Symmetric alternatives and semantic uncertainty modulate scalar inference

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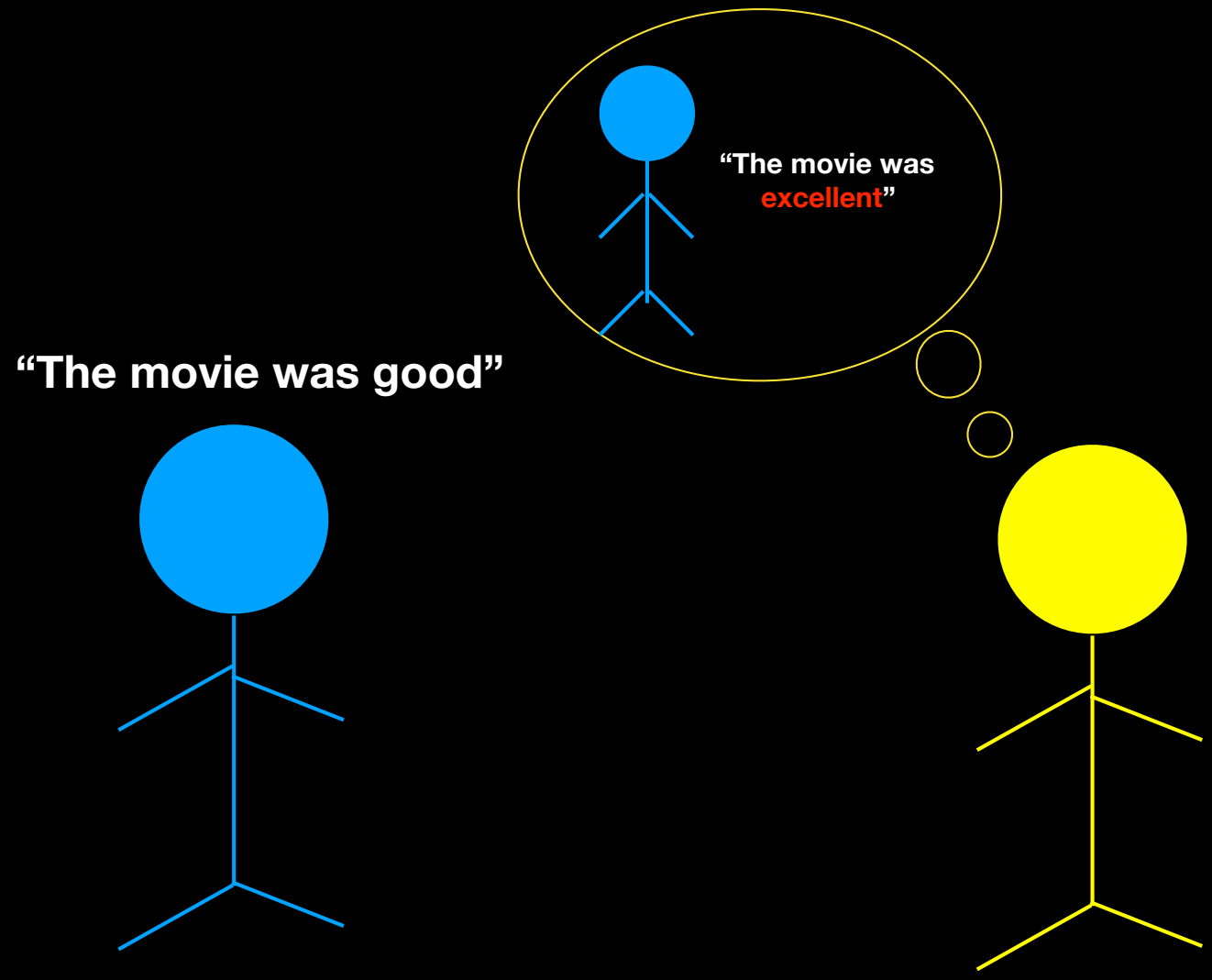
Scalar inference

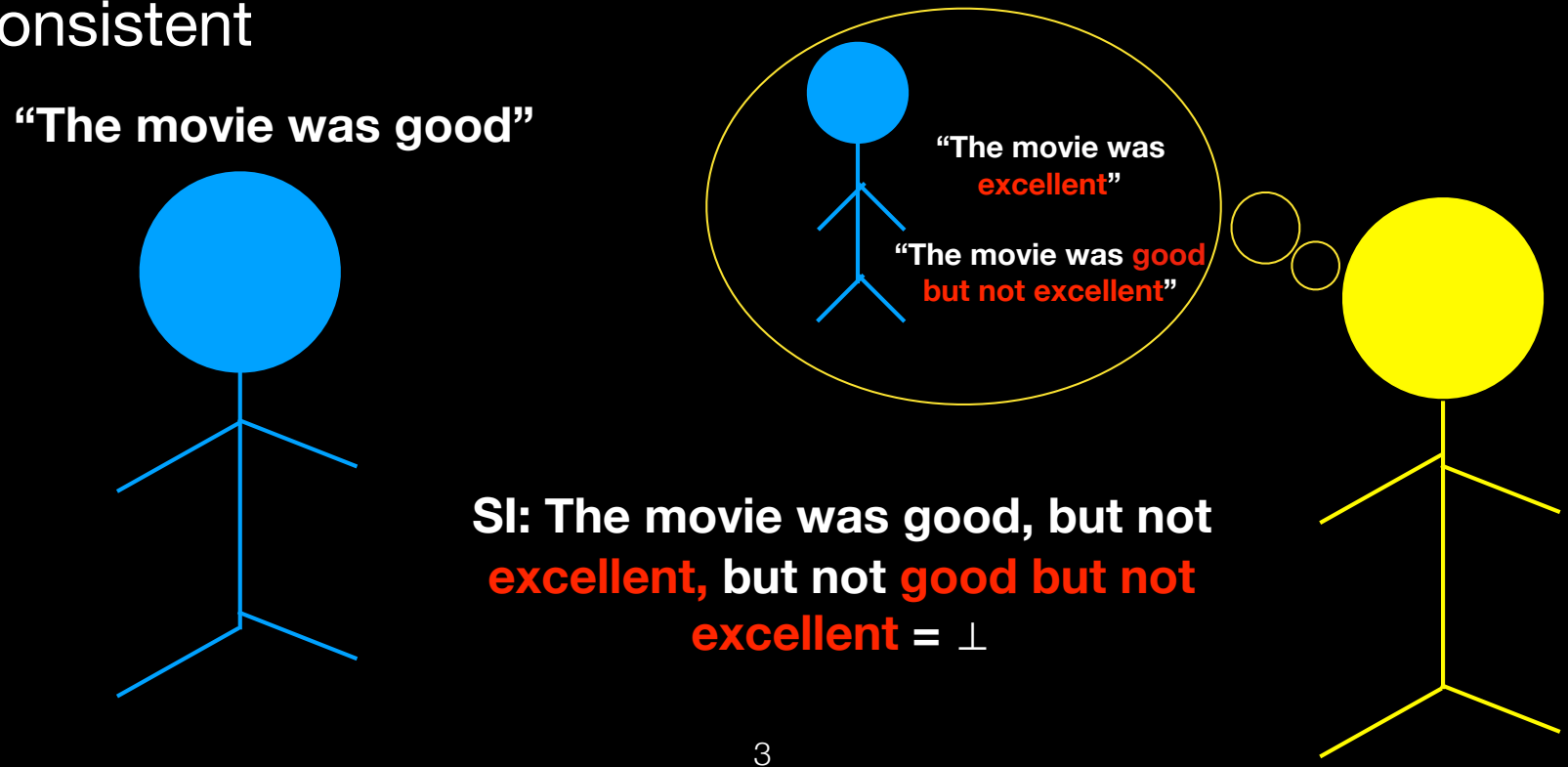


The movie was good, but not excellent.

