Inferring Semantic Meaning Using Persona-level Information

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Abstract

Information about the persona of a speaker affects the resolution of precision in numerical expressions of cost, distance, and time. Here, a model is developed following the Rational Speech Acts framework to account for the differences of interpretation based on inferences about the social and informational goals of a speaker.

Keywords: persona; Bayesian reasoning; RSA; social meaning

Introduction

Recent work has shown that information about the persona (Eckert, 2008; D'Onofrio, 2018) of a speaker impacts linguistic interpretation on several levels. On the phonological level, the belief that the speaker is a Valley Girl led listeners to hear ambiguous tokens as TRAP-backed items more often, as compared to when the listener believed the speaker to be a Nerd, and participants fixated longer on TRAP items than on their LOT counterparts when they believed the speaker to be either a Valley Girl or from California (D'Onofrio, 2015). Weatherholtz, Campbell-Kibler, and Jaeger (2014) found that automatic syntactic alignment of a listener with a speaker was mediated by social information, such as speaker accent, perceived intelligence, and the level of interpersonal similarity between speaker and listener. Finally, with regard to the interpretation of semantic meaning, Beltrama & Schwarz (under review) found that participants had different expectations on the level of precision of a speaker, based on whether that speaker represented a Chill persona or a Nerdy persona.

The fact that semantic meaning interpretation can change depending on the social characteristics of the person speaking suggests a process of pragmatic reasoning applied to the basic semantic meaning of utterances, resulting in pragmatically enriched speech. The observations of Beltrama & Schwarz (under review) lend themselves to a modelling of inference about language and the speaker in the Rational Speech Acts framework (Frank & Goodman, 2012; Goodman & Frank, 2016), a probabilistic Bayesian approach to language use and interpretation based on more general cognitive principles.

Politeness due to Competing Goals

An important precursor to the model presented below is that of Yoon, Tessler, Goodman, and Frank (2020). Yoon and colleagues expanded a basic RSA model to account for the competing speaker goals involved in polite speech; specifically, the sort of speech behavior engaged in when true utterances may be unkind, and kind utterances may be under- or non-informative. They identify the goals of being informative, being kind, and presenting oneself as caring about both of these goals (though it may be impossible to satisfy both in a given situation), and show how a speaker determines which form to use by reasoning over three levels of hypothetical interlocutors, two listeners and one speaker. Figure 1 diagrams their speaker's reasoning process.

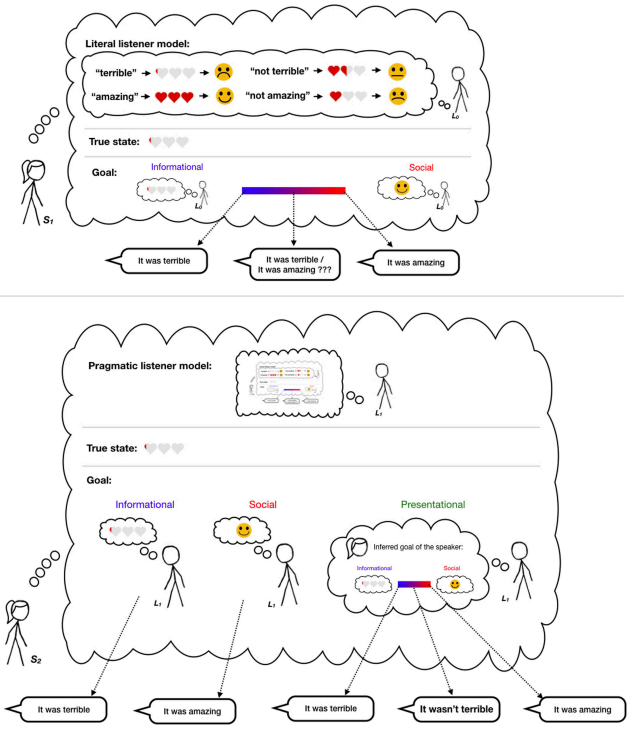

Figure 1: A speaker S_2 reasons about a listener L_1 reasoning about a speaker S_1 who reasons about a literal listener, L_0. From Yoon et al. (2020).

In Yoon et al.'s model, a speaker S_1 chooses an utterance based on the state of the world and their relative weighting of the goal of being kind and the goal of being informative, the latter of which is the informativity of an utterance for the literal listener L_0. The pragmatic listener L_1 then infers a state and S_1's weighting on goals, ϕ, based on S_1's choice of utterance, the prior distribution on states, and the prior distribution on values of ϕ. Finally, the speaker S_2 chooses an utterance based on its informativity to L_1, its kindness, her actual weighting on the goals of informativity, kindness, and being seen as polite, and the ϕ she expects to be inferred by

L_1 based on her utterance, which, practically, is the amount she cares about being kind, and the amount she cares about being informative, the balance of which she wants the listener to infer correctly.

Numerical precision and persona

This model for polite speech has parallels for a model of (im)precise speech based on competing goals. Beltrama & Schwarz (under review) used cartoon characters and dialogue about cost, distance, and time with varying degrees of numerical precision to investigate the effect of being a Nerdy person or a Chill person on expectations of precision. An example trial from their experiment is shown in Figure 2.

