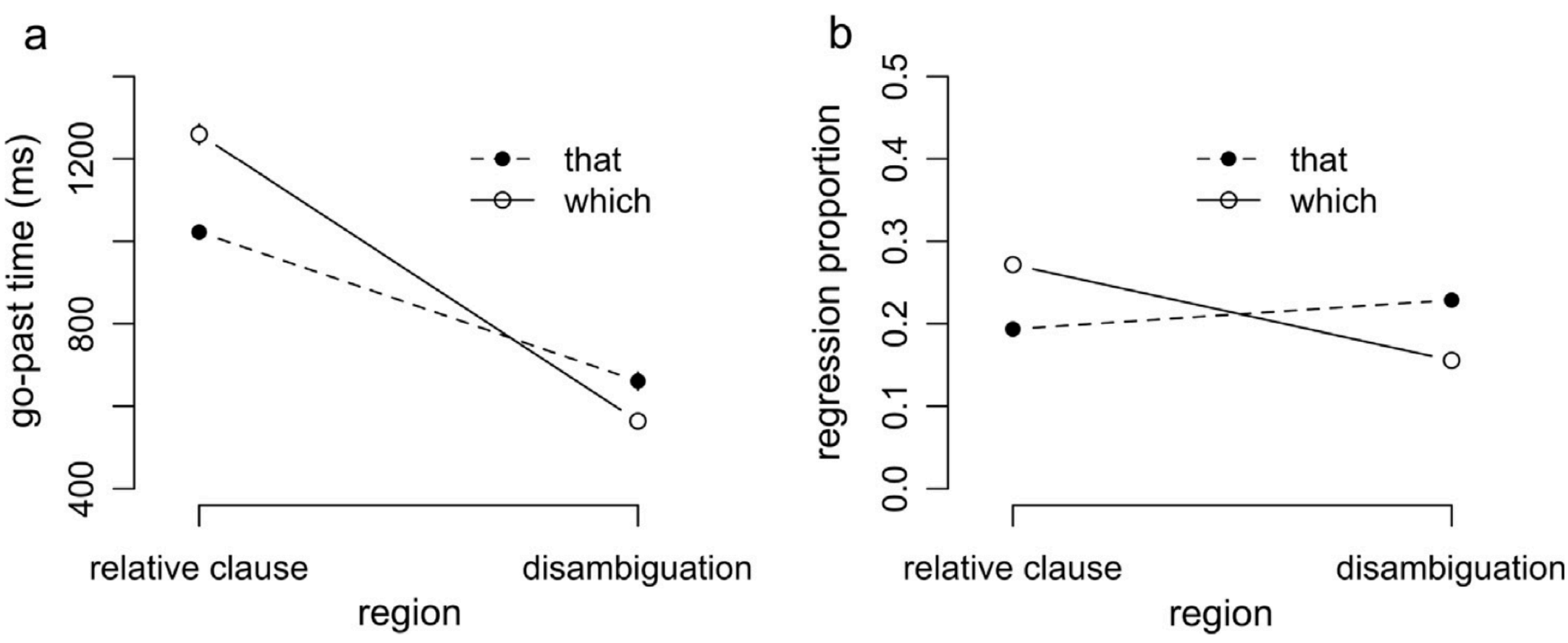


Fig. 7. Mean go past time with standard errors (a) and regression proportions (b) on each region, by relative pronoun type.

Staub et al (2018)

