How people talk affects the implicatures that others make

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After encountering *"some of today's letters have checks inside"* (1) people often make a scalar implicature, interpreting that not all of today's letters have checks inside. Goodman & Stuhlmüller (2013; GS13) showed that the interpretation of "some" depends on context: in a partial knowledge context, where only 2 of 3 letters have been examined, people were less likely to infer that "not all" was meant: they think that all of the letters might have checks inside.

In addition, Degen & Tanenhaus (2015; DT15) showed that people are slower to infer that "some" probably means "not all" when the speaker uses number alternatives like "two"–"five". However, how the presence of these number alternatives affects the *ultimate interpretation* of "some" has not been explored. To address this, we constructed a Rational Speech Acts model (Goodman & Frank, 2016) identical to GS13's, with the relevant alternatives added (5). The listener hears an utterance *u*, and computes a distribution over worlds *w*, by reasoning about how the speaker uses language. The speaker has a knowledge state *s*, and computes a distribution over utterances, by reasoning about which utterances will successfully communicate the knowledge state to the listener. The model predicts that, when the speaker uses number alternatives, people would make more of an implicature (to "not all") in partial knowledge contexts relative to when they do not use number alternatives. It predicts no effect of number alternatives in full knowledge contexts. The former is because of the presence of a new, informative alternative for the partially knowledgeable speaker: this speaker can say "two" (instead of "some") if both of the letters that were examined contain checks. When the listener hears "some," the presence of the alternative "two" leads to the inference that only one of the letters contains a check. To test these predictions (Figure 1A), we designed three experiments which manipulate the set of alternative utterances *A* that is available to the speaker.

In three experiments run on MTurk, we investigated whether having number alternatives like "two"–"five" in the context (as in DT15) might affect the meaning that people obtain in materials like (1). In a 2x2 design we crossed knowledgeability (partial, full) with numbers-present-in-exposure-trials ("with numerals", "no numerals"). DT15's setup was for full-knowledge contexts, so that the final inference was similar independent of speaker word choice. All of our 8 materials involved target sentences where the knowledge involved 2 vs. 3 (of 3) objects being known by the speaker. There were 16 items in the exposure trials, all which either contained numbers or did not (2). We ensured that participants understood each scenario by assessing their understanding through comprehension questions (3). The task was to estimate the probability of "all" in the relevant context (between 0 and 100 %) (4). In line with the model (5), we predicted (a) a main effect of knowledge, such that participants should make a greater implicature to "not-all" in full-knowledge (replicating GS13) and critically (b) an interaction, that this effect should be weakened in the numbers-present conditions (Figure 1A).

In E1 (Figure 1B, n=240, pre-registered), we found the predicted main effect of knowledgeability ($t = -9.20$, $p < 0.001$) and only a marginal interaction ($t = 1.70$, $p = 0.091$). In E2 (Figure 1C, n=240, pre-registered), we added 8 exposure (non-target) trials, because in pilot work we had found that the knowledgeability effect was larger with more distractor items. We replicated the main effect of knowledgeability ($t = -7.65$, $p < 0.001$) and observed a significant interaction ($t = 2.47$, $p = 0.018$). Pooling data from E1 and E2 we estimated that we needed approximately 350 participants in order to have 80% power to detect the interaction. We then ran a registered replication E3 (Figure 1D, n=390, pre-registered), and again found the predicted main effect ($t = -10.62$, $p < 0.001$) and interaction ($t = 2.50$, $p = 0.017$).

In summary, we replicated GS13 on new materials. More interestingly, we showed that how people talk actually affects the inferences that others make. The results are closely related to those of DG15, which demonstrated an effect of alternative utterances on on-line pragmatic processing. The current study extends that work, showing that changes to the set of alternative utterances can affect the *final interpretation* of a sentence—inferences about the speaker's intended meaning.

(1) *Letters to Laura's company almost always have checks inside. Today Laura needs to find out whether 3 of the letters have checks inside.*
a. **Partial knowledge (2 of 3 examined) target:** *Laura tells you on the phone: I have now looked at 2 of the 3 letters, and I can tell you that some of today's letters have checks inside.*
b. **Full knowledge (3 of 3 examined) target:** *Laura tells you on the phone: I have now looked at 3 of the 3 letters, and I can tell you that some of today's letters have checks inside.*

(2) a. **"no numerals" exposure:** *Mary tells you on the phone: I have now looked at the rooms, and given what I saw, I can tell you that I am very satisfied with the result.*
b. **"with numerals" exposure:** *Mary tells you on the phone I have now looked at 3 of the 3 rooms, and given what I saw, I can tell you that 3 of today's rooms have working smoke detectors.*

(3) *a. Did Laura look at all of today's letters? (correct answer: no in (1)a)*
b. Did Laura say that some of today's letters have checks inside? (correct answer: yes in (1)a)