Figure 2: Rachel and Arthur discuss the price of a car rental. From Beltrama & Schwarz (under review).

Participants were shown a dialogue between two speakers, either Rachel and Arthur or Eva and Alex, who were stereotypically visually Nerdy or Chill, respectively. The phone screen showed numbers that matched what the second speaker said (as here, $200.09), was a near near match (in this scenario, $191.09), was a near match ($182.09), or did not come close to matching what the speaker said ($500.09). The participants' task was to decide whether the character uttering the number expression was looking at the phone with the visible screen, or the one that was turned over; participants would choose the visible screen if they believed that the character could have been looking at that screen when they said what they said. A larger proportion of choices of the covered screen in the near match and near near match conditions would suggest that participants had higher expectations of precision for a given speaker.

What they found was that the Nerdy persona elicited a significantly higher proportion of covered screen choices than the Chill persona, which pointed toward an interpretation of numerical utterances by a Nerdy person as covering a smaller range of possible interpretations.[1]

Model

The model developed herein treats this interpretation of greater and lesser precision based on persona as a result of competing goals, as in the model Yoon et al. (2020) produced for polite speech. This model, however, does not extend to a second speaker, S_2, but only to the level of interpretation of the pragmatic listener, L_1.

The basic outline of the model is as follows. A literal listener L_0 reasons about the probability distribution over soft-semantic meanings of possible numeric utterances u, along with the prior distribution over states of the world s, as in (1):

$$P_{L0}(s|u) \propto \mathcal{L}(u,s) \cdot P(s) \quad (1)$$

The basic semantic meaning of each numerical expression is expected, therefore, to be probabilistic, rather than strictly mapping a single form to a single meaning. That is, the literal interpretation of the utterance *It's $300* would not exclude interpretations near, but not matching, $300.

The pragmatic speaker S_1 then chooses an utterance u based on the state of the world and their own ϕ, their relative weighting of the desire to be informative (which is the informativeness to L_0, the amount of information L_0 would still not know about the world after hearing u; this is the same as L_0's reasoning captured in (1) above) and the cost of the expression, with cost increasing with the number of syllables in a numeric expression. This cost may in part explain the bias toward round numbers: saying *$300*, for instance is three syllables 'cheaper' than *$292*.

The claim, then, is that Nerdy speakers place more importance on being informative and care less about the cost of an utterance, while Chill speakers consider cost relatively more heavily and treat informativity as less important, than do Nerdy speakers. Out of the interaction of these two considerations and their weightings, we get different expectations on how precise a speaker would be based on the persona they present, which informs the choice of ϕ, at least in stereotypical conventions.

In (2), we see the reasoning of S_1 using these two goals, informativity and establishing social closeness, and their relative weighting due to the constant ϕ.

$$P_{S1}(u|s,\varphi) \propto \exp\left[\alpha \cdot (\varphi \cdot lnP_{L0}(s|u) - (1-\varphi) \cdot C(u)\right] \quad (2)$$

Finally, the literal listener L_1 infers the state s of the world and the weighting on informativity vs. cost ϕ of the speaker S_1 based on the utterance chosen by S_1. The listener L_1 takes into their reasoning process the reasoning process of S_1 in the choosing of an utterance, the prior distribution over states s and the prior distribution over ϕ. The prior distribution over

[1] Note that they found this effect was amplified when the participant identified as out-group to the persona they were evaluating; that is, when a participant identified as Nerdy, the expectation on relatively less precision of Chill people was increased, and when participants identified as Chill, their expectation of relatively high precision of the Nerdy persona was intensified. However, we will not be addressing this portion of Beltrama & Schwarz' study.

ϕ is informed by cues given by the speaker as to their persona; a given persona has a specific weighting ϕ on their goals. In this way, the weight placed on informativity and cost by a speaker can lead to inferencing not only about that weighting, but also about their persona. That is, a listener does joint inference about a speaker's persona and about the semantic/pragmatic meaning of their utterances. As the data of Beltrama & Schwarz (under review) show, this inferencing about personae is critical to the interpretation of the meaning of a numeric expression. In the case of the model given here, visual information is taken to heavily disambiguate persona, and therefore the ϕ of the speaker; modelling the persona assignation process (that is, the joint inference described above, as opposed to reasoning from a pre-given persona), however, is beyond the scope of this paper. The literal listener L_1's reasoning process is given in (3).

$$P_{L1}(s, \varphi|u) \propto P_{S1}(u|s, \varphi) \cdot P(s) \cdot P(\varphi) \quad (3)$$

In the next section, we implement this model using the WebPPL probabilistic programming language[2].

Meaning resolution using persona-level information

An implementation of this model was created using WebPPL, and was used to compare the expectations on the actual cost of an item when given an utterance and a ϕ, which is equated with persona. The implementation can be found in the author's github repository.[3]

The model was given the possible states \$284, \$292, \$300, \$308, \$316, and \$788, which correspond to the variance from the \$300 utterance used in Beltrama & Schwarz (under review) in the plane ticket scenario, where the answer was *It's \$300*. The same amounts were the possible utterances, and a lower ϕ represented the Chill persona, a higher ϕ the Nerdy persona.