The ‘traditional’ view of SI

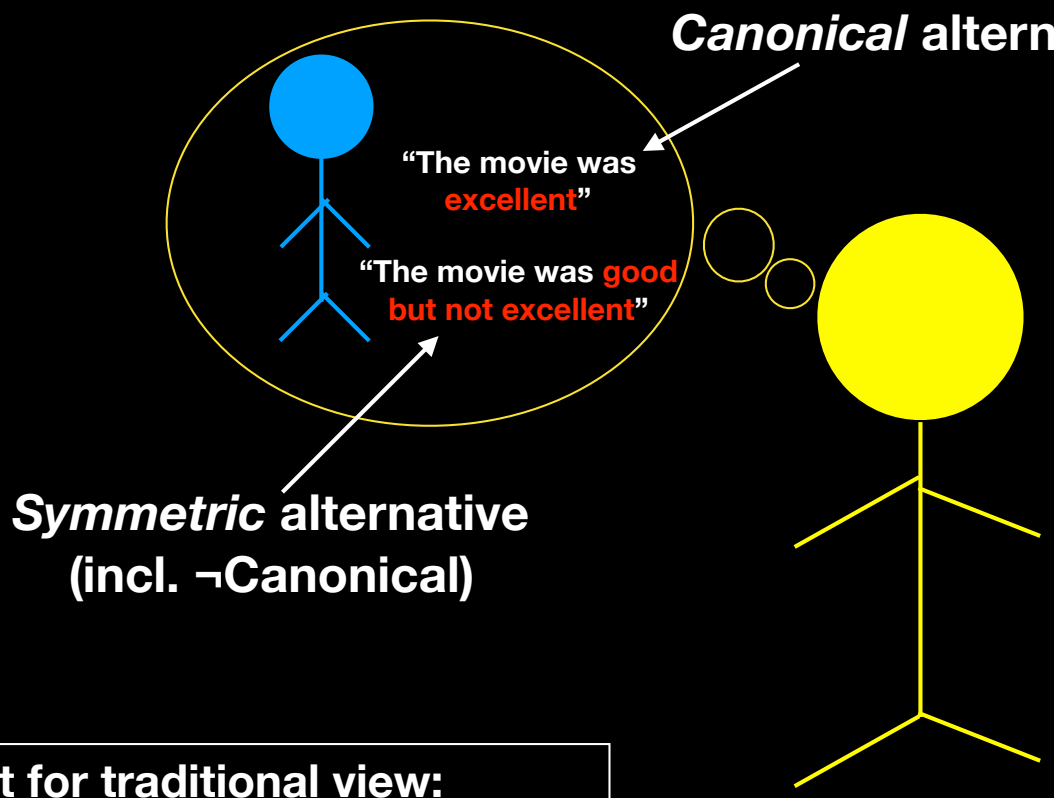
- Negation of stronger alternative forms (good, but not excellent; some, but not all) (Horn 1972; Grice 1975; Levinson 2000; Chierchia et al. 2012)

- Alternative sets are necessarily small and logically-consistent



SI: The movie was good, but not excellent, but not good but not excellent = ⊥

Symmetric alternatives

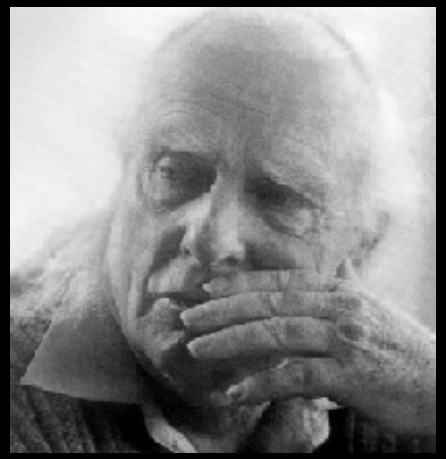


Research project for traditional view:
How to block activation of symmetric alternatives?
(Katzir 2007; Matsumoto 1995)

The ‘traditional’ view cont’d

Fixed, context-independent semantic lexicon for quantifiers and connectives: *some* = ∃; *all* = ∀

> *“It is commonplace of philosophical logic that there are, or appear to be, divergences in meaning between… FORMAL devices - ~, ∧, ∨, (x), ∃(x)… [and] what are taken to be their analogs in or counterparts in natural language… ‘not’, ‘and,’ ‘or’, ‘if’, ‘all’, ‘some’” - but this assumption is a “common mistake.”* - **Grice (1975)**



Challenges to the 'traditional' view

- Alternative sets may be larger than we thought
  - Number terms interfere with the computation of scalar implicatures from *some* to *not all* (Degen & Tanenhaus, 2015, 2016)

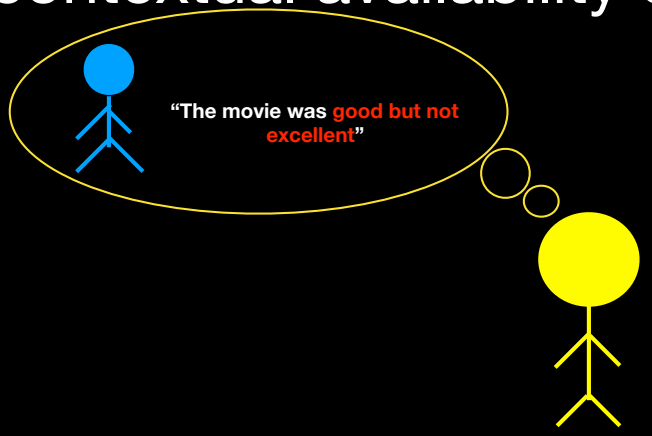
Are symmetric alternatives active in SI?

- Lexical Uncertainty extensions (Potts et al. 2016, Bergen et al. 2016) of the Rational Speech Act model (Frank & Goodman 2012, Goodman & Stuhlmüller 2013): some = ∃ OR ∃∧¬∀
  - Used to explain embedded implicatures & ignorance inferences

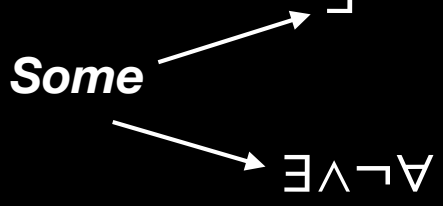
Is the semantic lexicon truly 'fixed' in SI?

Priming SI

- Can we modulate the rate of SI relative to some baseline…
  - By manipulating the contextual availability of symmetric alternatives?

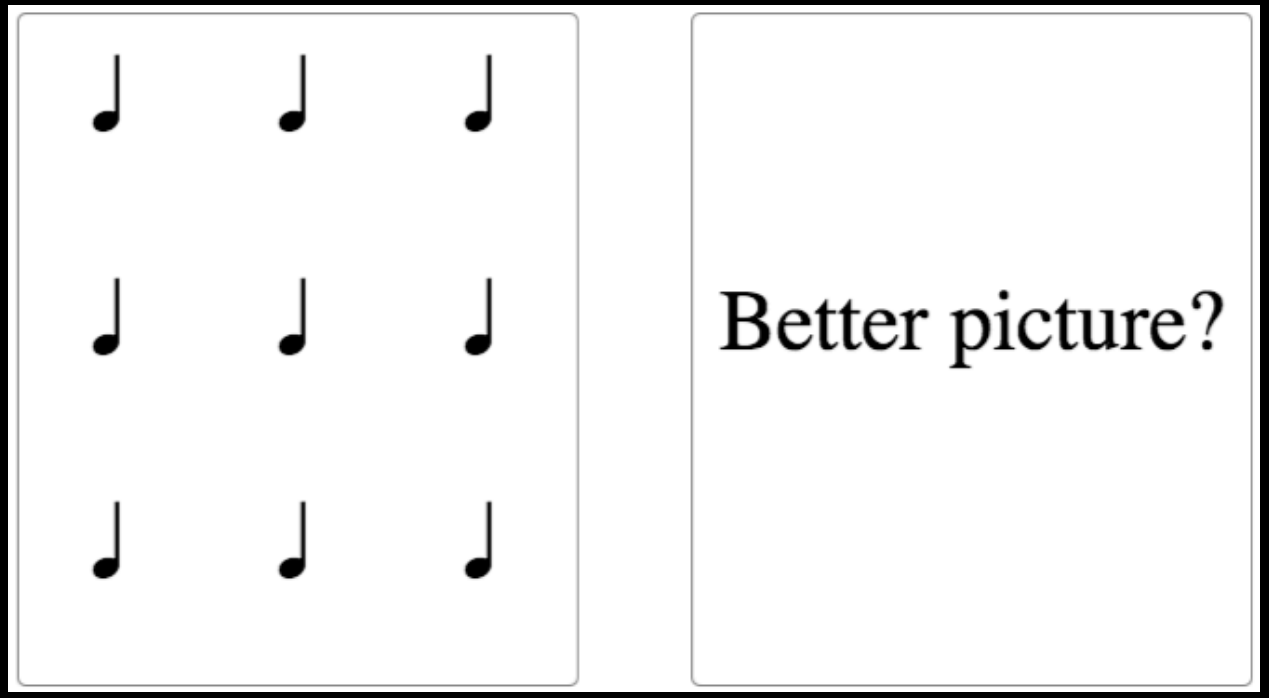


- By updating participant expectations about the form-meaning mapping of scalar items?



