

# Projection inferences: On the interplay of predicate meaning, at-issueness, and prior beliefs

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Based on joint work with Judith Degen, Stanford University

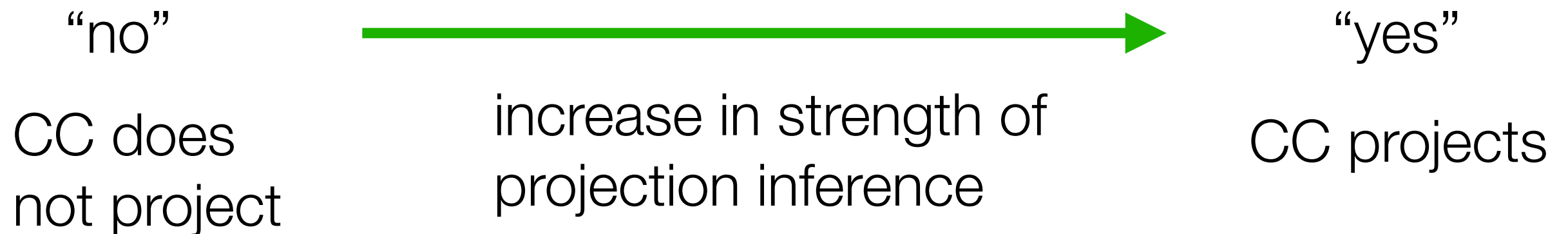
Workshop on clause-embedding predicates  
March 31 - April 2, 2021



# Projection inferences

Alex: *“Did Kim discover that Sandy’s work is plagiarized?”*

Do you, the listener, infer that Alex is committed to the truth of the content of the complement, that Sandy’s work is plagiarized?



# Central questions

In drawing projection inferences, which information sources do listeners attend to, and how are they integrated?

- Lexical meaning
- Common ground
- Information structure
- At-issueness/QUD
- Information about the speaker
- Prior beliefs

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(e.g., Stalnaker 1972; Karttunen 1974; Gazdar 1979; Heim 1982; Beaver 1995, 2010; Simons 2001; Simons et al 2010, 2017; Schlenker 2010; Beaver et al 2017; Djärv & Bacovcin 2017; Schlenker 2010; Abrusán 2011, 2013, 2016; Tonhauser, Beaver, & Degen 2018; Mahler 2020)

# Roadmap

In drawing inferences about the projection of the content of the complement of clause-embedding predicates, how are predicate meaning, at-issueness, and prior beliefs integrated?

1. Hypotheses about the influence of predicate meaning, at-issueness, and prior beliefs on projection
2. Comprehension experiment
3. Information sources and their interactions
  - A. Predicate meaning
  - B. Predicate meaning and at-issueness
  - C. Predicate meaning and prior beliefs
  - D. Predicate meaning, at-issueness, and prior beliefs

# Predicate meaning

Alex: “*Did Kim discover that Sandy’s work is plagiarized?*”

- English has thousands of clause-embedding predicates:  
*be annoyed, be right, know, announce, confirm, realize, acknowledge, pretend, confirm, think, consider,...*  
(see White & Rawlins 2018, Ross & Pavlick 2019)
- Mostly factive predicates have been investigated.  
Tonhauser, Beaver, and Degen 2018 (*Journal of Semantics*)  
*know, notice > discover > reveal*
- Empirical evidence that the content of the complement of some non-factive predicates may also project. (e.g., Simons et al 2017, de Marneffe et al 2019, Tonhauser & Degen under re-review)

# 20 clause-embedding predicates

(Tonhauser & Degen under re-review; Degen & Tonhauser under review)

