Joint Inference in Pragmatic Reasoning: Evaluating Probabilistic Models of Embedded Implicatures

The question whether and when pragmatic enrichments, like scalar implicatures, can occur in non-matrix position is crucial for understanding pragmatic inferences and processing in general. Many recent theoretical and experimental contributions have tried to shed more light on the issue, taking inspiration in particular from what is often called a *syntactic approach* to (scalar) implicature, according to which the available pragmatic enrichments of a sentence are generated by the presence or absence of silent exhaustivity operators in the syntax-driven computation of the sentence's meaning (e.g. Chierchia, 2004; Chierchia et al., 2012). Most of the recent debate has focused on the **existence problem**, i.e., whether "local enrichments" of scalar items in embedded position exists. For example, does the sentence in (1) have a (non-negligible, unmarked, ...) reading to the extent that exactly one of the students read some but not all of the papers?

(1) Exactly one of the students read some of the papers.

(2) All of the students read some of the papers.

Here, we would actually like to address a more fine-grained question, an answer to which may also entail an answer to the previous issue. We may call it the **disambiguation problem** (c.f. Chemla and Singh, 2014): any theory of implicature-like meaning enrichments should ideally specify, for any sentence and context pair, which candidate readings are preferred, and to what extent even dispreferred readings may be selected.

With this goal in mind, we turn to probabilistic computational pragmatics, which is a rather novel approach to bridging classical formal pragmatic theory and the demands of empirical data analysis (see Franke and Jäger, 2015, for overview). In particular, we pick up the approach of Potts et al. (2015) who apply the probabilistic joint-inference model of Bergen et al. (2012, 2014) to cases like in (1) or (2). The general idea of a joint-inference model is that listeners jointly or holistically infer several parameters of interest. For example, Potts et al. (2015) model the possibility of "local enrichments" for sentences like in (1) or (2) by assuming that listeners draw inferences not only about the most likely world state depicted by an utterance of (1) or (2), but also about the speaker's lexical entry for *some*. This makes it possible to (i) account for "local enrichments" as the outcome of a global pragmatic inference and to (ii) predict the probability with which these "local readings" should be expected.

The model assumed by Potts et al. (2015) is not the only plausible joint-inference approach to the disambiguation problem. In fact, it is possible to accommodate the syntax-driven grammaticalist approach to embedded implicatures (e.g. Chierchia, 2004; Chierchia et al., 2012) in a probabilistic joint-inference model as well. In that case, listeners would reason about the likely world state that triggered an utterance (as before), but also make joint inferences about the likely syntactic parse (replacing the joint inference about the speaker's lexicon in Potts et al.'s approach).

Yet another possibility is that the listener performs joint inference over the state of the world and the speaker's QUD/communicative goals. We have implemented a prototype of this approach, and have shown that it can be used to derive the embedded implicature associated with (2). In this model, the speaker has a QUD, which

determines the aspects of the world that they want to communicate information about. Crucially, the speaker may want to communicate propositions which are strictly logically weaker than their knowledge state. For example, consider a speaker who knows that all of the students read some but not all of the papers. Such a speaker may have the goal of communicating that all of the students read (at least) some of the papers, as this proposition is entailed by their knowledge state. Given this goal, it is rational for the speaker to say sentence (2), as this sentence will fully communicate the answer to their QUD. The listener, in turn, has uncertainty both about the speaker's knowledge state and about the speaker's QUD. After hearing an utterance, the listener performs inference both over the speaker's knowledge state, and over the aspects of this knowledge state that the speaker was trying to communicate. If the listener hears sentence (2), there are two possible explanations for this. First, it may be that the speaker knows that all of the students read some (and possibly all) of the papers, and wants to communicate this. Second, it may be possible that the speaker knows that all of the students read some but not all of the papers, and wants to communicate that all of the students read (at least) some of them. Thus, depending on the context, sentence (2) may indicate that the speaker knows that all of the students read some but not all of the papers.

What this means is that we have at least three conceptually motivated instances of joint-inference models as answers to the disambiguation problem: lexical enrichment, syntax-driven exhaustification, QUD/goal-based. It is clear that these make qualitatively and quantitatively different predictions in certain cases. At the present (early) stage of our project, we will present the results of a formal (simulation-based) exploration of these prediction differences and hope to receive feedback on our ideas about experimental approaches to testing alternative models empirically.

References

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