Target trial

“Some of the symbols are notes”



Indicative of SI

Bott & Chemla (2016); Rees & Bott (2018)

Experiment

- 480 participants recruited through Amazon Mechanical Turk (US IP addresses; minimum 95% prior approval rating). $2.20 compensation, average completion time ~13 minutes.

- Extends Experiment 1 of Rees & Bott (2018). We add:

  - An explicit Baseline condition

  - Symmetric alternative priming conditions

Priming types

Weak priming: participant selects image compatible with unenriched meaning

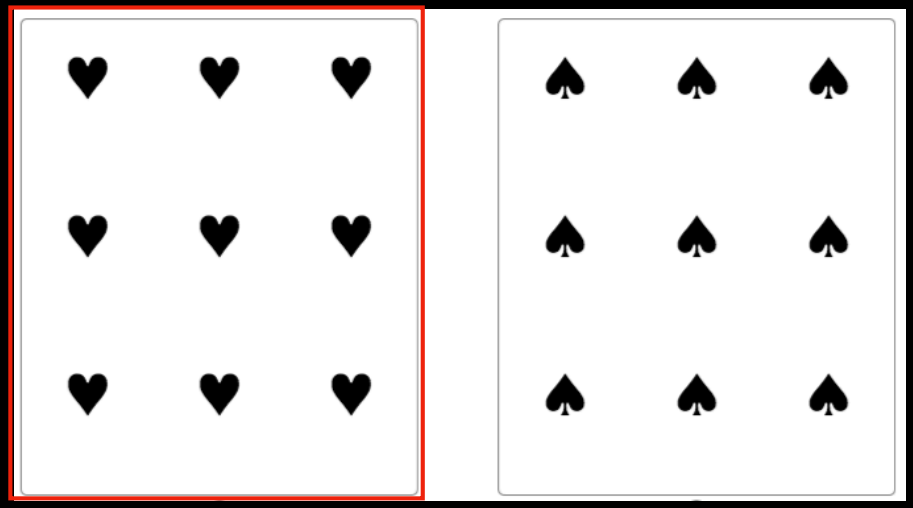
Update form-meaning mapping:

Some → ∃

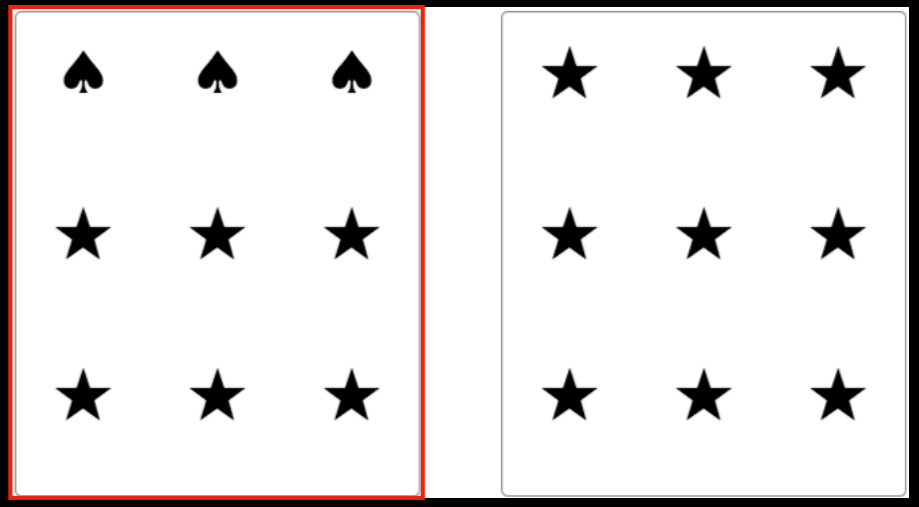
Some → ∃∧¬∀

Strong priming: participant selects image compatible with enriched meaning

"Some of the symbols are hearts"

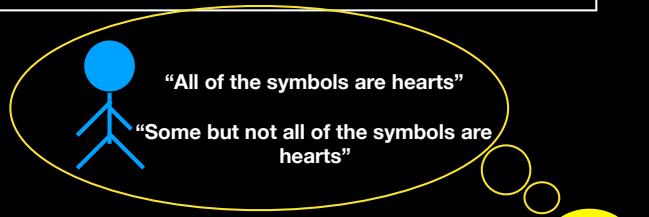


"Some of the symbols are clubs"



Priming types

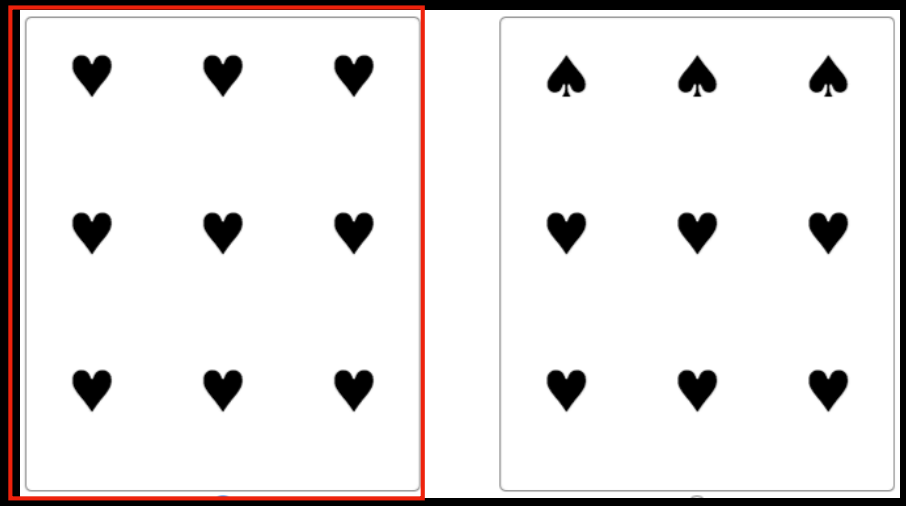
Canonical alternative priming: participant selects image compatible with a scalar form's canonical pragmatic alternative



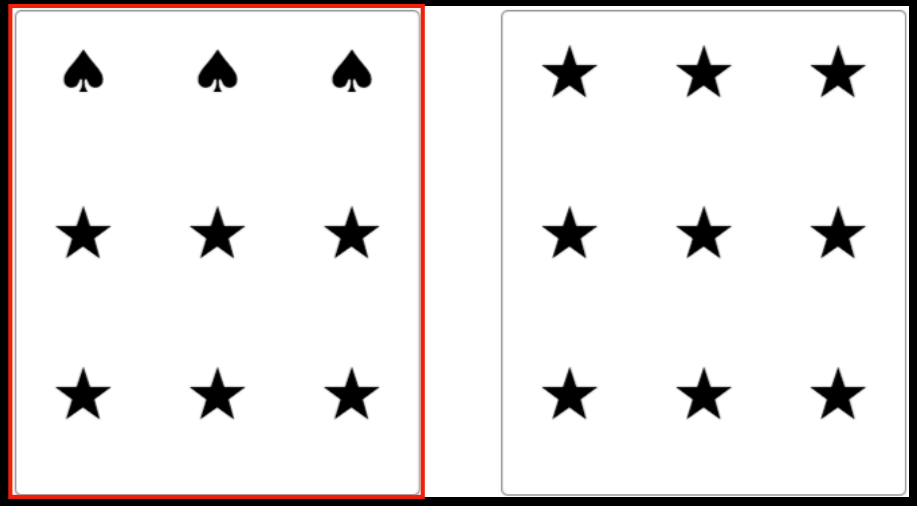
Update salience of alternative forms

Symmetric alternative priming: participant selects image compatible with a scalar form's symmetric alternative

"All of the symbols are hearts"