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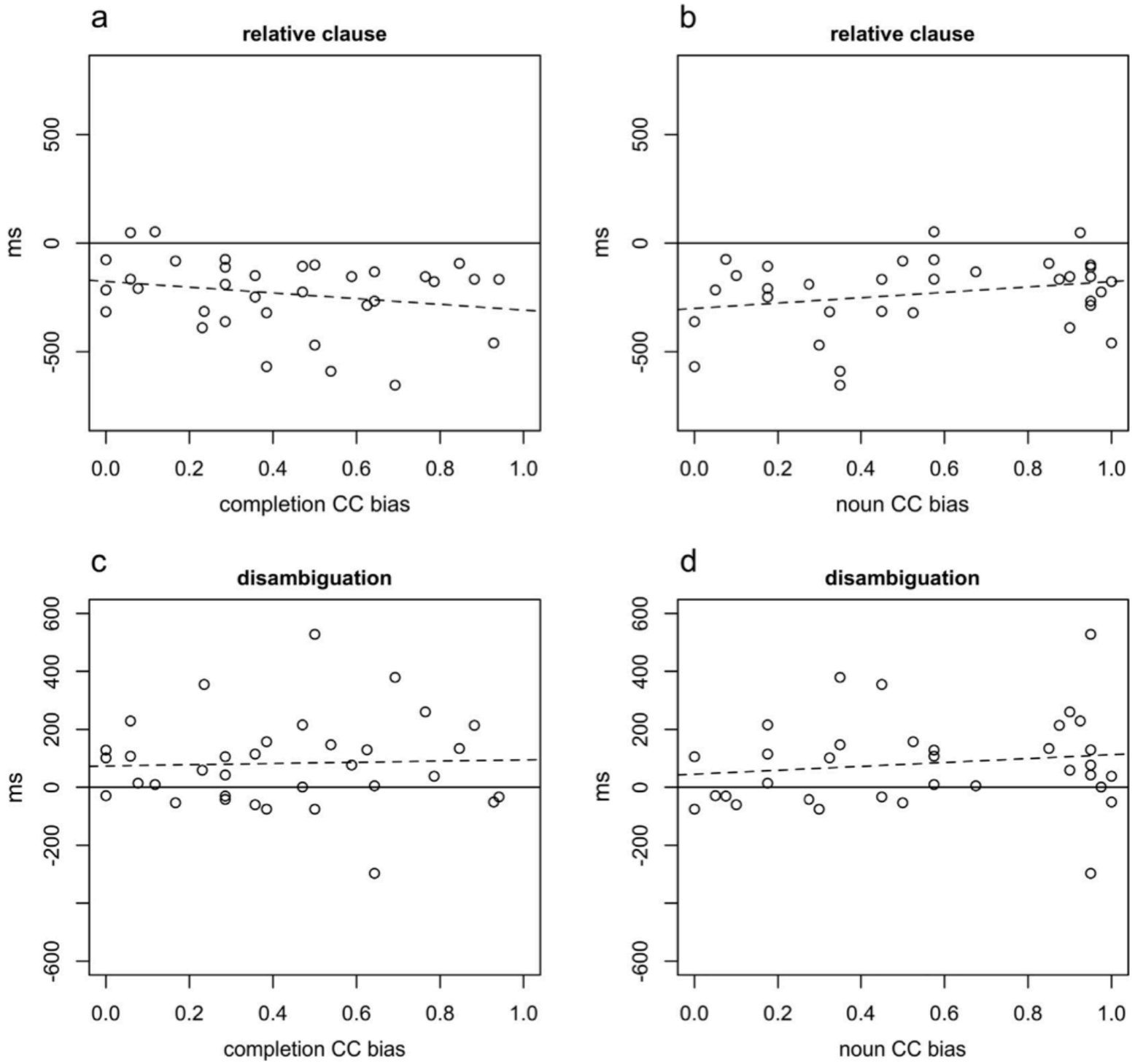

Staub et al (2018)

→ **Empirical premises:**

- Ambiguous ‘that’ clauses create processing difficulty when they are disambiguated towards a relative clause.
- Early disambiguation towards a relative clause facilitated reading of the subordinate clause. Plausibly interpreted as: CCs read faster than RCs.
- Neither one of these effects consistently interacted with the availability of a CC for a given head noun.

→ **Conclusions:**

- Readers pursue CC parse over RC parse consistently, even when the RC parse is plausible and highly likely given head noun.
- This is as predicted by MCP - the CC parse avoids introducing a filler-gap structure into the sentence.

→ **Questions:**

- Convinced that a structural parsing heuristic is guiding interpretation here?
- Does this view make other testing predictions?