The Interactive Best Response Paradigm: Taking into account the production of sentences with scalar terms

Introduction. Theories of implicature make different predictions concerning the inferences arising from sentences with multiple scalar items. For example, a sentence like (A-E) *Each girl found some of her marbles* potentially gives rise to the inference that each girl found some but not all implicatures. In Gotzner & Benz (in revision), we have developed a scenario in which participants' interpretation can be inferred from action choices. We compared four theories[1] with respect to their prediction about implicatures of (A-E) and (E-E) *Some of the girls found some of their marbles* and it turned out that the IBR model of Franke (2009) fit best to the data. Whereas for the A-E sentence almost all participants arrived at the strong interpretation, there was a notable gap between the expected and observed interpretation for the E-E sentence: contrary to all theories, not all participants were consistent with the E-E implicature *not all found some of their marbles* (¬A-E).

In this talk, we present a formal model that sheds light on the reasons for this gap: It considers three cognitive principles that allow the elimination of linguistic material: (ENA-Elim) the simplification of *some but not all* to *some*, (N-X-Elim) the elimination of *none found X* and (X-N-Elim) the elimination of *X found none* from utterances. As can be shown, the derivation of implicature (¬A-E) from an utterance of E-E involves the (X-N-Elim) rule. We concluded that difficulties with inferring the application of this rule were the reason why some subjects did not arrive at the (¬A-E) implicature. We therefore got interested in the utterance strategy based on the (ENA-Elim) and (N-X-Elim) rules alone.In contrast to other theories, the model predicts utterances of differential length for different possible worlds. Here, we present an experiment that tests the efficiency of this strategy for all seven worlds that can be distinguished by A-E type sentences. Specifically, we tested whether the strategy is successful, and how it compares to strategies pursued by test subjects, in particular whether subjects produce shorter utterances, and if so, whether they are still successful. The experiments indicate that the critical strategy based on the new model is among the shortest with almost maximal communicative success.

In order to test these predictions, we have developed an interactive version of the previous best response paradigm by Gotzner & Benz (in revision). In particular, we programmed a system that allowed us to run a combined production and interpretation experiment in the lab.

Interactive Best Response Paradigm. *Methods*: Participants in our experiment were presented with a scenario involving six girls who each own a set of four special edition marbles (based on Degen and Goodman, 2014). While the girls are playing the marbles get lost and they have to find them again. During the experiment, participants took two different roles. (1) The speaker had to describe a picture representing how many marbles each girl found. (2) The hearer received a message from the speaker and had to buy sweets to reward the girls. The speaker was allowed to produce up to five sentences by typing in one the following words into a sentence frame: *all, some, none, some but not all, some and possibly all* and *any* (in German).

Subsequently, the hearer received the sentences the speaker produced and had to choose the appropriate sweets as rewards. The reward system was defined such that a girls gets...

[1] (Chierchia, 2004; Sauerland, 2004; Franke, 2009; Benz, 2012)

- chocolate if she finds all 4 of her marbles
- candy if she finds fewer than 4 of her marbles
- a gummy bear when she finds none of her 4 marbles (as a consolation prize).

Seven possible worlds were represented by six items in total. The system randomly paired two participants for a given production-interpretation trial and each participant took a certain role three times. In total, 38 native German participants (mean age: 29.3, 21 female, 17 male) took part in the experiment. Participants took the experiment in groups of varying sizes: there were groups with 4 players (2), with 2 players (5), and groups with 3 players in addition to the experimenter (6), who played a strategy based on the new version of Error models.

Results: We analysed participants' success rate (expected utility) as a function of whether the hearer selected the appropriate sweets depending on the picture the speaker saw. Overall, the success rate was quite high (89.7 %), showing that participants understood the task. We, then evaluated how successful different production strategies were, also taking into account utterance length. A t-test showed that the critical strategy (red in Figure 1) was significantly better than the average participant strategy (orange) and it was also significantly shorter in terms of sentence length (p-values <.001). Interestingly, when participants produced exact descriptions such as *Each girl found some but not all of her marbles* the communicative success was not better compared to utterances where the short form was used.

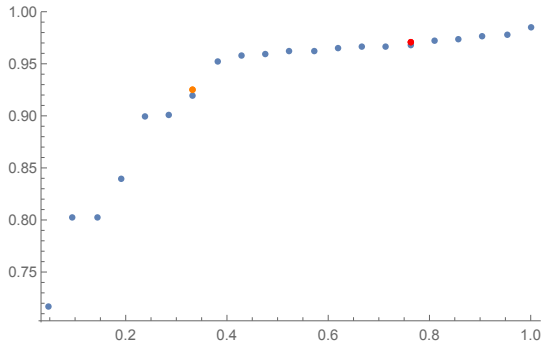

Figure 1: Success rate/expected utility of different strategies (orange: average) and critical strategy (red).

Conclusions. We have introduced a new experimental paradigm which takes into account that typically speakers and hearers jointly communicate about a given state of the world and that implicatures arise in interactive contexts. Further, we have developed a game-theoretic model for the experimental data which successfully predicts the optimal utterances with greatest communicative success and shortest length. In our talk, we will also evaluate other interactional models (especially IBR and RSA) with respect to the data.

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