Non-sinking marbles are wonky: world knowledge in scalar implicature

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Background: integrating world knowledge in utterance interpretation

Questions

1. How does world knowledge enter into utterance interpretation?
2. When do listeners update their beliefs about common ground?

Case study: scalar implicature

(1) *Some of the boys drank beer.* ⇝ Not all of the boys drank beer.
(2) *Some of the marbles sank.* ⇝ Not all of the marbles sank.

The scalar implicature should intuitively be weaker with increasing subjective prior probability of the all-state. But: when the prior probability of the all-state is very high, as in (2), the implicature is intuitively very strong (Geurts, 2010). Here, we

1. collect empirical estimates of subjective **prior probabilities** of events (**world knowledge**)
2. collect empirical estimates of subjective **posterior probabilities** of events (**interpretation** of an utterance)
3. use **Bayesian social reasoning** models to explore when listeners update prior beliefs (**common ground**)

Rational Speech Act models

(Frank & Goodman, 2012; Goodman & Stuhlmüller, 2013)

Regular RSA

$$P_{L_0}(s|u) \propto \delta_{[\![u]\!](s)} \cdot P(s)$$
$$P_{S_1}(u|s) \propto \exp(\lambda \ln P_{L_0}(s|u))$$
$$P_{L_1}(s|u) \propto P_{S_1}(u|s) \cdot P(s)$$

Wonky RSA (wRSA)

$$P_{L_0}(s|u,w) \propto [\![u]\!](s) \cdot P(s|w)$$
$$P_{S_1}(u|s,w) \propto \exp(\lambda \ln P_{L_0}(s|u,w))$$
$$P_{L_1}(s,w|u) \propto P_{S_1}(u|s,w) \cdot P(s|w) \cdot P(w)$$
$$P(s|w) \propto \begin{cases} 1 & \text{if } w \\ P_{\text{usual}}(s) & \text{if not } w \end{cases}$$

If world is wonky, use uniform prior, else use 'usual' prior. Probability of wonkiness increases with unexpectedness of utterance.

States of the world

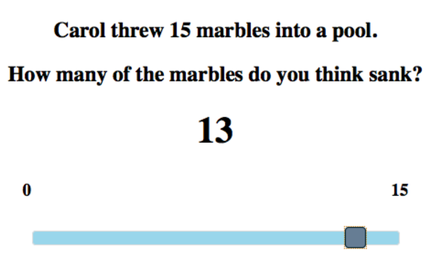
$S = \{s_i | 0 \le i \le 15\}$, where i indicates the number of X that *Yed*

Utterances

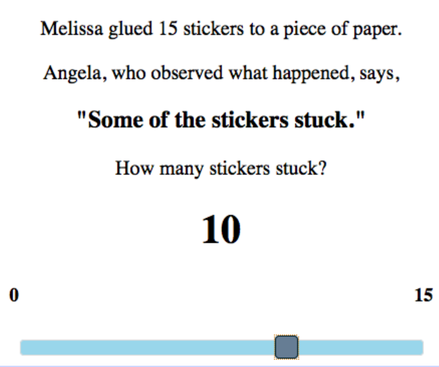
$[\![u_{\text{none}}]\!] = \{s_i | i = 0\}$
$[\![u_{\text{some}}]\!] = \{s_i | i > 0\}$
$[\![u_{\text{all}}]\!] = \{s_i | i = 15\}$

Experiments

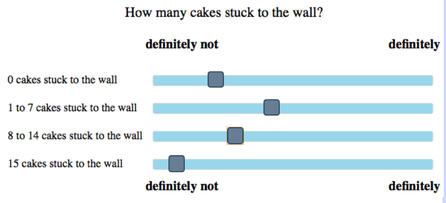
Experiment 1: prior elicitation



Experiment 2a: comprehension (expected number of objects)



Experiment 2b: comprehension (posterior all-state probability)



Overview

1. Estimate prior beliefs about how many X Y (Exp. 1)
2. Estimate listeners' posterior beliefs about how many X Yed (Exp. 2a and 2b) and how likely the world is wonky (Exp. 3) to test RSA and wRSA models

Experimental details

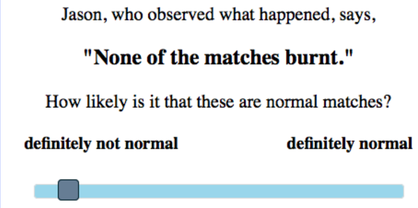
90 items: ***Q of the X Yed***
Q: *some* (10), *all* (5), *none* (5)
X: *marbles, shirts, carrots,...*
Y: *sank, ripped, dissolved,...*

30 trials per participant in each experiment, including 5 short fillers (*Typical*) and 5 long fillers (*What a stupid thing to do.*)