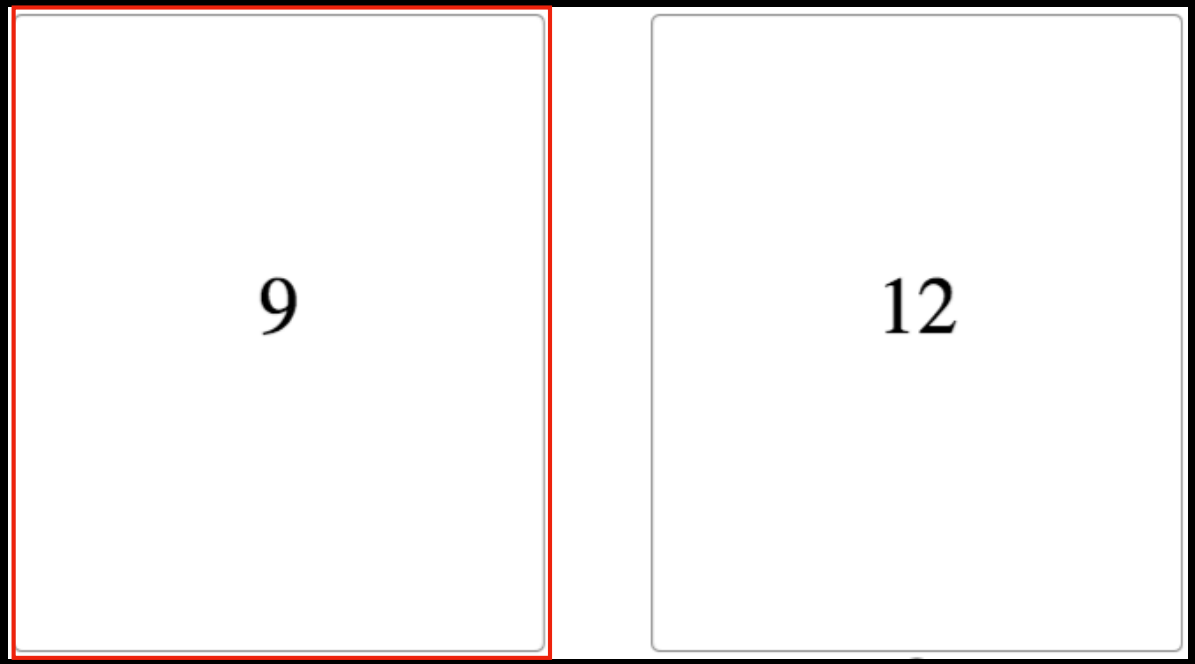


"Some but not all of the symbols are clubs"



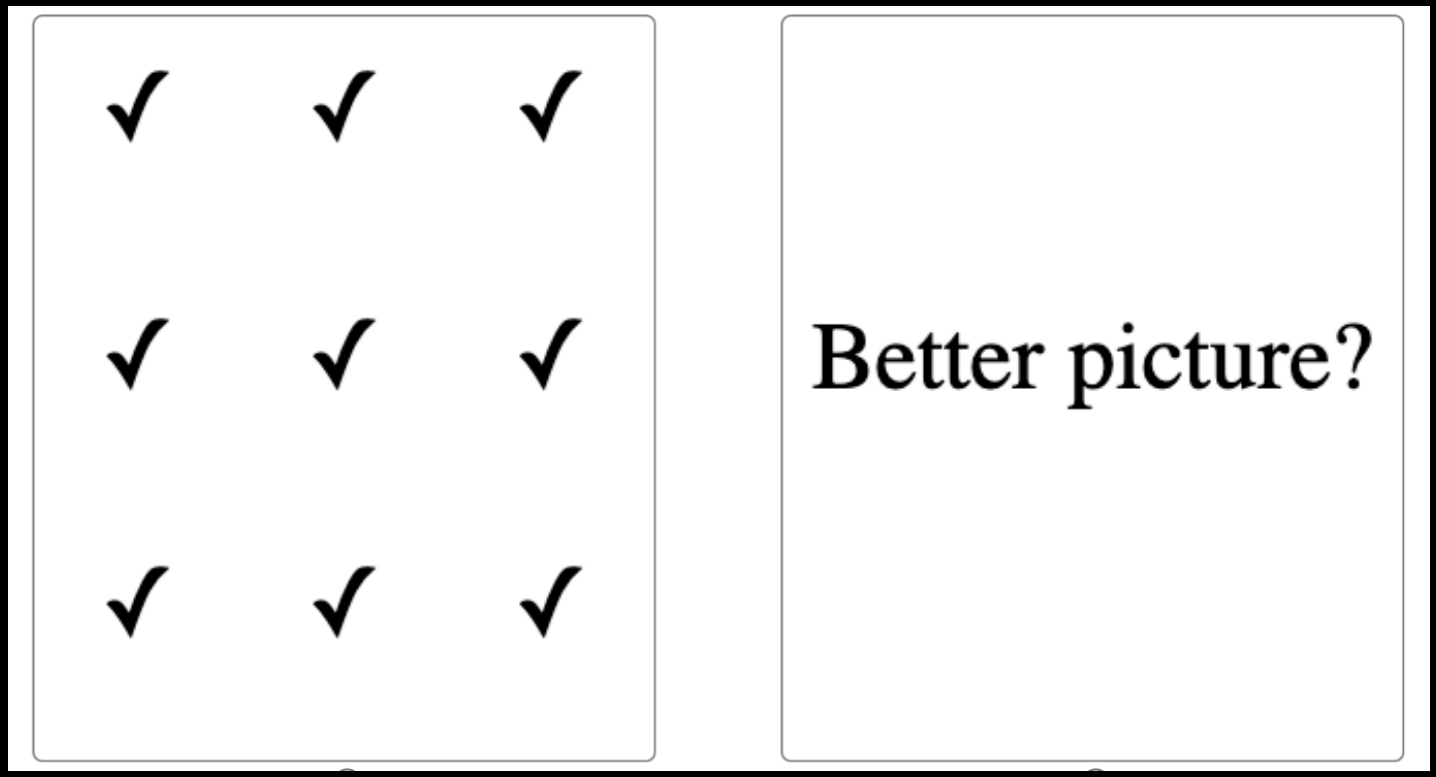
Baseline trial

“4 + 5 = ?”



Filler trial

“Some of the symbols are hearts”



Design

Canonical alt: *all*

Canonical alt: *six*

- Expressions: *some,* cardinal numbers (*four*), and ad-hoc existential constructions (*there is an X*)

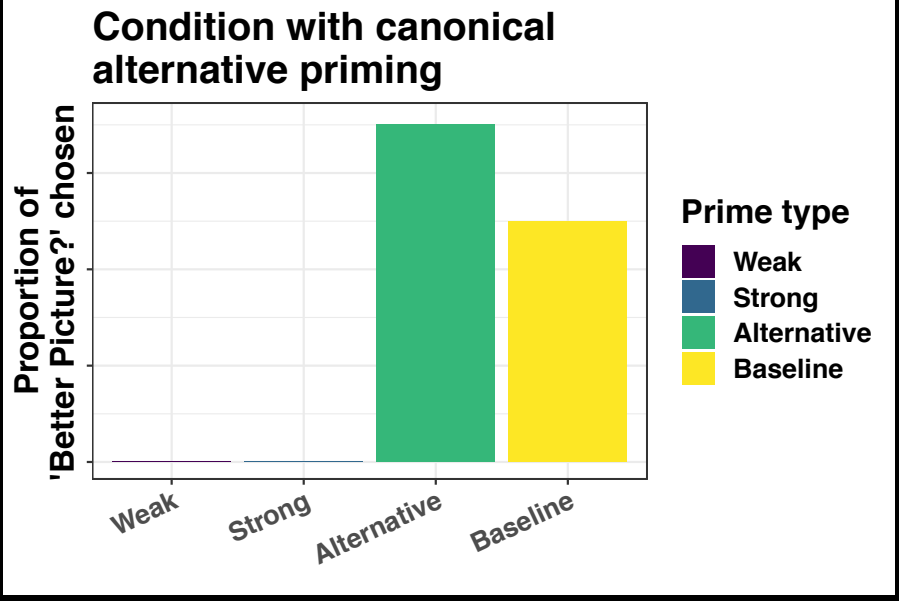
Canonical alt: *There is an X and a Y*

- Target trials follow 2 priming trials of a given type
- All participants see Weak, Strong, Alternative and Baseline priming blocks (4 of each per expression type)
- Alternative priming type is a between-subjects manipulation:

Canonical: *All of the symbols are X*
Symmetric-only: ***Only** some of the symbols are X*
Symmetric-subclausal: *Some **but not all** of the symbols are X*
Symmetric-clausal: *Some of the symbols are X, **but not all of them are X***