## Factive

*be annoyed*

*know*

*discover*

*reveal*

*see*

## Non-factive

*prove*

*confirm*

*establish*

*announce*

*confess*

*admit*

*acknowledge*

*hear*

*inform*

*pretend*

*think*

*say*

*suggest*

*be right*

*demonstrate*

# At-issueness/QUD

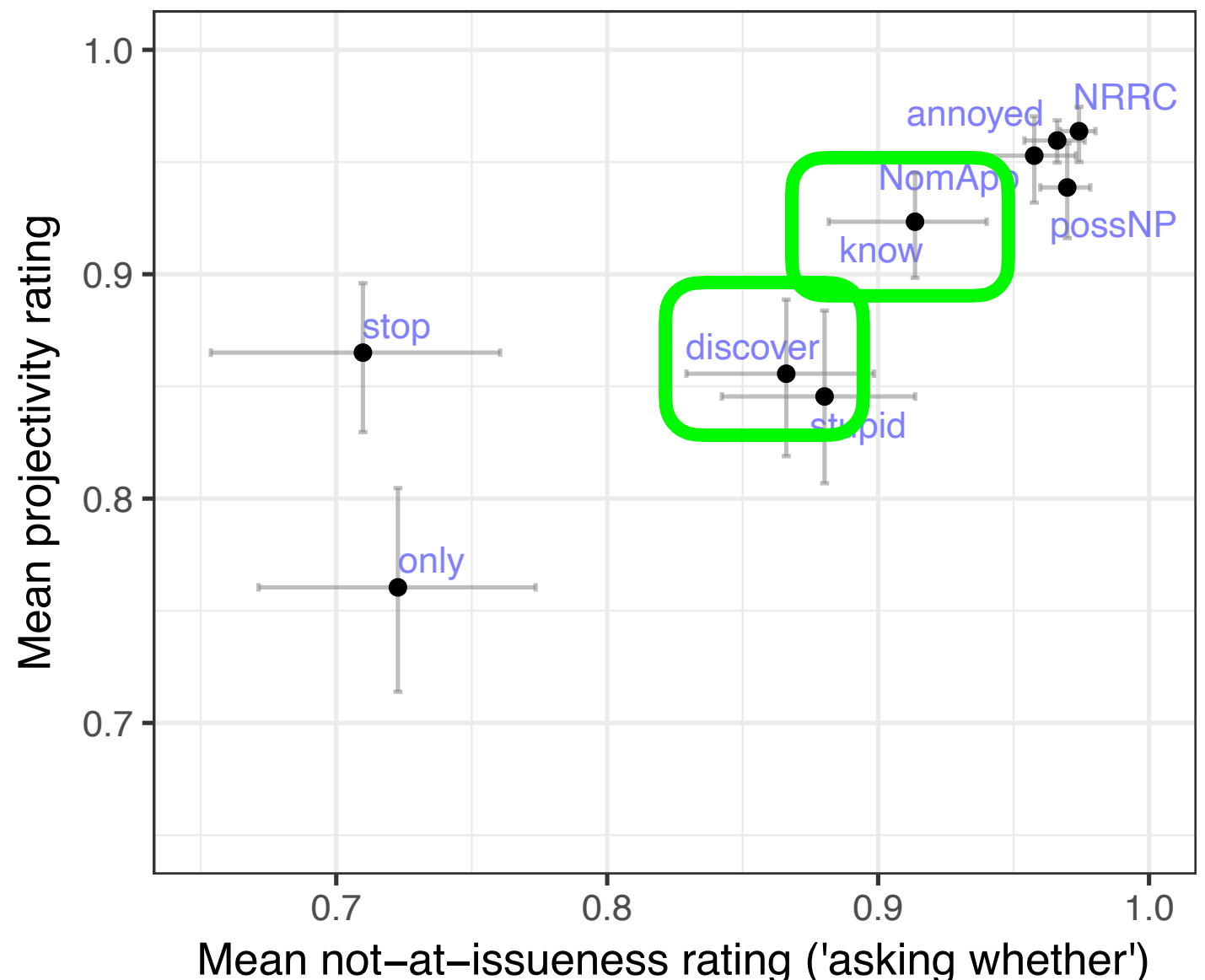
Tonhauser, Beaver, and Degen 2018 (Journal of Semantics)

Gradient Projection Principle:  
Content projects to the extent that it is not at-issue.

(building on Simons et al 2010, 2017; Xue & Onea 2011; Cummins & Rohde 2015)

Alex:

*“Did Kim discover /  
Does Kim know  
that Sandy’s work is  
plagiarized?”*



# Prior beliefs

Listeners bring their beliefs about the world ( $\approx$  world knowledge) to bear on utterance interpretation, e.g., in ambiguity resolution or scalar implicatures, and also projection.

e.g., Winograd 1972; Altmann & Kamide 1999; Chambers et al 2002, 2004; Hagoort et al 2004; Bicknell & Rohde 2009; Degen et al 2015; Kravtchenko & Demberg 2015; Tessler & Goodman 2019; Mahler 2020

Tonhauser, Beaver, & Degen 2018: Some content is more projective than other content.

Alex: *“Does Kim know that ...Jane has a sick aunt?  
...Jack is playing outside with the kids?”*

Hypothesis: Content is more projective the higher its prior probability, i.e., the stronger listeners' prior belief in the content.



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# Materials

800 combinations of a polar question and a fact



Fact: Julian is German.

Sally: “*Did Cole demonstrate that Julian dances salsa?*”

400 polar questions:

- 20 clause-embedding predicates (e.g., *discover*, *confirm*)
- 20 complements (e.g., *Julian dances salsa*)

2 facts per complement to manipulate the prior:

High probability fact: Julian is Cuban.

Low probability fact: Julian is German.

# Materials and blocks

505 self-declared native speakers of American English

Each participant: 20 randomly created combinations of a polar question (20 unique predicates and complements) and a fact (10 higher probability, 10 lower probability).

Fact: Julian is German.

Sally: *“Did Cole demonstrate that Julian dances salsa?”*

Three blocks (order of 2./3. random)

1. Prior belief (of the CC, given the fact)
2. Projection (of the CC, given the fact and the predicate)
3. At-issueness (of the CC, given the fact and the predicate)

## Block 1: Prior probability of the CC, given the fact

lower  
probability  
fact

**Fact:** Julian is German.

How likely is it that Julian dances salsa?

