# Note on a noisy variant of the RMD

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## Motivation

Our present model computes the mutation probability that a teacher type $t_i$ has offspring of type $t_j$ as:

$$Q_{ij} \propto \sum_{d \in D} P(d|t_i) F(t_j, d)\,, \quad \text{where} \;\; F(t_j, d) \propto P(t_j|d)^l \;\; \text{and} \;\; P(t_j|d) \propto P(t_j)P(d|t_j)$$

What makes for the evolution of a natural lower-bound-only semantics for *some* is the **cognitive bias** encoded in the prior $P(t_j)$. While it is not unnatural or indefensible to assume such a cognitive bias, we also do not have a strong argument in support of it. We also do not want to argue that *this* is the right explanation, do we? Our main achievement is rather a perspicuous alignment of conceptual bits and pieces into a working formal model. The main ingredients of this model are (i) a combination of learning biases and selective pressure towards efficient communication, and (ii) the distinction between semantic meaning and pragmatic use, both of which are shaped and honed by evolution at once. This is great, but maybe we might want to have more.

Let's focus on (i) for a moment. In a recent paper, Pedro Correia and I have explored an evolutionary dynamic that ensues from "noise-perturbed imitation" (Franke and Correia, to appear). The idea is that agents update their strategies by occasionally imitating choices with a probability proportional to how good these observed choices are. Crucially, however, agents may not always perceive a state correctly. We applied this to vagueness, where this is most natural: some actual state $s_a$ has a chance $P_N(s_p \mid s_a)$ of being observed as $s_p$, e.g., maybe $P_N(s_p \mid s_a) = \text{Gaussian}(s_p, \mu = s_a, \sigma = \text{something})$ is a normal distribution around the actual state. What we showed in this paper is that noisy perception of states not only leads to vagueness in signal meaning, but also speeds up the evolutionary process by unifying and regularizing agents' strategies. We interpreted this as a sort of emergent "*as-if* generalization": at the population level it seems as if agents would extrapolate and generalize what they have learned about one state to nearby similar states. But this is not, of course, what actually happens. The mere presence of systematic noise in the transmission of strategies can introduce regularization that looks as if the agents have a learning bias. But, most importantly, this disturbance of transmission fidelity is due to perceptual noise and properties of the environment, not learning biases. In other words, learning biases are clearly not the only transmission biases that can shape evolution alongside functional pressure. Environmental and perceptual noise can play a role too. This also ties in with a bunch of work on work that tries to explain some features of language as being optimal adaptations to a "noisy-channel" model (work by Ted Gibson, Steve Piantadosi etc.). However, in this work the noise is rather in the signal $m$ not the state perception $t$. In general, then, I believe that there is a certain lacuna here: paying attention to the effects of systematic distortions of state perceptions on the cultural evolution of language.

So, I asked myself whether noisy perception of states could also be included into our model and whether this could have a similar effect to a cognitive bias in favor of lower-bound-only semantics, without actually making use of such a cognitive bias. The answers in short are: "yes, yes". However, perhaps unsurprisingly, not all conceivable kinds of perception error lead to this outcome. So, if we wanted to defend that such-and-such a model is the right explanation we'd be hard pressed to defend a particular noise structure. I don't think that we can do this. The main message, in my view, should rather be: look we have two possible lines of explanation for lower-bound semantics, one with cognitive biases, the other with perceptual errors. Our main contribution is showing how two things can interact in cultural evolution, namely (i) transmission biases and (ii) functional pressure, and that, crucially, transmission biases need not only be cognitive/learning biases but can also ensue from perception and the environment. We then have a case study that puts everything into place and demonstrates the latter claim. That's the story line that we could adopt if we like the following model extension and whatever comes with it.

When talking to Kenny Smith at CogSci, I realized that there is

# References

Franke, Michael and José Pedro Correia (to appear). "Vagueness and Imprecise Imitation in Signaling Games". In: *The British Journal for the Philosophy of Science*.