Exclusive disjunction

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Abstract

If someone says ‘Donald ate a pretzel or a donut’ the hearer may infer that Donald did not eat both a pretzel and a donut. This exclusive reading of ‘or’ is often explained as a scalar implicature. We tested this explanation by investigating how the robustness of the exclusive reading of ‘or’ is influenced by three contextual factors: relevance, competence, and prior probability. We found that only prior probability has a significant effect on the robustness of the exclusive reading, thus disconfirming the scalar implicature account. Instead, we propose that the exclusive reading of ‘or’ is a probabilistic inference based on world knowledge.

1 Introduction

Introductions to logic usually distinguish between two readings of ‘or’: an inclusive and an exclusive reading (e.g., McCawley, 1981; Copi & Cohen, 2005). The inclusive reading corresponds to the meaning of logical disjunction. According to this reading, ‘*A* or *B*’ is true if at least one and possibly both of *A* and *B* are true. The exclusive reading is more strict in that it excludes the possibility that both *A* and *B* are true. So on its exclusive reading, ‘*A* or *B*’ is true if exactly one of *A* and *B* is true. To illustrate, consider:

(1) Joe supports Donald or Hillary.

On its inclusive reading, this sentence is true whenever Joe supports Donald, Hillary, or both. The exclusive reading, which is arguably more prominent in this example, excludes the latter possibility. That is, on its exclusive reading, (1) is true whenever Joe supports Donald or Hillary, but not both.

The presence of these two readings might suggest that ‘or’ must be associated with two distinct lexical entries (e.g., Basson & O’Connor, 1960; Baum, 1996;

Rescher, 1964). There are, however, good reasons to reject such a lexicalist approach. Perhaps the most compelling reason is that, in some contexts, ‘or’ can only receive one interpretation. To illustrate, consider the following sentence, in which ‘or’ occurs in the scope of negation:

(2) Joe does not support Donald or Hillary.

This sentence only has one interpretation, namely that Joe supports neither Donald nor Hillary (cf. Crain, 2008). This interpretation corresponds to the inclusive reading of ‘or’. It does not have an interpretation corresponding to the exclusive reading; in other words, it does not have a reading according to which Joe either supports both Donald and Hillary, or neither of them. Since ‘or’ is systematically monosemous in certain contexts—negation being one of them—it follows that the two readings of ‘or’ cannot simply be due to a lexical ambiguity.

An attractive alternative to the lexicalist approach stems from Grice’s (1975) theory of conversational implicature. According to Grice, natural conversation is governed by the assumption that speakers are cooperative; that is, they attempt to further the purpose of conversation by means of their utterances. Speakers are cooperative by adhering to four maxims that enjoin their utterances to be truthful, informative, relevant, and clear. Sometimes hearers have to make ancillary assumptions in order to align a speaker’s utterance with the assumption of cooperativity. Such ancillary assumptions are called *conversational implicatures*. An example, from Grice’s own work, is given in the following conversation:

(3) A: I am out of petrol.
B: There is a garage around the corner.

B’s utterance would be irrelevant, and hence uncooperative, if he knew that the garage was closed or did not sell petrol. Since A assumes that her interlocutor is cooperative, she thus concludes that the garage is open and sells petrol.

Horn (1972) was the first to argue that the exclusive reading of ‘or’ can be explained as a conversational implicature, too, based on the assumption that the primary meaning of ‘or’ is inclusive. To illustrate, consider (1) again. Assuming that the primary meaning of ‘or’ is inclusive, the speaker of (1) could have been more informative, and hence cooperative, by saying ‘Joe supports Donald and Hillary.’ Why didn’t she? Presumably because she does not believe that this alternative is true. This is a weak inference that is compatible with a situation in which the speaker is unsure about whether or not Joe supports both Donald and Hillary. This weak inference can be strengthened if there is reason to believe that the speaker knows whether or not Joe supports both Donald and Hillary. This assumption is often called the *competence assumption*. If the competence assumption is sufficiently plausible, it follows that, according to the speaker, Joe does not support both Donald and Hillary.