complement

impossible

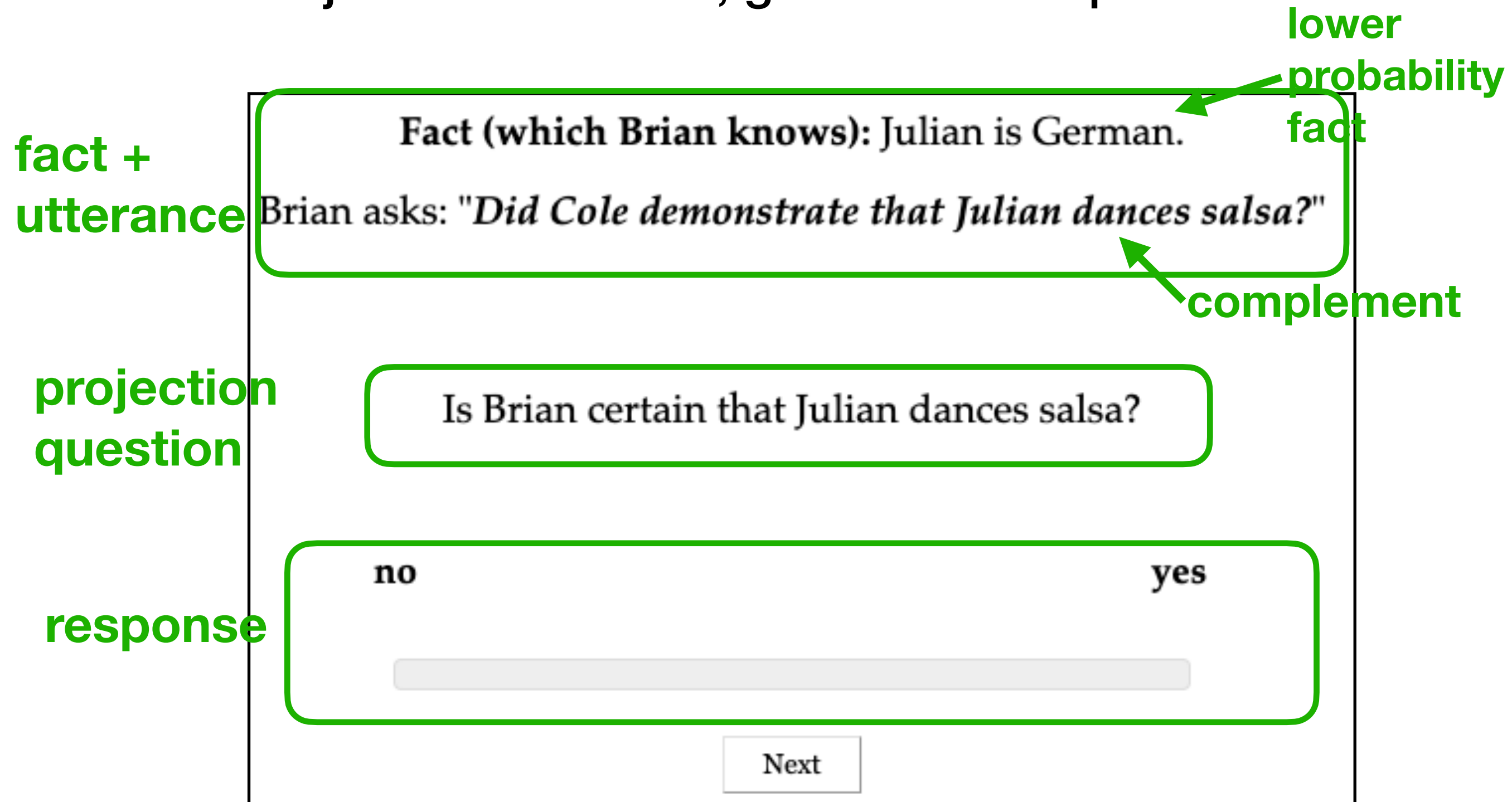
definitely

Next

response

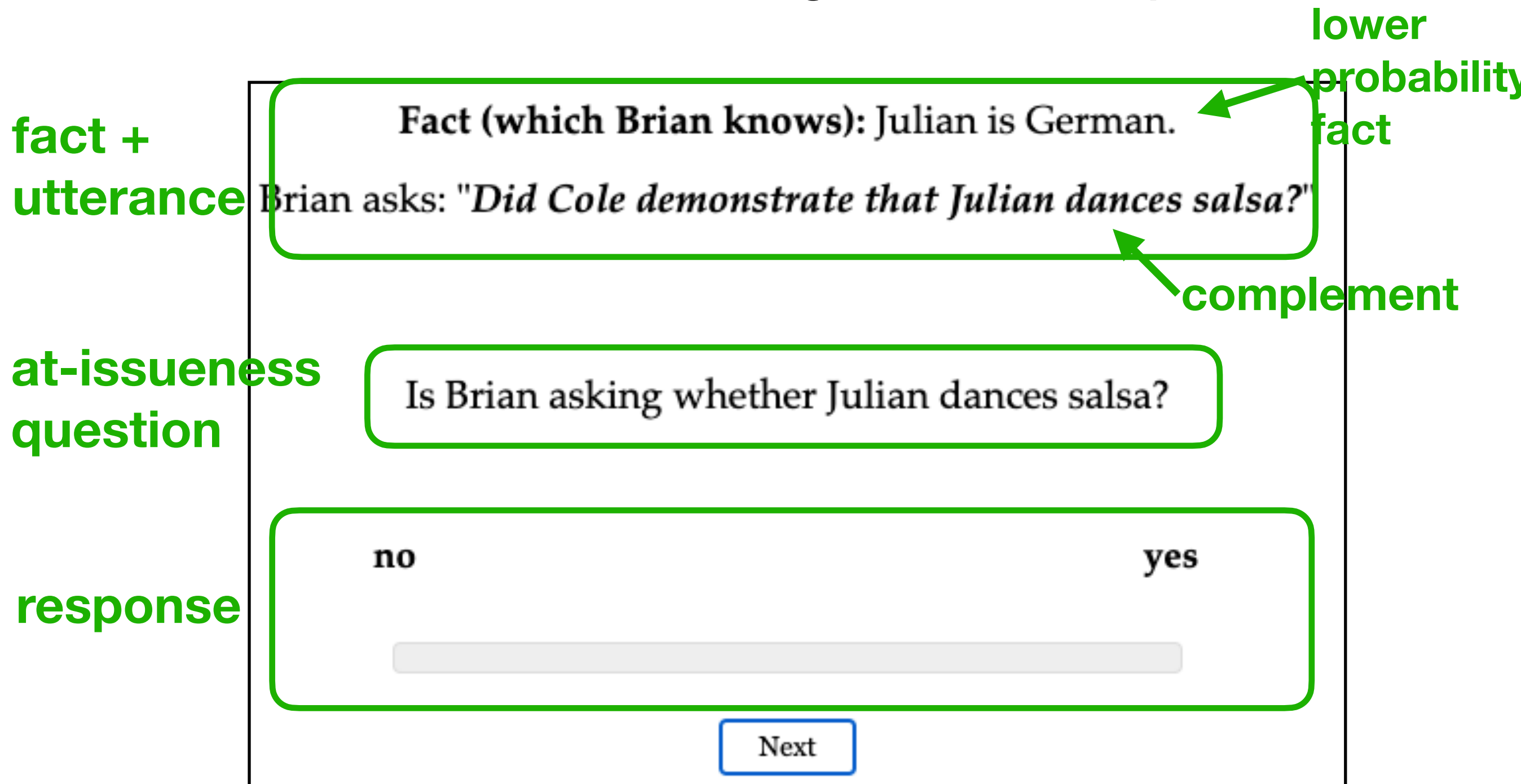
Each participant rated the prior probability of their 20 CC/fact combinations (10 with higher and 10 with lower probability facts).