We can evaluate the behavior of the model in the situation given by Beltrama & Schwarz, that is, when the utterance is *\$300* and the participant is asked to determine whether the speaker could have meant \$292 or \$284 by this utterance. Figure 3 shows the model output for the Chill persona, and Figure 4 for the Nerdy persona.

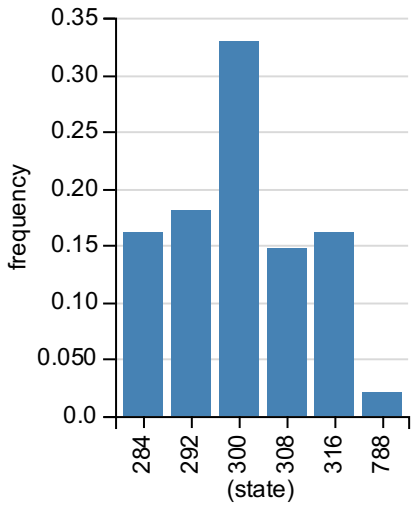

Figure 3: Posterior distribution on states given the utterance *\$300* and the ϕ consistent with a Chill persona.

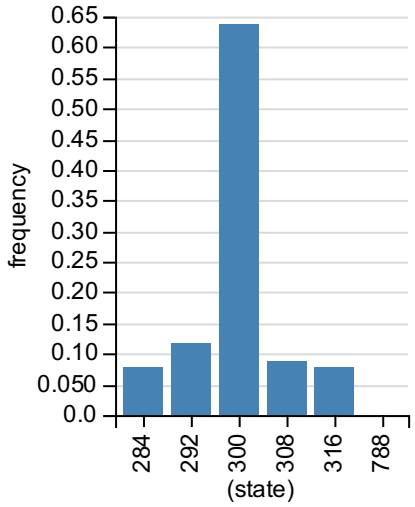

Figure 4: Posterior distribution on states given the utterance *\$300* and the ϕ consistent with a Nerdy persona.

What these outputs show is that the model would predict that a speaker who places higher emphasis on informativity (the Nerdy speaker) will have a higher expectation placed on them to be communicating the actual price as \$300, whereas a person less concerned with informativity (the Chill speaker) will be seen as less likely to be communicating \$300 than the Nerdy speaker, and more likely to be communicating a different amount within a certain range.

Discussion and Future Directions

The model, then, correctly predicts the effect shown by Beltrama & Schwarz in a broad manner. However, what is not captured by the model in its current state is the lower likelihood for all speakers to refer to the amounts \$284 and

[2] http://webppl.org/

[3] https://github.com/avelasqz/persona_effects_on_precision.git

$316 than to the amounts $292 and $308 with the utterance *$300*. At the moment there appears to be no difference in expectations of the former pair and the latter, which is not consistent with the data collected in the experiments of Beltrama & Schwarz or in a later replication conducted by the author.

In considering the basic structure of the model, an expansion or further detailing seems available based on the differing social goals of Nerds and Chills. Where above the competing pressures were proposed to be informativity and cost, it is reasonable to suppose that there may be differences in a social utility, such as kindness in Yoon et al.'s (2020) politeness model, between Nerds and Chills that, like the two pressures proposed here, also impact inferencing and speech behavior. The pragmatic speaker S_1 would then choose an utterance *u* based on the desire to be informative, the cost of the utterance, and the desire to reach some social goal. A good candidate for this social goal is that of interpersonal closeness, or the signaling of informal setting.

Informality/decreased social distance has been shown to be an important social meaning, associated with features of speech such as 'g dropping' (*walkin' and talkin'* rather than *walking and talking*) in English (Campbell-Kibler, 2011; Kiesling 1998; see analysis of these and other work in Velasquez, unpublished MS), and I suggest that it is this social goal which competes with the goal of informativity in pragmatic reasoning around using (im)precise numeric expressions.

The suggestion here is that Nerdy and Chill people are not less precise with their expressions only because of a production or cognitive cost; rather, by using an imprecise number to communicate information about time, cost, or distance, they are attempting to signal informality and social closeness, rejecting the sort of formal or clinical connotations of giving an exact number. This fits with the persona of the Chill person: they are expected to give more weight to the goal of establishing informality (perhaps even in formal situations) than to the goal of communicating precisely, with the important caveat that they are not likely to be so imprecise as to prevent understanding. The Nerd, on the other hand, is (at least stereotypically) expected to give more weight to the goal of communicating precise information than to the goal of establishing informality; this is what is partly responsible, perhaps, for the characterization of Nerds as disregarding social norms in order to be more precise.

Finally, it would be of interest not only to extend the model to an S_2, but also to extend the experimental paradigm to try to capture speaker behavior, rather than that of a listener, in situations of numerical (im)precision.

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