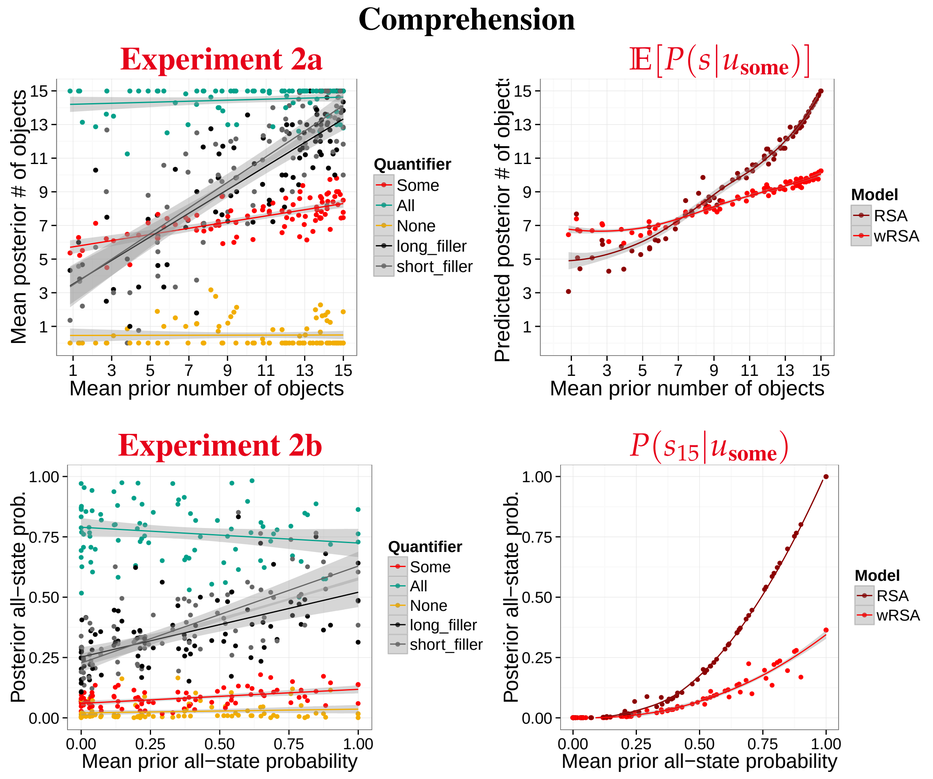
Participants in each experiment

	Exp. 1	Exp. 2a	Exp. 2b	Exp. 3
n	60	120	120	60

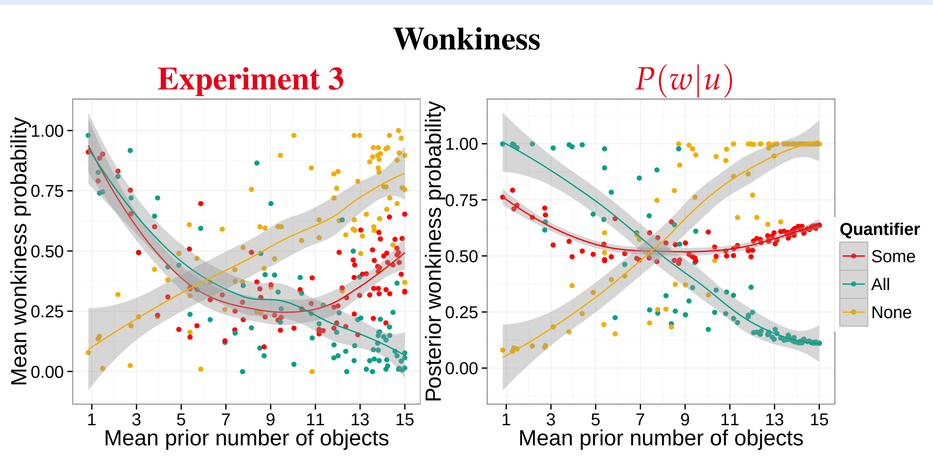
Experiment 3: wonkiness



Empirical results



Robust effect of prior on posterior expectation (β=.18, SE=.02, t=7.4, $p<.0001$) and all-state probability (β=.06, SE=.01, t=5.0, $p<.0001$). But: effect is much smaller than predicted by RSA. The data are much better fit by the wonky RSA model.



Model predictions

Conclusion

The effect of world knowledge (prior beliefs) on interpretation was much smaller, and qualitatively different, than predicted by a standard Bayesian model of quantifier interpretation (RSA). Extending RSA with a lifted wonkiness variable that captures whether listeners think the world is wonky upon encountering an odd utterance, and allows them to back off to alternative beliefs, provided a good fit to the data, suggesting: **listeners revise common ground when utterances are odd**.

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