## Block 2: Projection of the CC, given fact and predicate



Each participant rated the projection of their 20 CCs, given a fact and a predicate (and 6 main clause controls).

## Block 3: At-issueness of the CC, given fact and predicate



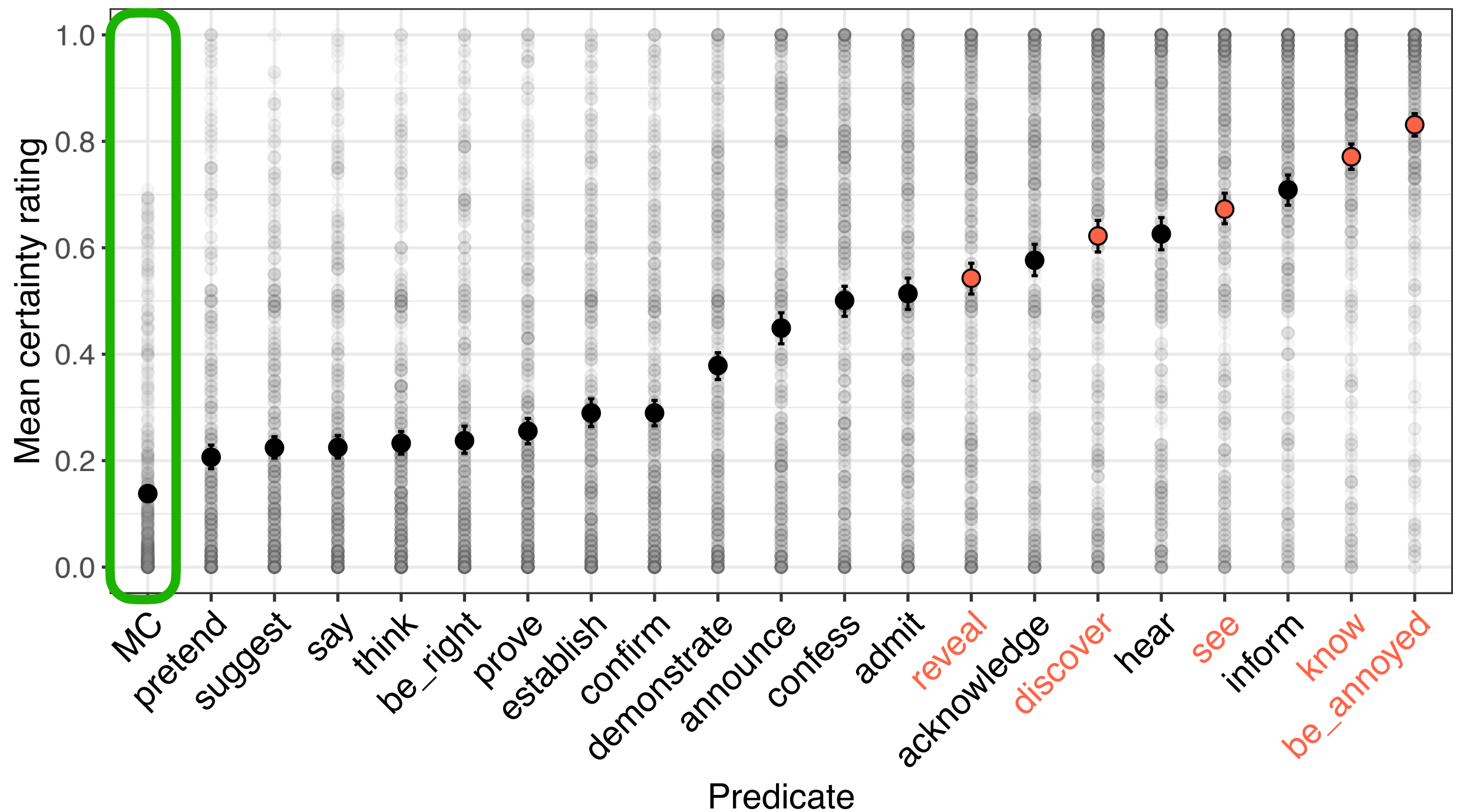
Each participant rated the projection of their 20 CCs, given a fact and a predicate (and 6 main clause controls).

# Roadmap

In drawing inferences about the projection of the content of the complement of clause-embedding predicates, how are predicate meaning, at-issueness, and prior beliefs integrated?