Predictions

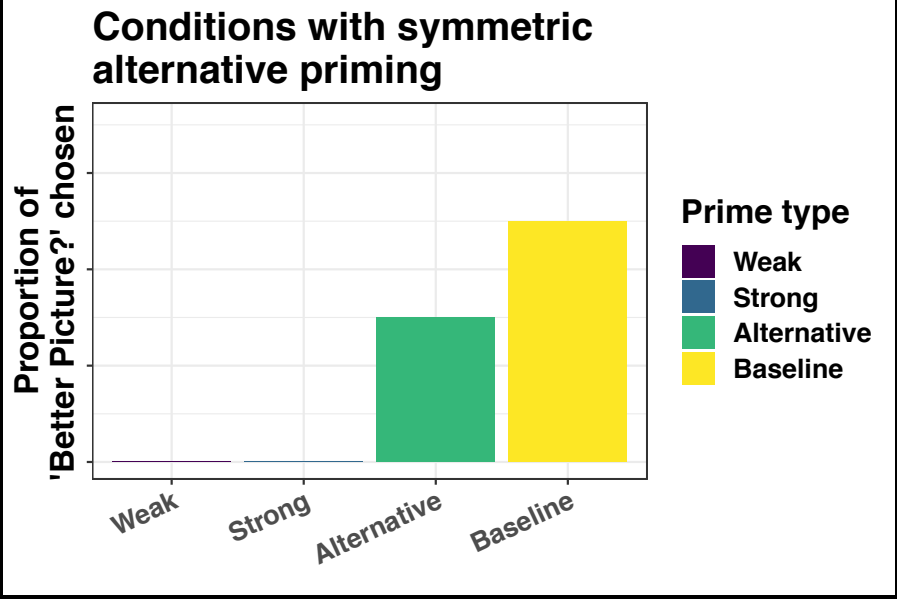
Canonical alternative hypothesis: increasing contextual availability of canonical alternatives → more SI



Prediction: more "Better Picture?" selection after Canonical alternative priming relative to Baseline

Predictions

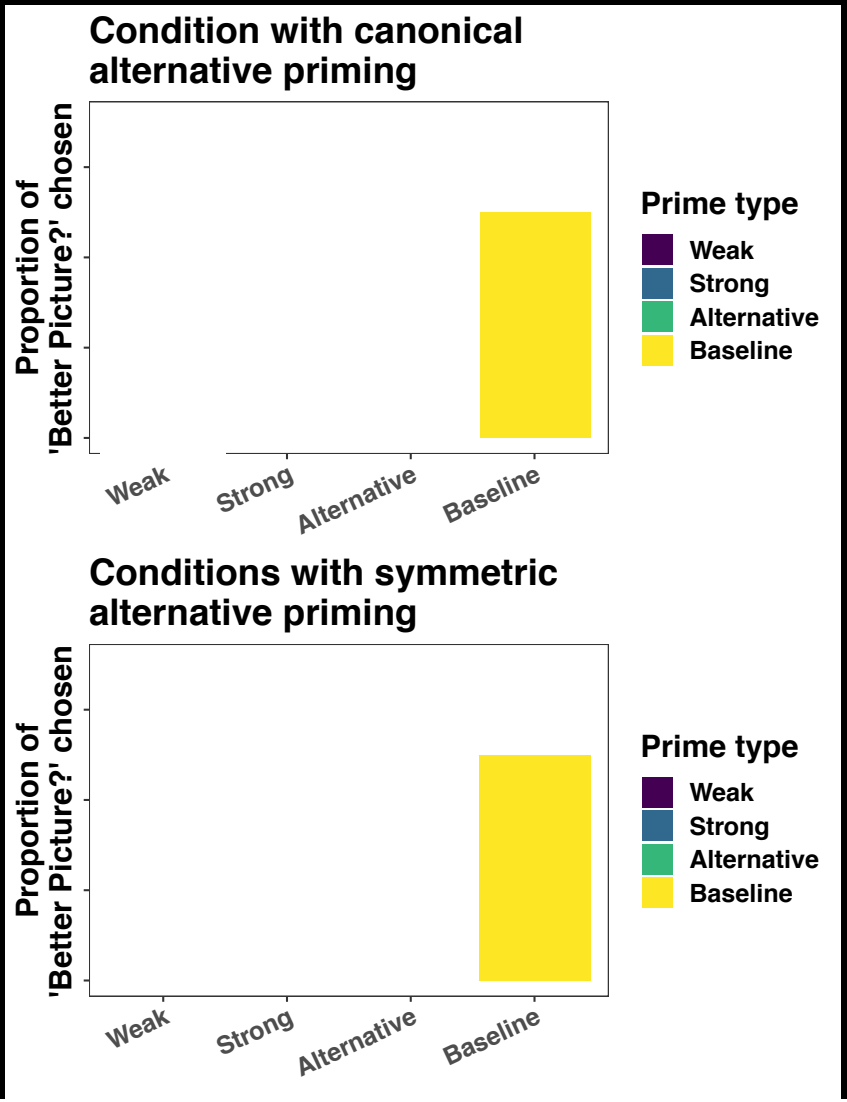
Symmetric alternative hypothesis: increasing contextual availability of symmetric alternatives → less SI



Prediction: less "Better Picture?" selection after Symmetric alternative priming relative to Baseline

Predictions

Semantic uncertainty hypothesis: Weak/Strong priming modulates SI beyond Alternative priming



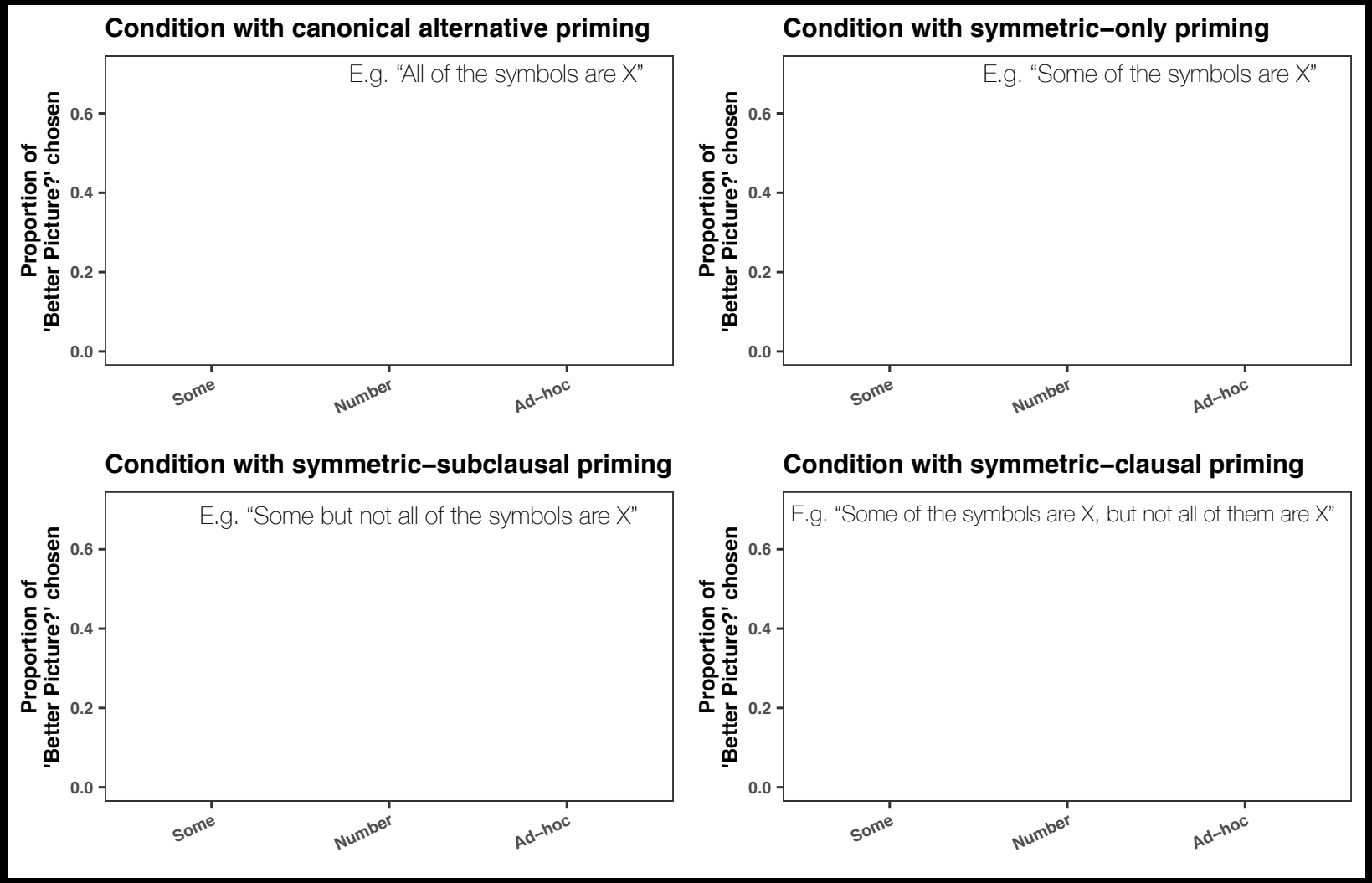
Prediction 1: more "Better Picture?" selection after Strong priming relative to Baseline.

