The added informativity of ambiguous utterances

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a feature, not a bug

Traditionally, linguists have treated **ambiguity** as **a bug in the communication system**, something to be avoided or explained away (Grice, 1975; Chomsky, 2002).

More recent research has begun to take notice of the **efficiency** ambiguity affords to us: by relying on context to fill in missing information, we can **reuse lightweight bits of language** rather than fully specifying the intended message (Levinson, 2000; Piantadosi et al., 2012; Wasow, 2015).

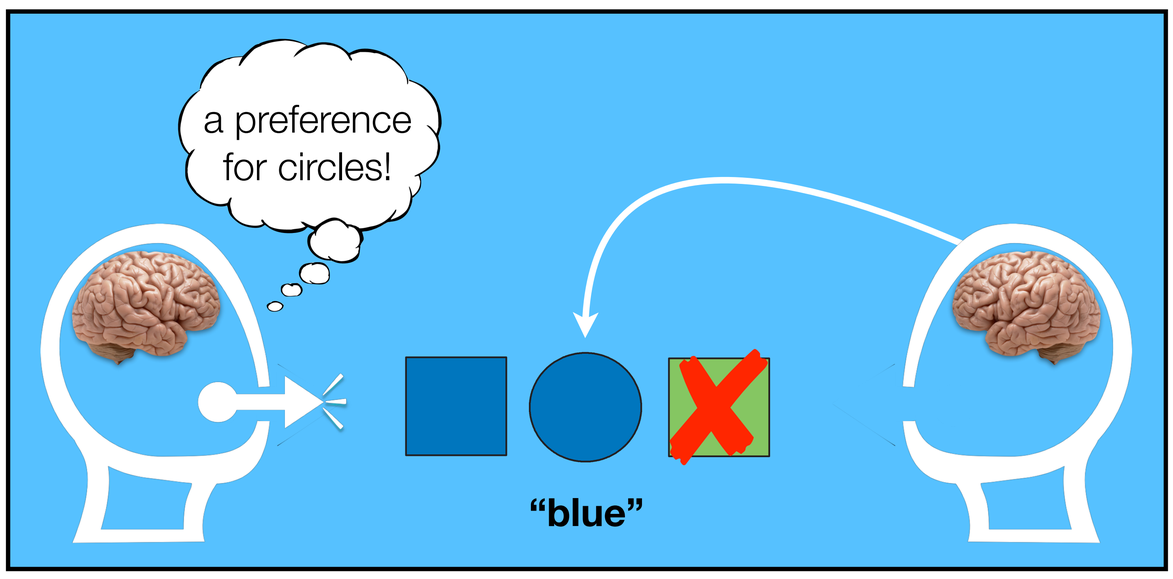
Viewed in this way, ambiguity serves as a feature, not a bug, of an **efficient communication system**.

The current work identifies **an additional benefit** in using ambiguous language: the **extra information** we gain from observing how our listeners resolve ambiguity.

We propose that **language users learn about each other's private knowledge by observing how they resolve ambiguity**.

simple reference games

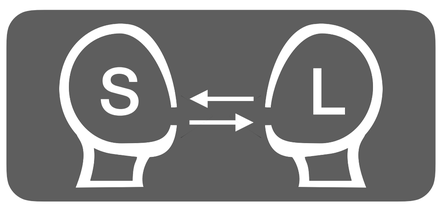
If language does not do the job of specifying the information necessary for full interpretation, then listeners are left to draw on their opinions, beliefs, and preferences to fill in the gaps; **by observing how listeners fill those gaps, speakers learn about the opinions, beliefs, and preferences of listeners**.



a computational model

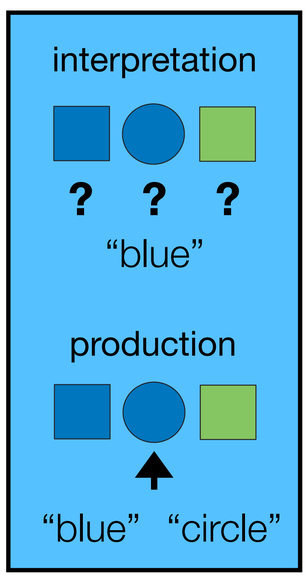
Rational **S**peech **A**ct

speaker observes state, chooses utterance
listener hears utterance, infers state



speaker and listener coordinate:
utterance + interpretation that maximizes the probability of correctly resolving the **Q**uestion-**U**nder-**D**iscussion

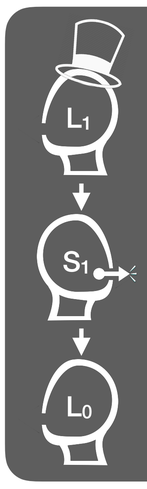
(Frank & Goodman, 2012; Goodman & Frank, 2016)



introducing preferences

The pragmatic listener **interprets utterances** by **reasoning about the process that generated them** (i.e., the speaker); the speaker **chooses utterances** by **reasoning about how they would be interpreted** by a naive, literal listener.

a **pragmatic** listener:



$$P_{L_1}(s \mid u, f) \propto P_{S_1}(u \mid s) \cdot \mathbf{P(s \mid f)}$$

$$P_{S_1}(u \mid s) \propto exp(\boldsymbol{\alpha} \cdot [\log(P_{L_0}(s \mid u)) - C(u)])$$

$$P_{L_0}(s \mid u) \propto [\![u]\!](s)$$

Preference strength ($P(s \mid f)$) and the "hardness" of the utterance semantics ($[\![u]\!](s)$) can be fit to human data.