1. Hypotheses about the influence of predicate meaning, at-issueness, and prior beliefs on projection
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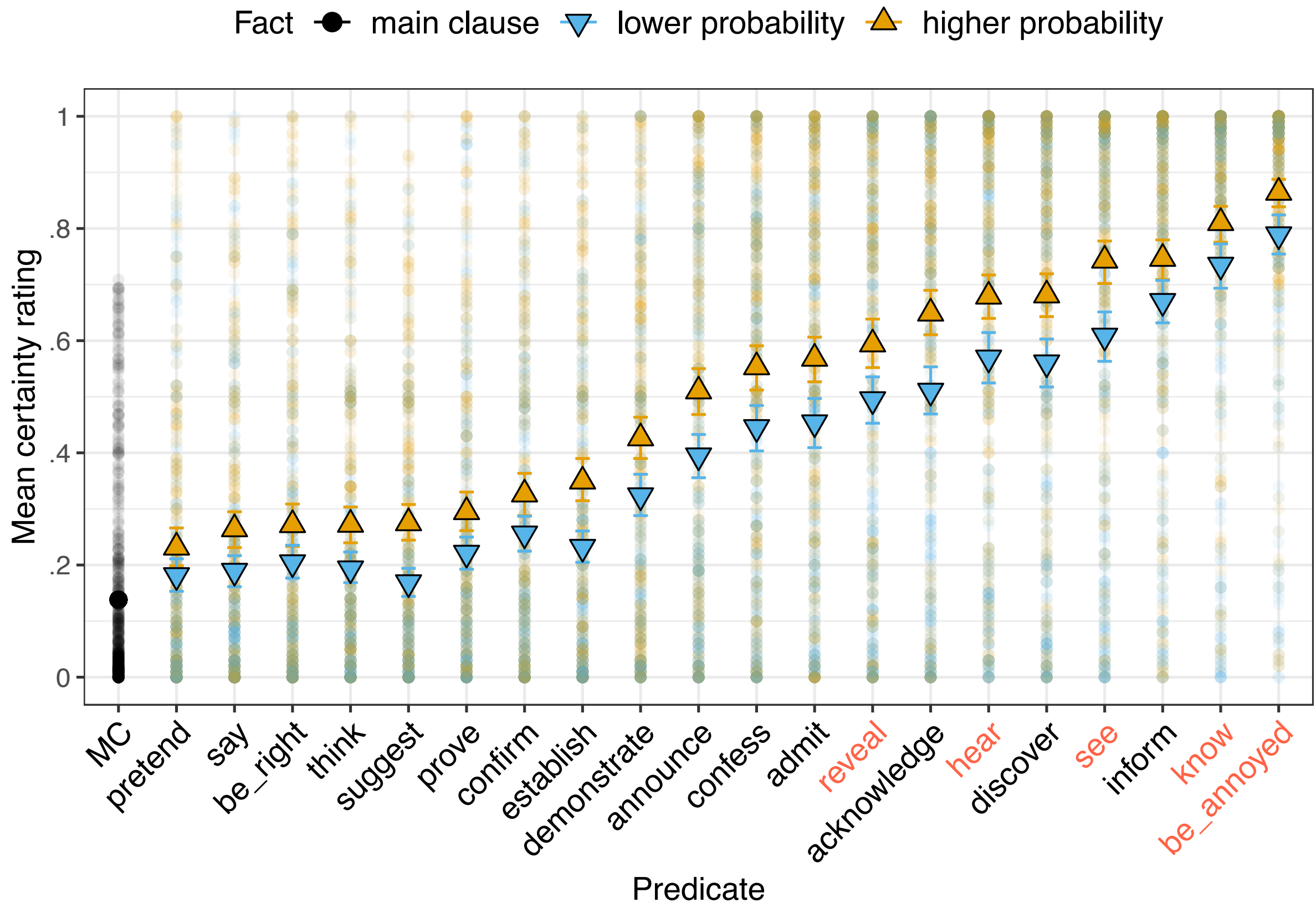
# Predicate meaning modulates projection



Tonhauser & Degen under re-review: the CC of all 20 predicates is projective compared to (non-projective) main clause content, albeit to different degrees.