This specific kind of conversational implicature is often called a *scalar implicature* because it is assumed that 'or' forms a lexical scale with 'and', and that alternatives are generated by substituting the scalemates 'or' and 'and'. Other lexical scales are ⟨some, all⟩, ⟨warm, hot⟩, and ⟨intelligent, brilliant⟩ (cf. e.g., van Tiel, van Miltenburg, Zevakhina, & Geurts, 2016).

The pragmatic proposal straightforwardly explains the absence of exclusive readings under negation. Consider (2) again. Here, unlike in the case of (1), the alternative with 'and' is less informative than the utterance itself. After all, (2) is only compatible with a situation in which Joe supports neither Donald nor Hillary, whereas the sentence with 'and' is also consistent with situations in which Joe supports exactly one of Donald and Hillary. So the speaker was already maximally informative and therefore no implicature is derived.

Although the pragmatic account has since become the standard in the literature (e.g., Chevallier, Noveck, Nazir, Bott, Lanzetti, & Sperber, 2008; Gazdar, 1979; Sauerland, 2004; Geurts, 2010), it is not without its problems, as we will see in the next section. Therefore, we set out to experimentally test the adequacy of the pragmatic account. To that end, we tested the effect of three factors on the robustness of exclusive readings: (i) the *relevance* of the sentence with 'and' to the hearer, (ii) the *competence* of the speaker about the truth of the sentence with 'and', and (iii) the *prior probability* that the sentence with 'and' is true. These factors are usually taken to influence the robustness of scalar implicatures. Hence, if the pragmatic account is correct, we expect these factors to influence the robustness of the exclusive reading of 'or', too.

For comparison, we also investigated how relevance, competence, and prior probability influence the robustness of a bona fide scalar implicature, namely the inference from 'some' to 'not all'. To illustrate, consider:

(4) Some of my friends support Donald.

An utterance of this sentence may convey that not all of the speaker's friends support Donald. The derivation of this upper-bounding construal runs analogous to that of the exclusive reading of 'or': the speaker could have been more informative by saying 'All of my friends support Donald'. Why didn't she? Presumably because she does not believe that this alternative is true. If, moreover, the speaker knows whether or not all of her friends support Donald, it follows that she believes not all of her friends support Donald.

As we will see, it turns out that there are marked differences in how relevance, competence, and prior probability influence the robustness of the exclusive reading of ‘or’ compared to how they influence the robustness of the inference from ‘some’ to ‘not all’. These findings will force us to reconsider the pragmatic account of the exclusive reading of ‘or’.

In the next section, we explain our three factors of interest in more detail. Afterwards, we outline the details of our experiments and discuss the results.

2 Relevance, competence, and prior probability

Almost all theorists agree that the robustness of scalar implicatures is modulated by various extralinguistic factors. The only exceptions are so-called *defaultist* accounts, which assume that the process of deriving scalar inferences is completely blind to extralinguistic factors (e.g., Chierchia, 2004; Levinson, 2000; Storto & Tanenhaus, 2005). According to these accounts, scalar expressions such as ‘or’ are always interpreted as ‘or but not and’, even though this exclusive reading can be cancelled afterwards.

There is, however, an extensive body of experimental work that disproves the predictions made by defaultist accounts (e.g., Bott & Noveck, 2004; Breheny, Katsos, & Williams, 2006; Huang & Snedeker, 2011). Hence, we will not consider such accounts in what follows. However, we return to the possibility of salvaging certain corollaries of defaultist accounts in the discussion section.