Prediction 2: less "Better Picture?" selection after Weak priming relative to Baseline.

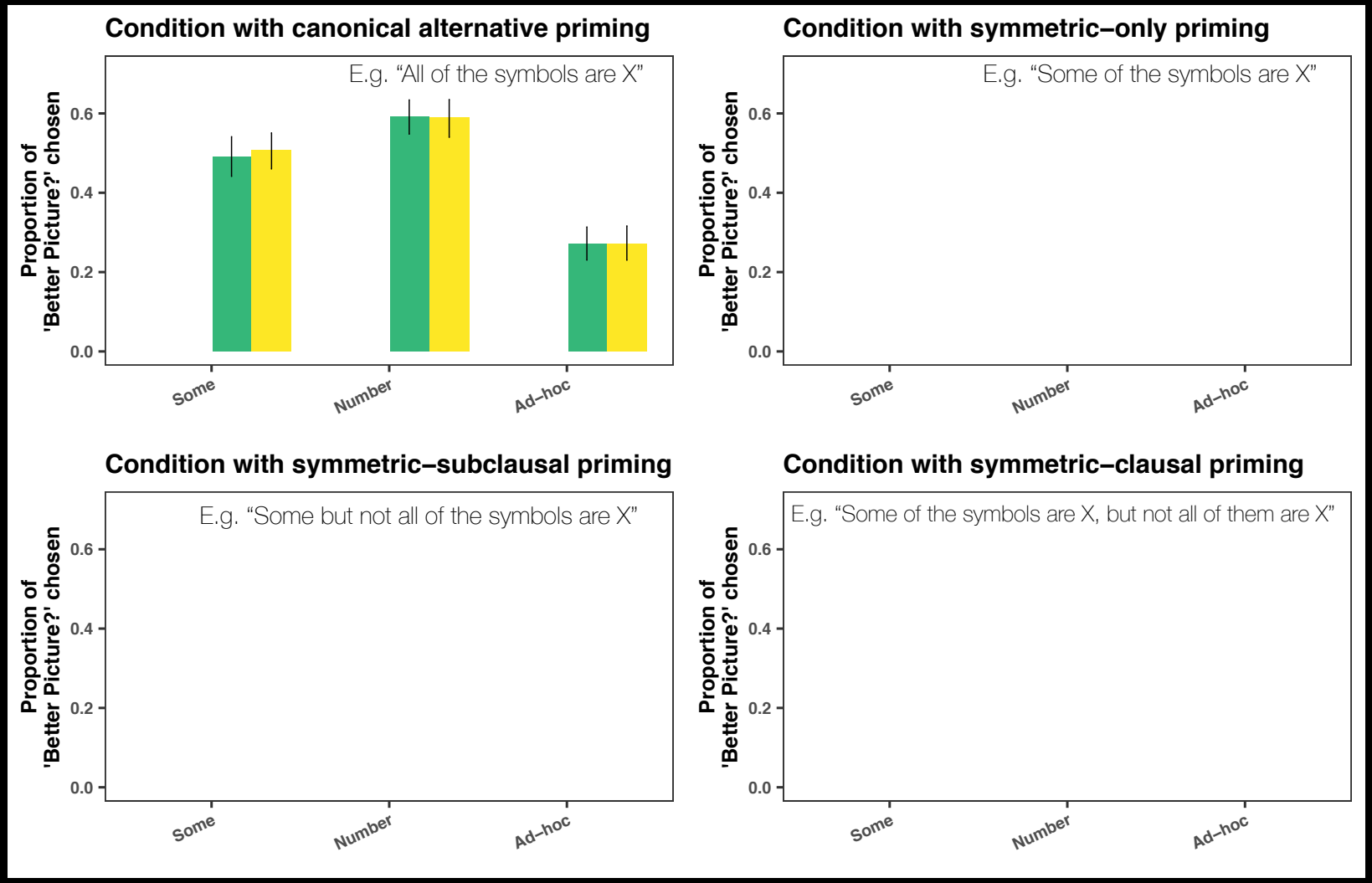
Prediction 3: Strong priming increases "Better Picture" selection more than Canonical alternative priming

Prediction 4: Weak priming decreases "Better Picture" selection more than Symmetric alternative priming

Results


Condition with canonical alternative priming
E.g. "All of the symbols are X"
Condition with symmetric–only priming
E.g. "Some of the symbols are X"
Condition with symmetric–subclausal priming
E.g. "Some but not all of the symbols are X"
Condition with symmetric–clausal priming
E.g. "Some of the symbols are X, but not all of them are X"
Proportion of 'Better Picture?' chosen
0.0
0.2
0.4
0.6
Some
Number
Ad–hoc
Prime type
Weak
Strong
Alternative
Baseline