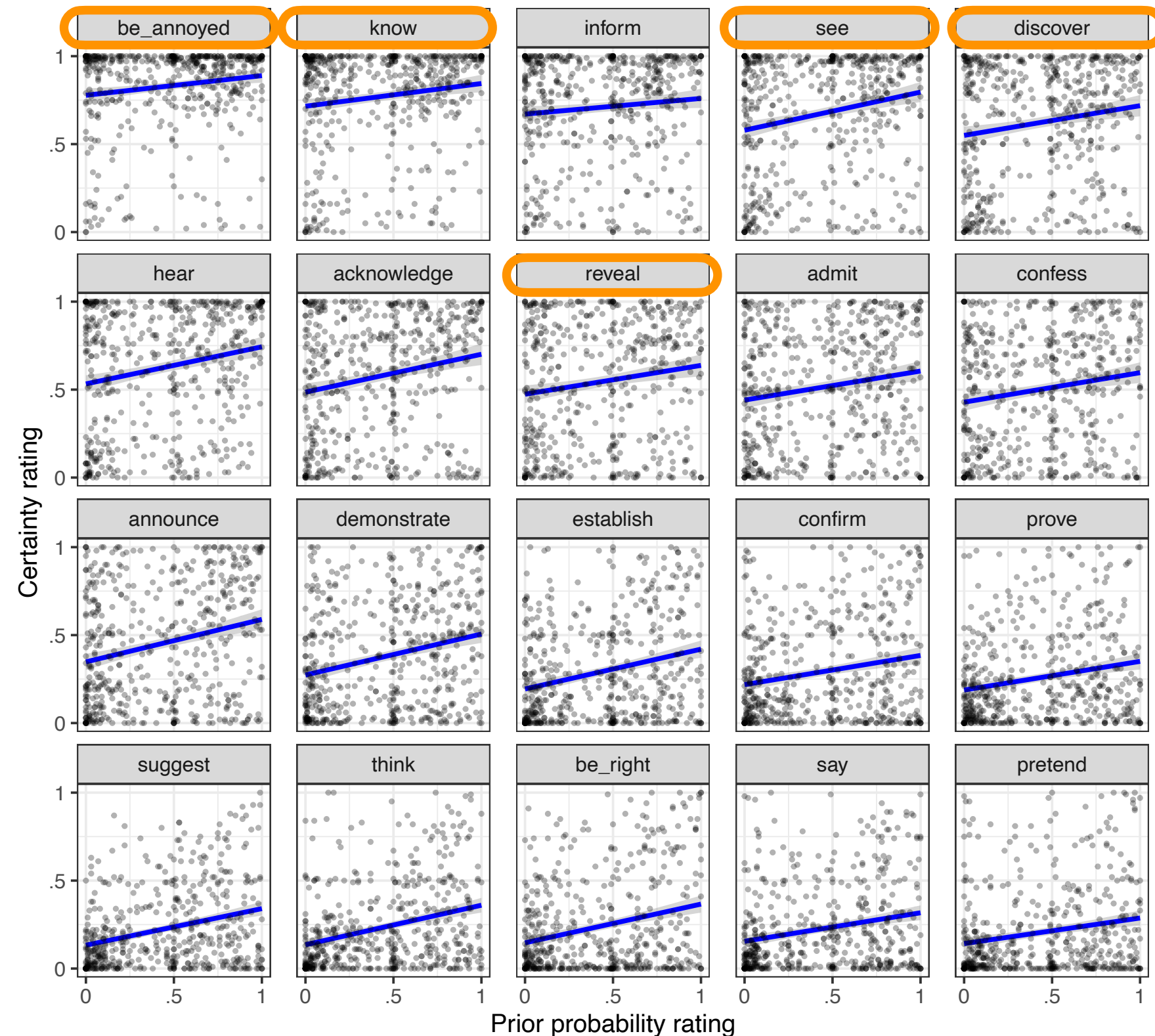


# Prior probability: Higher probability content is more projective



ME linear regression predicting certainty ratings from fact type, random by-item and by-participant intercepts and slopes for fact type ( $\beta = 0.094$ , S E = 0.007,  $t = 12.94$ ,  $p < .0001$ ).

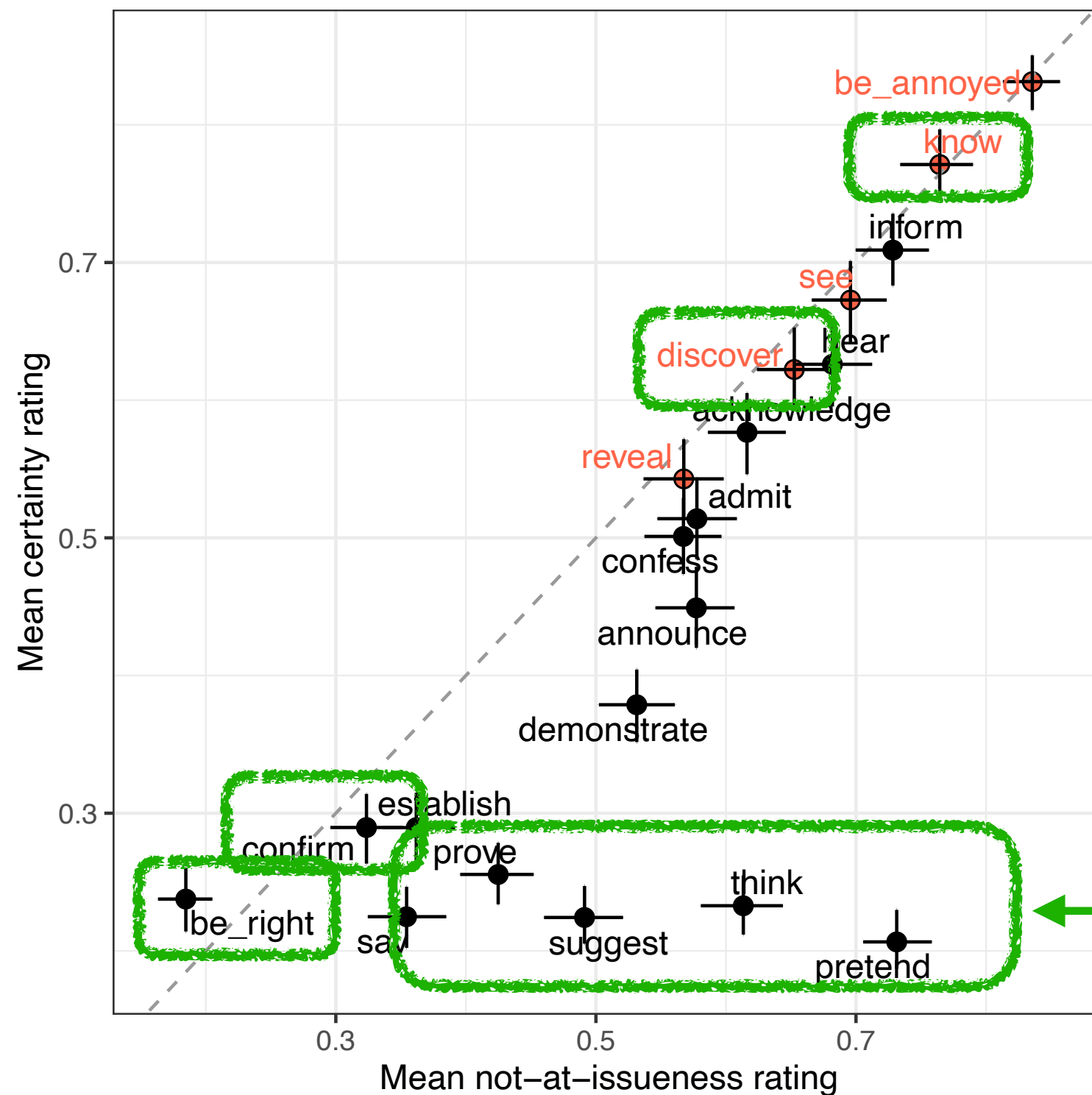
# Prior probability: Higher probability content is more projective