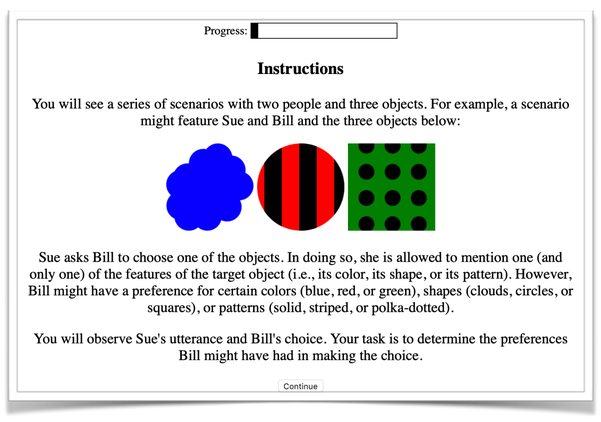
inferring preferences

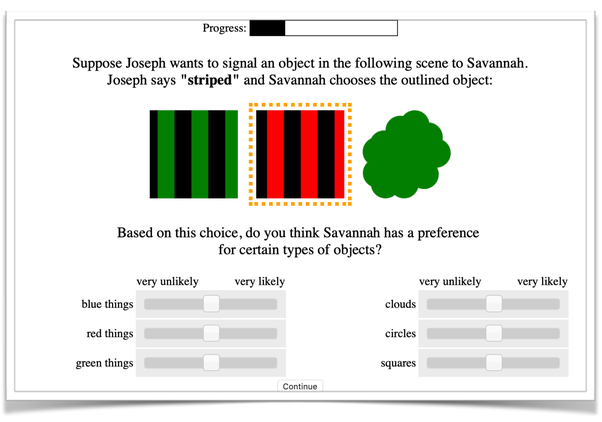
The speaker **observes** the listener's **object choice;** then **infers the preferences** that led to the choice.

$$P_{S_2}(\mathbf{f} \mid s, u) \propto P_{L_1}(s \mid u, f) \cdot P(f)$$

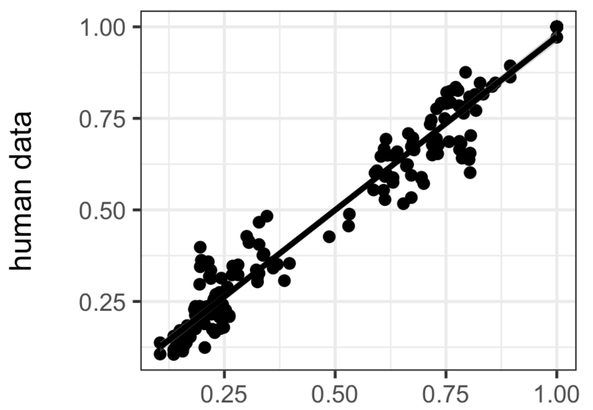
$$P_{L_1}(s \mid u, \mathbf{f}) \propto P_{S_1}(u \mid s) \cdot \mathbf{P(s \mid f)}$$

experiment 1





- **82 native speakers** of English
- Followed Frank & Goodman 2012 in stimuli creation
- **15 trials**: 10 potentially informative about preferences, 5 uninformative
- **Preference strength** ($P(s \mid f)$) **fit to** individual participant **data**
  - ✦ **18** participants had **weak preferences**, suggesting lack of engagement with task
  - ✦ **64** participants had **strong preferences**



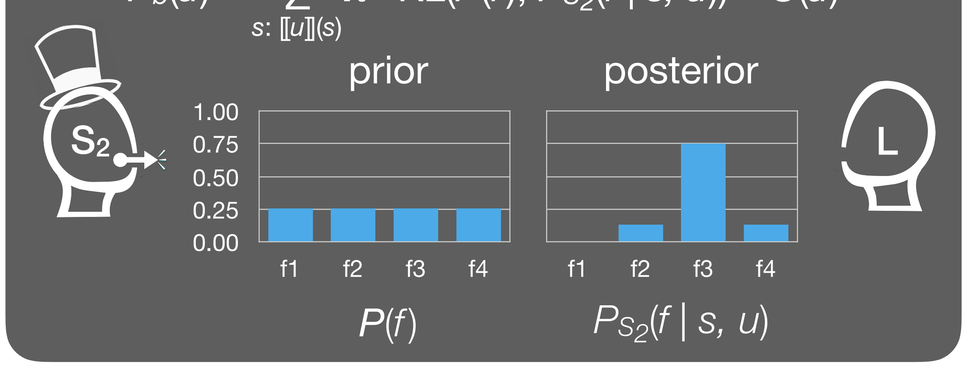
$r^2 = 0.96$, 95% CI [0.94, 0.97]