Relevance

Aside from the defaultist accounts, almost all current theories assign some importance to relevance in the derivation of scalar inferences (e.g., Geurts, 2010; Magri, 2011). To illustrate, we consider *relevance theory* (Sperber & Wilson, 1995). According to relevance theory, the relevance of an inference is determined by two factors: (i) the positive cognitive effects it has on the hearer—i.e., to what extent it makes “a worthwhile difference to the individual’s representation of the world” (Wilson & Sperber, 2002, p. 251)—and (ii) the effort needed to process that inference. In what follows, we focus on the first factor, assuming that processing effort remains invariant across the scenarios that we tested (cf. Chevallier et al. 2008 for a series of experiments on ‘or’ that manipulate processing effort).

According to relevance theory, communication is aimed at maximising relevance, so that hearers only derive inferences whose positive cognitive effects outweigh their processing cost. Hence, relevance theory predicts that the robustness of a scalar implicature is an increasing function of its importance to the hearer. To illustrate, consider:

(5) Donald won the primaries in Nebraska or Indiana.

According to relevance theory, the robustness of the exclusive reading of this sentence depends on how important it is to the hearer whether Donald won the primaries in both Nebraska and Indiana. Suppose, for example, that the hearer made a large bet that Donald would not win both primaries. In that case, she would be more likely to arrive at an exclusive reading than if, for example, she made a large bet that Donald would win at least one of the primaries.

Hence, if relevance theory is correct, we expect the robustness of the inference from ‘some’ to ‘not all’ to be positively affected by the relevance of the upper-bounded reading to the hearer. If, in addition, the pragmatic account is correct, we expect the same effect on the exclusive reading of ‘or’.

As noted before, most other theories follow relevance theory in assigning an important role to relevance in the derivation of scalar inferences.

Competence

In the previous section, we have seen that competence plays an important role in the derivation of scalar implicatures. Initially, pragmatic reasoning yields a weak inference according to which the speaker does not believe that the more informative alternative is true. This weak inference can be strengthened if the competence assumption holds; that is, if it is assumed that the speaker knows whether or not the more informative statement is true. If so, it follows that, according to the speaker, the more informative statement is false.

Although the workings of the competence assumption tend to be unproblematic for most scalar expressions, they are rather precarious in the case of ‘or’. Indeed, the need to invoke competence to arrive at an exclusive reading of ‘or’ gives rise to what Zondervan (2010) calls the *speaker expertise paradox* (cf. Geurts, 2006). To explain this paradox, consider (1) once again:

(6) Joe supports Donald or Hillary.

We have already seen that someone who utters this sentence implies that Joe does not support both Donald and Hillary. Presumably, however, she also implies that she does not know whether Joe supports Donald and that she does not know whether Joe supports Hillary. After all, if the speaker knows that Joe supports Donald, she should have said ‘Joe supports Donald’, and mutatis mutandis if she knows that Joe supports Hillary. However, in order to arrive at the exclusive reading through pragmatic reasoning, it has to be assumed that the speaker knows whether Joe supports both Donald and Hillary.

More abstractly, in order to derive the exclusive reading of a disjunction ‘*A* or *B*’, it has to be assumed that the speaker is ignorant about the truth of *A* and *B* individually, but knowledgeable about the truth of ‘*A* and *B*’. Such an epistemic state is possible but intuitively improbable, which contradicts the observation that exclusive interpretations are far from uncommon.

In order to arrive at a more decisive verdict, however, we tested the effect of competence on the robustness of the exclusive reading of ‘or’ and the upper-bounded construal of ‘some’. Previous experimental research has shown that the robustness of the upper-bounded reading of ‘some’ increases with the competence of the speaker (Goodman & Stuhlmüller, 2013). We expect to replicate this effect in our study. If, moreover, the exclusive reading is due to a scalar implicature, we expect a similar effect in the case of ‘or’.

[mf: maybe add something like this to this section: “Contextual assumptions about speaker competence are also hypothesized to influence the strength of exclusive readings in recent grammaticalist accounts of scalar implicature (e.g. Fox, 2007, 2014).”]