...by-group- and  
by-participant

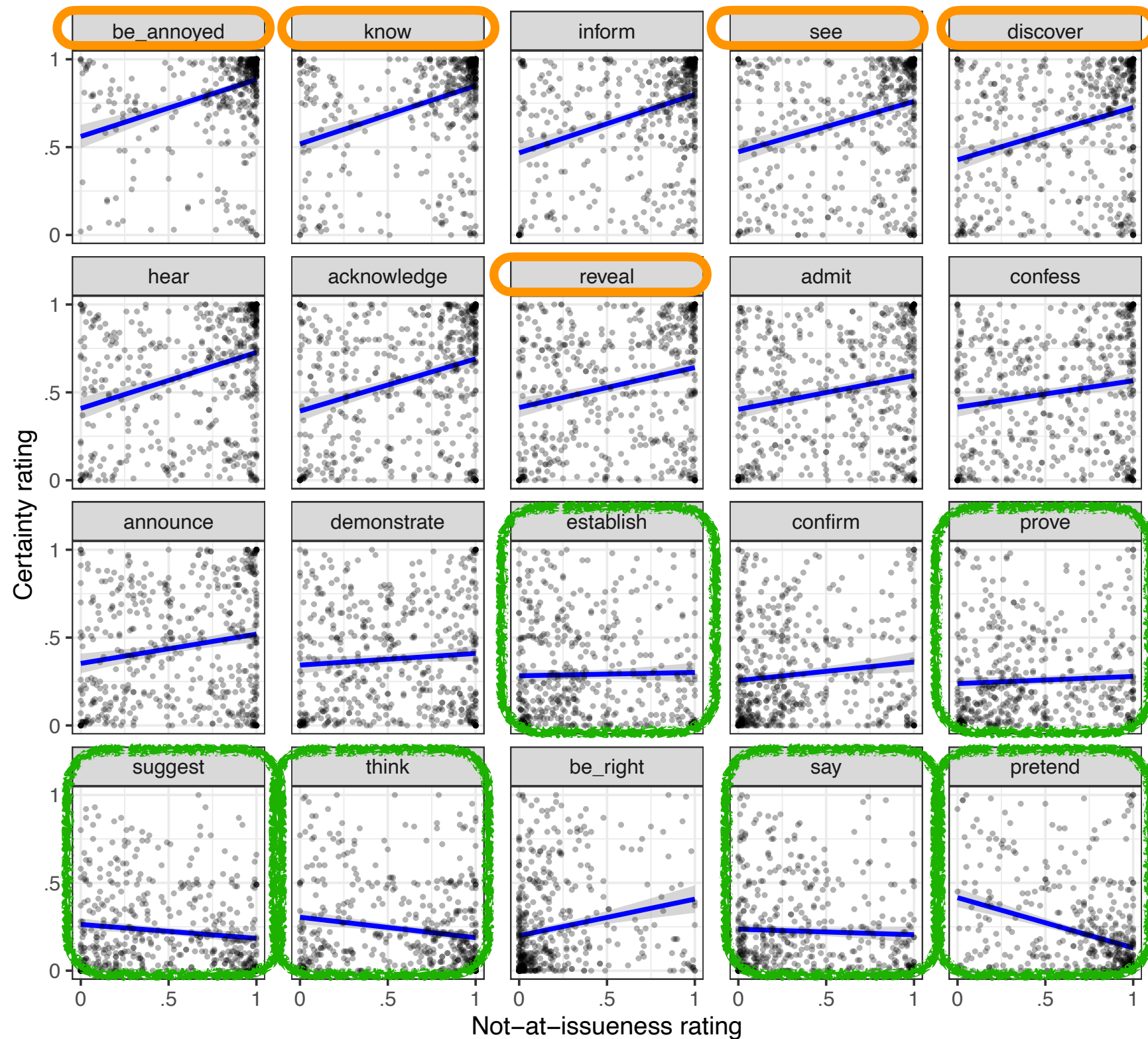
ME linear regression predicting certainty ratings from prior ratings, random by-item and by-participant intercepts and slopes for prior ( $\beta = 0.17$ ,  $SE = 0.01$ ,  $t = 14.1$ ,  $p < .0001$ ).

# At-issueness: The more not-at-issue, the more projective



exceptions!

# At-issueness: The more not-at-issue, the more projective



...by-group- and  
by-participant

← exceptions!