Results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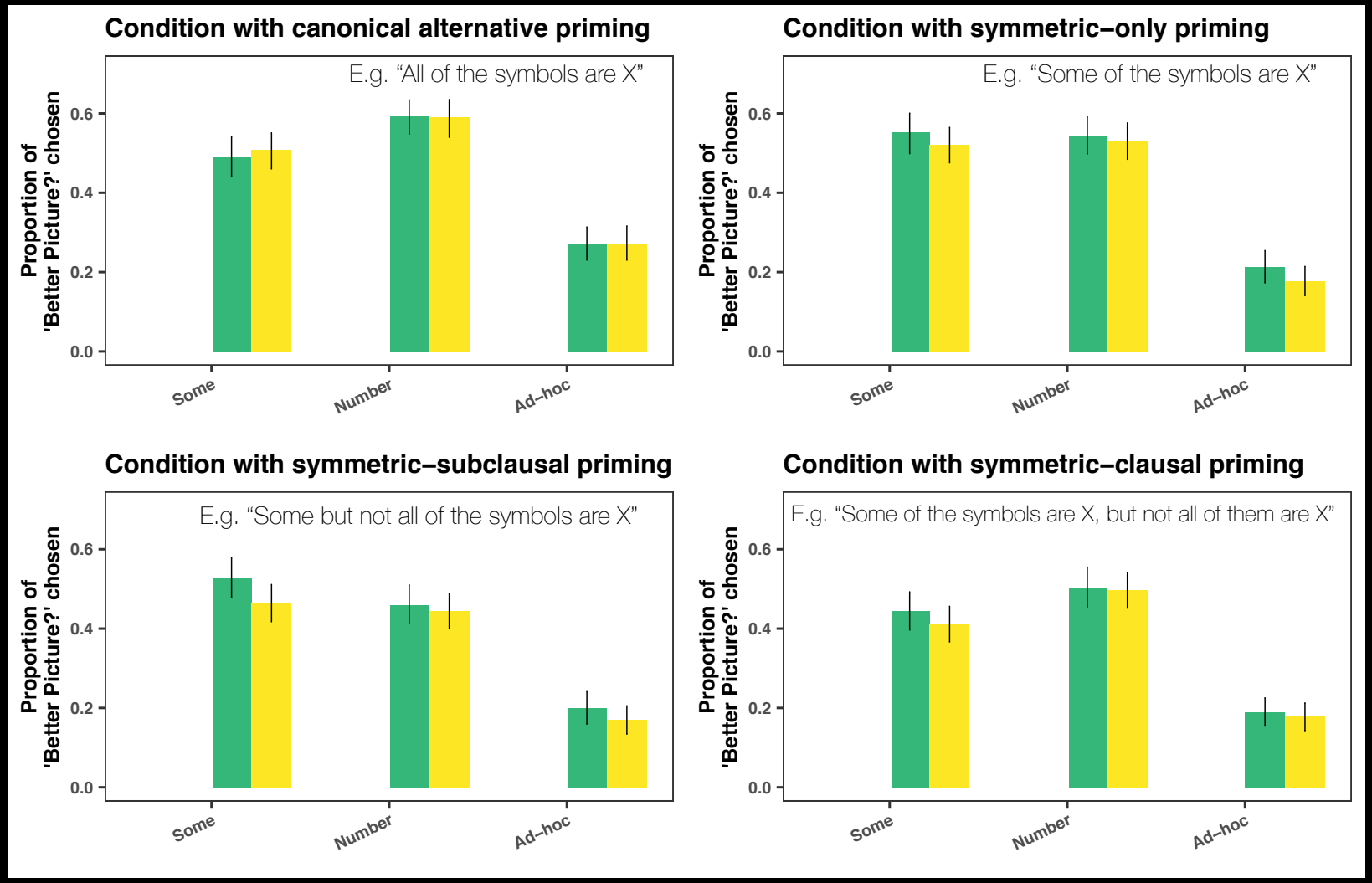
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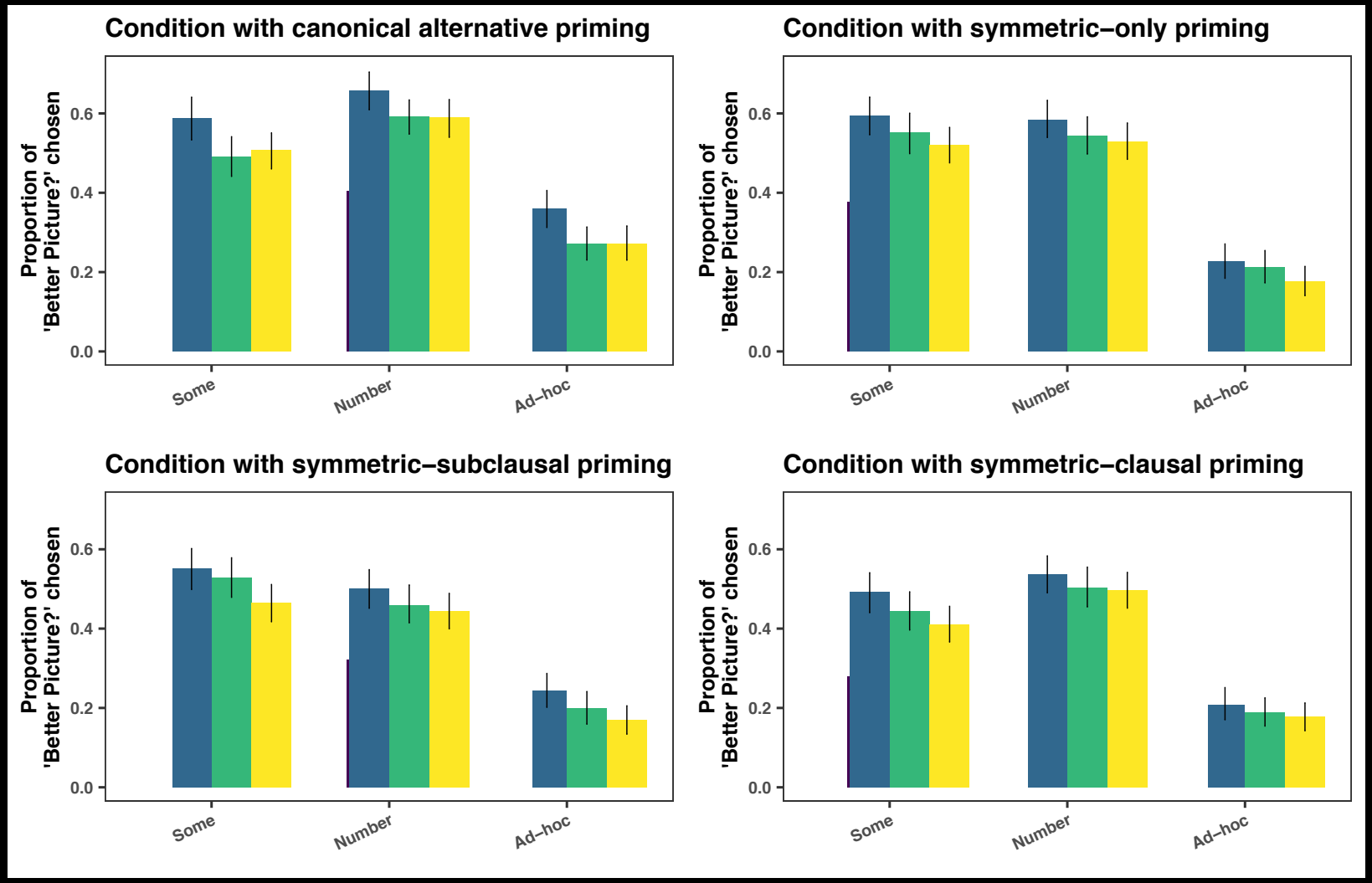
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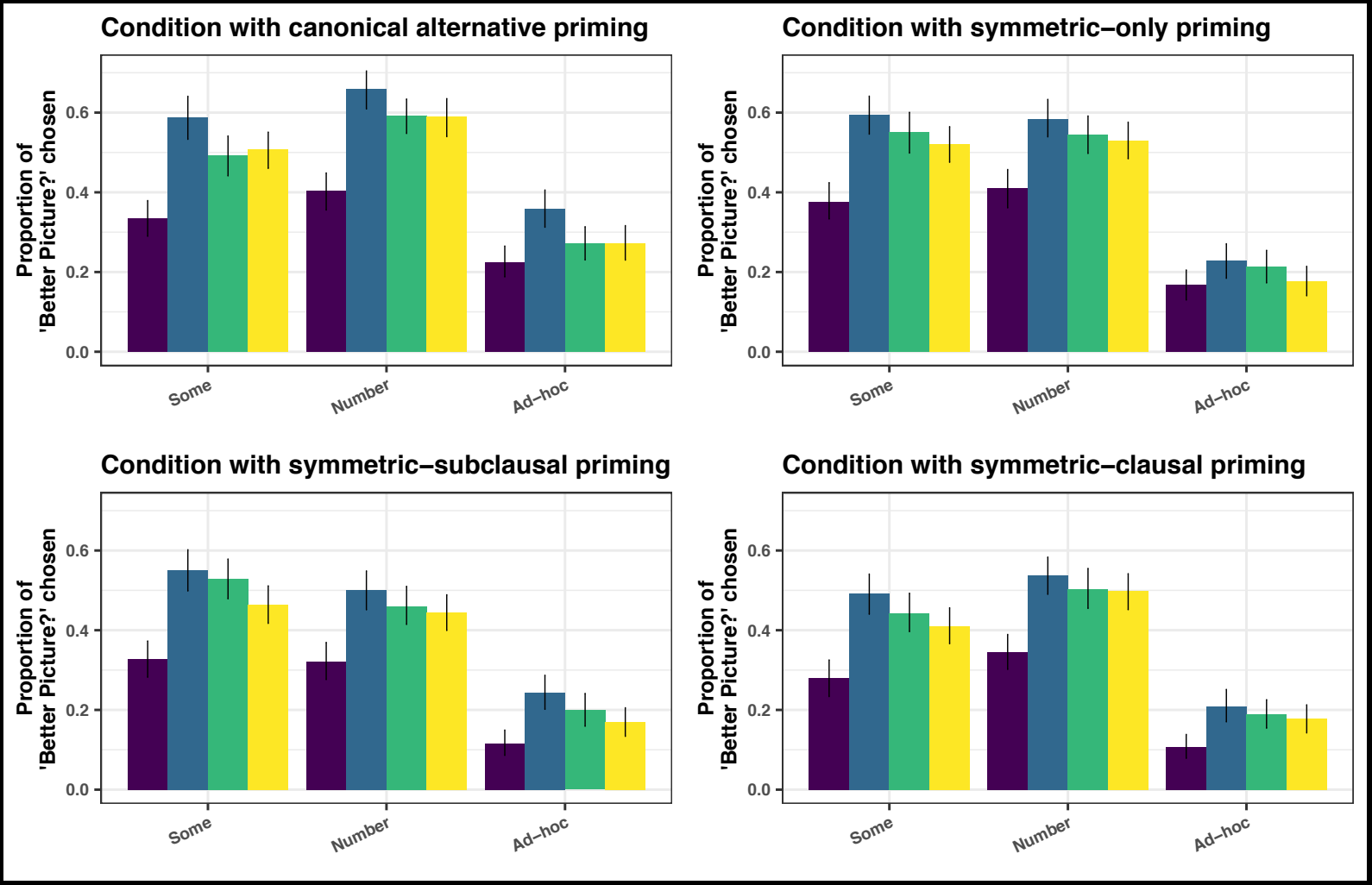
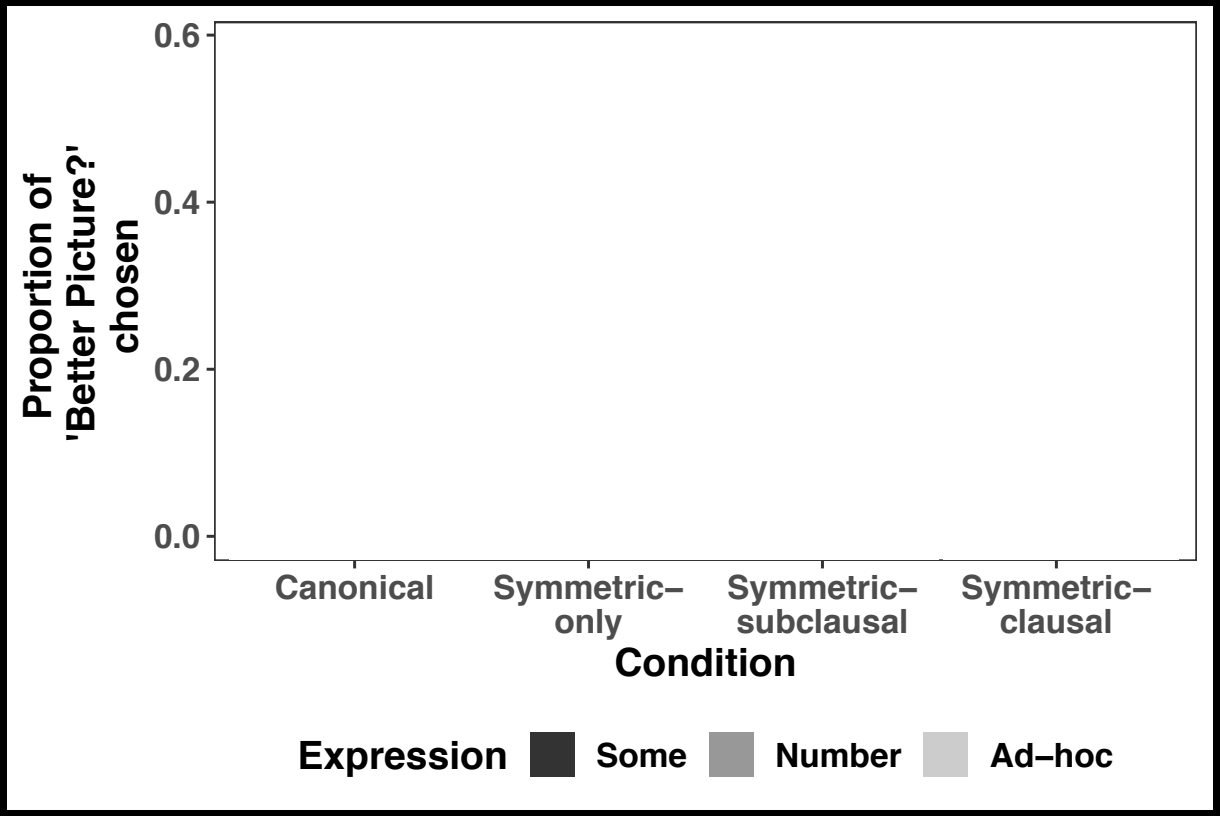