(4) *Assuming that the speaker is providing an accurate description of her knowledge, how likely is it that all of today's letters have checks inside? Please provide a probability between 0 and 100 percent: ____%*

(5)

$$L_0(w|u) \propto P(w)\mathbb{1}_{w\in[\![u]\!]} \qquad L_1(w|u) \propto \sum_s P(s|w) S_1(u|s)$$

$$U_1(u|s) = \sum_{w\in s} P(w|s) \log L_0(w|u) \qquad S_1(u|s) = \frac{e^{U_1(u|s)}}{\sum_{u'\in A} e^{U_1(u'|s)}}$$

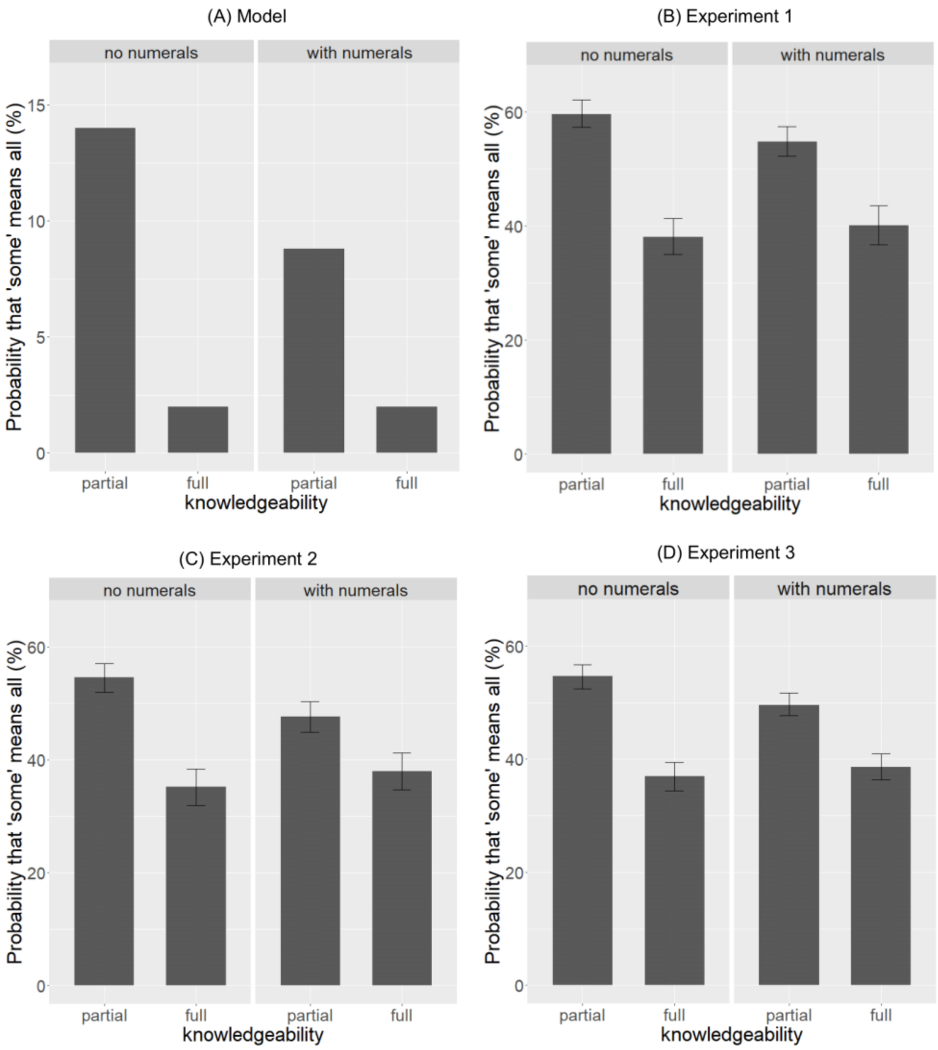

Figure 1: (A) Model predictions for the four experimental conditions. Note that model parameters were not optimized to fit experimental results. The interaction is robust across a range of model parameters. The absolute y-axis scale is therefore not meaningful; all that is relevant is the relative proportions across conditions. **(B)** E1: main effect of knowledgeability (β=-18.08, SE=1.95, t=-9.26, p<0.001); marginal interaction (β=6.54, SE=3.86, t=1.70, p=0.091). **(C)** E2: main effect of knowledgeability (β=-14.60, SE=1.91, t=-7.65, p<0.001); interaction (β=9.76, SE=3.95, t=2.47, p=0.018). **(D)** E3: main effect of knowledgeability (β=-14.24, SE=1.34, t=-10.62, p<0.001); interaction (β=6.90, SE=2.76, t=2.50, p=0.017).

References:
Degen & Tanenhaus 2015 *Cognitive Science*.
Goodman & Frank 2016 *Trends in Cognitive Sciences.*
Goodman & Stuhlmüller 2013 *Topics in Cognitive Science*.