# Projection of the CC of clause-embedding predicates...

...is modulated by:

## INTEGRATION

- predicate meaning (and the CC of so-called non-factive predicates is projective, too!)
- prior beliefs: independent effect seen for all predicates, in support of Tonhauser, Beaver, and Degen 2018
- at-issueness: effect seen for broader set of predicates (in support of Tonhauser, Beaver, and Degen 2018), but not for all predicates (*establish, say, prove, suggest, think, pretend*).

**Question for future research:** How does predicate meaning interact with at-issueness, to predict projection?

# At-issueness and prior beliefs are not independent

Non-redundancy principle (Tonhauser, de Marneffe, and Degen 2020)

The more the interpreter takes content to be a priori true, the less likely the content is to be at-issue in an utterance.

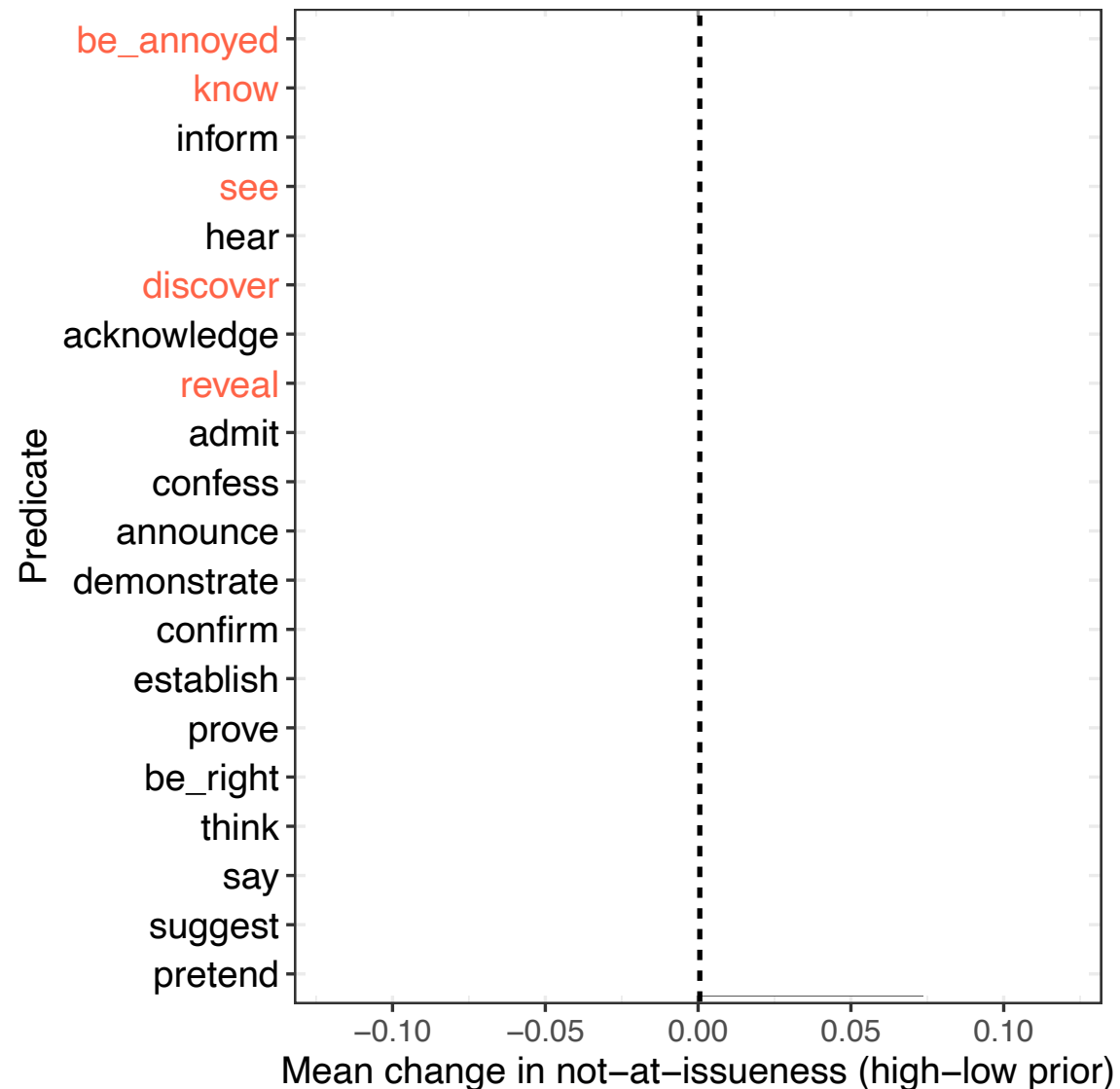
Sandy: *“Did Paul discover that Julian dances salsa?”*

Prediction: The higher the content prior, the more not-at-issue the content.

Expectation: The higher the content prior, the more not-at-issue the content.



predicted:



data:



exceptions

**Question for future research:** How do prior probability and at-issueness interact with predicate meaning?

In drawing projection inferences, which information sources do listeners attend to, and how are they integrated?

- The CCs of clause-embedding predicates is projective, albeit to varying degrees (not just factive predicates).

(de Marneffe, Simons, & Tonhauser 2019; Tonhauser and Degen under-review)

- Prior content probabilities modulate projection, across all 20 predicates (including so-called factive and non-factive ones).

(Degen & Tonhauser under review; as predicted in Tonhauser et al 2018)

- At-issueness modulates projection, but interacts with predicate meaning in ways not yet predicted.

(only partially confirms Tonhauser, Beaver, & Degen 2018)

- Prior probability and at-issueness interact with predicate meaning in predicting projection.

(contra Tonhauser, de Marneffe, & Degen 2020)

HOW?



**Supplementary slides**

# Prior probability of the 20 CCs is influenced by their facts