Condition with canonical alternative priming
Condition with symmetric–only priming
Condition with symmetric–subclausal priming
Condition with symmetric–clausal priming
Proportion of 'Better Picture?' chosen
0.0
0.2
0.4
0.6
Some
Number
Ad–hoc
Prime type
Weak
Strong
Alternative
Baseline

Effects of symmetric alternatives across conditions



Target trial selections, aggregated across between-subjects condition (x-axis labeled according to type of Alternative prime seen in that condition)

Evidence of effect of symmetric-subclausal priming on data subset to number expression type.

Evidence of effects of two symmetric primes on data subset to ad-hoc expression type.

Discussion

- Are symmetric alternatives active in SI?
  - Evidence suggests **yes** - though effects not observable when directly comparing symmetric alternatives to Baseline priming
  - Effect emerges at the experiment level across condition types
- Is the semantic lexicon truly ‘fixed’ in SI?
  - Evidence suggests **no** - effects of Strong/Weak priming beyond Alternative priming.

Desiderata of successful analysis

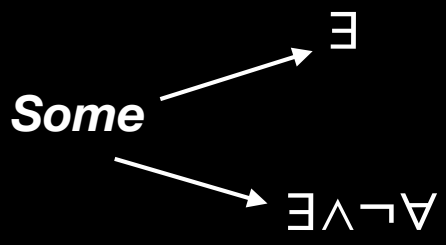
Allow for generation of both canonical and symmetric alternatives

(Utterance production expectations updated gradually throughout the experiment)

Allow for a priori uncertainty re: form-to-meaning mapping

(Mappings updated after just two priming trials)

→ suggests two channels for modulating SI



Analysis

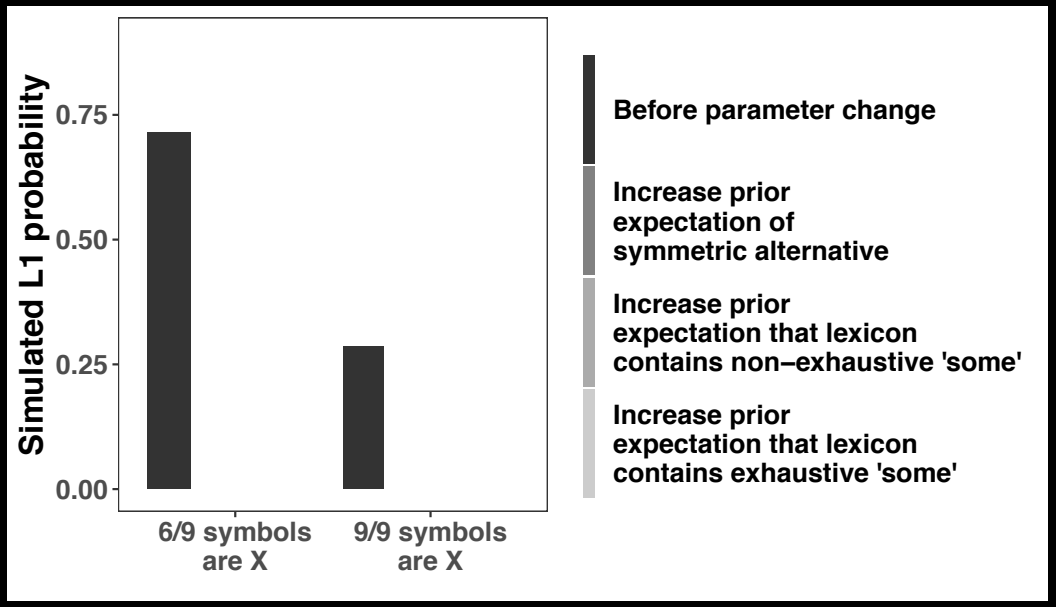
Lexical-Uncertainty Rational Speech Act (RSA) model (Bergen et al. 2016; Potts et al. 2016)

$$L_1(m \mid u) \propto \sum_{\mathscr{L} \in \Lambda} S_1(u \mid m, \mathscr{L}) P(m) P_\Lambda(\mathscr{L})$$

$$S_1(u \mid m, \mathscr{L}) \propto e^{log(L_0(m|u,\mathscr{L}))-C(u)}$$

$$L_0(m \mid u, \mathscr{L}) \propto \mathscr{L}(u, m) P(m)$$

Interpretation of *Some of the symbols are X:*



Lexical uncertainty and alternative salience modulate SI independently!

Conclusions

- Our analysis suggests that the observed results reflect *adaptive* linguistic processes rather than simple bottom-up priming.
    - Follow up: more naturalistic paradigms (e.g. Grodner & Sedivy 2011; Yildirim et al. 2016; Ryskin et al. 2019; Schuster & Degen 2020)
- Results constitute one of a growing number of challenges to the traditional view of SI
    - We need a richer, more gradient understanding of the relationship between language, context, and inference - as offered by contemporary probabilistic pragmatic frameworks.

Thank you!

- We gratefully acknowledge Leyla Kursat and Benjamin Sparkes for their assistance in implementing the experiment. We also wish to thank Cleo Condoravdi, Daniel Lassiter, Christopher Potts, our three anonymous Cog Sci reviewers, the interActive Language Processing Lab at Stanford (ALPS), and the audience at CAMP3 for feedback and discussion.

- This work was supported by a National Science Foundation Graduate Research Fellowship (#2019289423, to BW).

- References and links to GitHub repository & Open Science Foundation preregistration can be found in paper.