choosing utterances

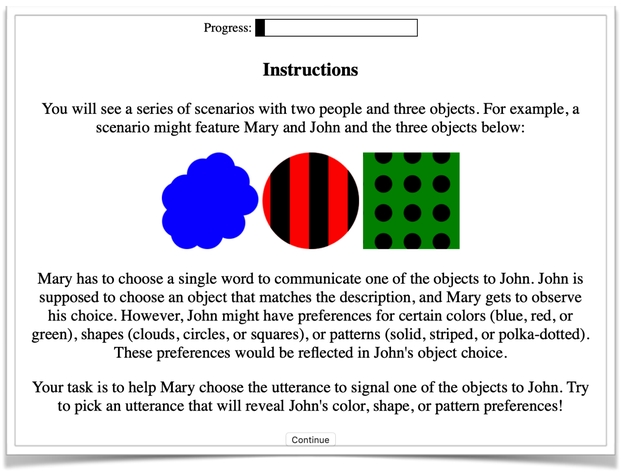
Useful utterances **maximize information gain.**

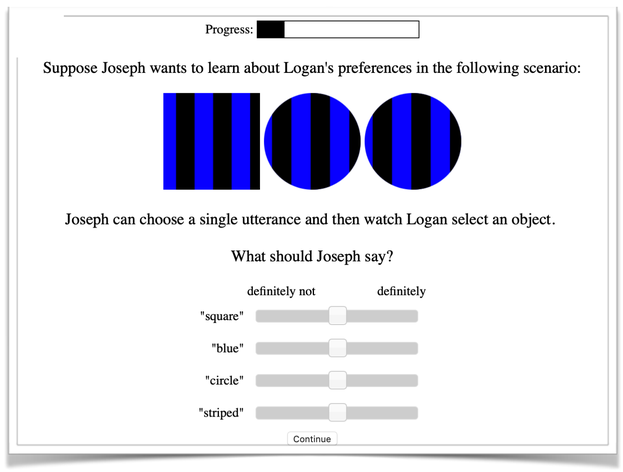
They maximize the **difference between** the **prior** and the **posterior**.

$$P_b(u) \propto \sum_{s:\, [\![u]\!](s)} \boldsymbol{\lambda} \cdot \mathrm{KL}(P(f), P_{S_2}(f \mid s, u)) - C(u)$$

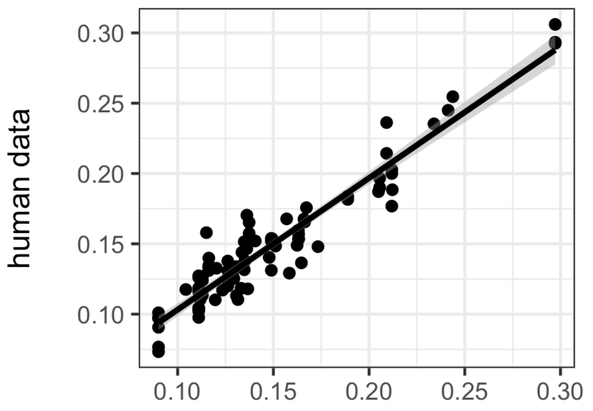


experiment 2





- **82 native speakers** of English
- Object scenes from Experiment 1
- **15 trials**: 10 potentially informative about preferences, 5 uninformative
- **Sensitivity to informatively** (λ) **fit to** individual participant **data**
  - ✦ **18** participants had λ **close to 0**
  - ✦ **32** participants had λ **less than 0**
    - ▸ Prefer **unambiguous** utterances
  - ✦ **32** participants had λ **greater than 0**
    - ▸ Prefer **ambiguous** utterances



$r^2 = 0.91$, 95% CI [0.84, 0.95]

References: **Chomsky (2002)**. An interview on minimalism. In A. Belletti & L. Rizzi (Eds.), *On nature and language* (p. 92-161). Cambridge: Cambridge University Press. **Frank & Goodman (2012)**. Predicting pragmatic reasoning in language games. *Science*, *336*, 998- 998. **Goodman & Frank (2016)**. Pragmatic language interpretation as probabilistic inference. *Trends in Cognitive Sciences*, *20*(11), 818-829. **Grice (1975)**. Logic and conversation. In P. Cole & J. L. Morgan (Eds.), *Syntax and semantics 3: Speech acts* (p. 26-40). New York: Academic Press. **Levinson (2000)**. Presumptive meanings: The theory of generalized conversational implicature. Cambridge, MA: MIT Press. **Piantadosi et al. (2012)**. The communicative function of ambiguity in language. *Cognition*, *122*, 280-291. **Wasow (2015)**. Ambiguity avoidance is overrated. In S. Winkler (Ed.), *Ambiguity: Language and communication* (p. 29-47). de Gruyter.

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