A probabilistic, goal-sensitive model of normative rule interpretation

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This analysis extends the the Rational Speech Act (RSA) framework of modeling pragmatic interpretation (Frank & Goodman, 2012); it takes particular inspiration from RSA analyses whereby listeners jointly infer speaker intended meanings and speaker non-communicative goals. (See e.g. Kao, Wu, Bergen, & Goodman, 2014 for an application to hyperbolic language; Kao, Bergen, & Goodman, 2014 for metaphor; Burnett, 2019 for social meaning and joint inference re: multiple social goals). On our account, interpretation of normative rules is sensitive to contextual evidence as to the rule-maker's intended policy goal (e.g. limiting pollution in the case of *No vehicles allowed*). We call our proposed model the **the goal-sensitive model:**

$$L_1(obj, goal|rule)^1 \propto S(rule|obj, goal)^2 \cdot P_G(goal|rule)^3 \cdot P_{CAT}(obj|rule)^4$$

[1] $L_1(obj, goal|rule)$: Joint posterior probability that object *obj* is prohibited and signaler has particular policy *goal*, given observation of a *rule*.

(Other possible prohibition state: $\neg obj$ [*obj* is not prohibited])

[2] $S(rule|obj, goal)$: Signaler prob. of producing *rule*, given *goal* and intention to prohibit *obj*.

$$\propto e^{\alpha \cdot ln(U(goal,obj) - cost(rule))}$$

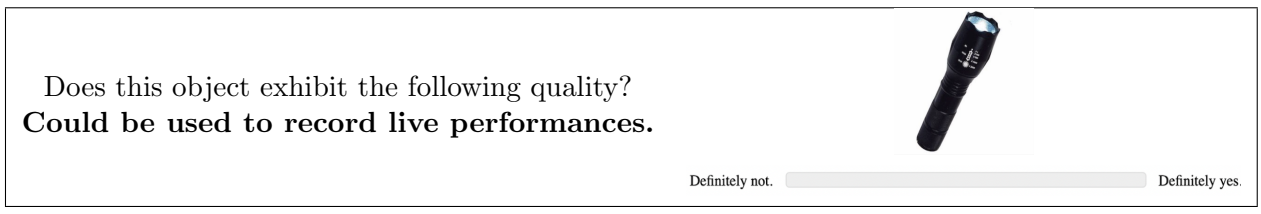
... where α is an optimality parameter, *cost* is a cost function on signal choices, and $U(goal, obj)$:

- Tracks utility of prohibiting *obj* given a policy *goal*.
- Outputs on the interval [0,1] (the greater the extent to which prohibiting *obj* advances *goal*, the higher the output value).

$$U(goal, \neg obj) = 1 - U(goal, obj)$$

(Failing to prohibit objects that would advance *goal* is low utility).

- Is parameterized via a norming study in which objects in the experiment are normed for goal-relevant features, e.g.:



[3] $P_G(goal|rule)$: Prior over policy goals (given observation of *rule*). Parameterized via a norming study in which policy goals are normed for a priori plausibility, e.g.:

The managers of a theater are concerned that audience members might try to record performances and distribute pirate recordings online.

How plausible is it that the **motivation** above could have given rise to the rule below?

No electronic devices are allowed in the theater.

Highly implausible. Highly plausible.

[4] $P_{CAT}(obj|rule)$: Prior beliefs that *obj* is prohibited, given lexical content of *rule*. (In particular, prior beliefs about the membership of *obj* in the category denoted by an artifact noun that features in the rule).

$$P_{CAT}(\neg obj|rule) = 1 - P_{CAT}(obj|rule)$$

Is this object an electronic device?

Definitely not. Definitely yes.

The goal-insensitive baseline model:

$$L_1(obj|rule) = P_{CAT}(obj|rule)$$

For the purposes of model comparison, we assume:

- A space of possible messages that includes a scene's featured *rule* and an alternative, *silence* (following Lassiter & Goodman, 2013) with the following properties:
  - $S(silence|obj, goal) = S(silence|\neg obj, goal)$ for any *obj* and any *goal*.
  - For any $goal_1$, $goal_2$ in the space of possible policy goals, $P_G(goal_1|silence) = P_G(goal_2|silence)$
  - $P_{CAT}(obj|silence) = P_{CAT}(\neg obj|silence)$ for any *obj*
- For trials in which participants are exposed to an explicit policy goal $goal_x$, $P_G(goal_x|rule) = 1$.
- $cost(rule) = cost(silence) = 0$

Model comparison was conducted in WebPPL (Goodman & Stuhlmüller, 2014) from a uniform prior over model architectures (goal-sensitive vs. goal-insensitive) and a uniform prior over α values.

References

Burnett, H. (2019). Signalling games, sociolinguistic variation and the construction of style. *Linguistics and Philosophy*, *42*(5), 419–450.

Frank, M. C., & Goodman, N. D. (2012). Predicting pragmatic reasoning in language games. *Science*, *336*(6084), 998–998.

Goodman, N. D., & Stuhlmüller, A. (2014). *The Design and Implementation of Probabilistic Programming Languages.* `http://dippl.org`.

Kao, J., Bergen, L., & Goodman, N. (2014). Formalizing the pragmatics of metaphor understanding. In *Proceedings of cog sci* (Vol. 36).

Kao, J., Wu, J. Y., Bergen, L., & Goodman, N. D. (2014). Nonliteral understanding of number words. *Proceedings of the National Academy of Sciences*, *111*(33), 12002–12007.

Lassiter, D., & Goodman, N. D. (2013). Context, scale structure, and statistics in the interpretation of positive-form adjectives. In *Semantics and linguistic theory* (Vol. 23, pp. 587–610).