Prior probability

Prior probabilities do not feature in any of the traditional theories of scalar implicature, and have even been explicitly rejected as playing any role in their derivation (Geurts, 2010). However, more recent probabilistic approaches assign an important role to prior probabilities (e.g., Russell, 2012; Frank & Goodman, 2012; Franke & Jäger, 2016). According to at least some these accounts, the robustness of a scalar implicature is an increasing function of the prior probability that it is true. To illustrate, consider the following sentence once again:

(7) Donald won the primaries in Nebraska or Indiana.

Probabilistic theories predict that, if it is deemed extremely unlikely that Donald wins the primaries in both states, someone who hears an utterance of (7) will be more likely to arrive at an exclusive reading of ‘or’, compared to when the hearer is expecting Donald to win both primaries.

Interestingly, a number of theorists have argued that the robustness of exclusive readings is exhaustively determined by prior probabilities (e.g., Rubin & Young, 1989; Yanal, 1988). These authors hold that ‘or’ is monosemous and always interpreted inclusively. The appearance of an exclusive reading is caused by probabilistic reasoning about possible states of the world. An especially clear example that illustrates this point is:

(8) Joe voted for Donald or Hillary.

Here, it seems that the speaker’s utterance rules out the possibility that Joe voted for both Donald and Hillary. According to the aforementioned monosemists, this inference is not due to an exclusive reading of ‘or’ but rather to an inclusive reading along with the commonsense information that one can only vote once in a democratic election. In this way, then, world knowledge is responsible for seemingly exclusive interpretations of ‘or’. Importantly, this position is distinct from the pragmatic proposal because it holds that the derivation of exclusive readings does not involve any reasoning about the intentions of the speaker.

Previous experimental research has confirmed that the robustness of the upper-bounded reading of ‘some’ is positively affected by the prior probability that it is true (Degen, Tessler, & Goodman, 2015). We expect to replicate that result in our study. In addition, if exclusive readings are due to scalar implicatures, we expect a similar effect in the case of ‘or’.

Predictions

In summary, we have discussed three factors that have variously been taken to increase the robustness of scalar implicatures: (i) the relevance of the more informative statement to the hearer, (ii) the competence of the speaker about the truth of the more informative statement, and (iii) the prior probability that the more informative statement is false. [mf: I would probably add here something about the direction of influence as well, maybe like so: “More concretely, standard pragmatic theory would have us expect that exclusive readings should be more prominent under higher contextual relevance, higher speaker competence and lower *a priori* probability of the corresponding conjunction.”] The effects of relevance and prior probability have been disputed, but all current theories agree that competence is a crucial ingredient in the derivation of scalar implicatures.

Therefore, we will be especially interested in the results for that factor.

In the next section, we discuss two experiments in which we measured the effect of relevance, competence, and prior probability on the robustness of, on the one hand, the upper-bounded construal of ‘some’ (Exp. 1) and, on the other hand, the exclusive reading of ‘or’ (Exp. 2). We hypothesise that all three factors influence the robustness of the upper-bounded construal of ‘some’. If the pragmatic account is correct, we expect that the exclusive reading of ‘or’ patterns with the upper-bounded construal of ‘some’ in this respect.

Since Exps. 1 and 2 share the same methodology, we discuss them in tandem. However, the results will be discussed separately.

3 Experiments 1 and 2

Design

The goal of Exps. 1 and 2 was to determine the effect of relevance, competence, and prior probability on the strength of the upper-bounded construal of ‘some’ (Exp. 1) and the exclusive reading of ‘or’ (Exp. 2). To measure these three factors, we designed different stories that systematically varied along the three relevant dimensions. We used a slider-rating task to assess participants’ intuitive judgement of all four notions of interest: strength of the inference, relevance, competence, and prior probability.

Intuitive judgements for the four notions of interests were measured between-participants: each participant only answered one of the four relevant test questions for a given story. This was to prevent cross-contamination of answers, e.g., asking first about relevance might influence subsequent answers about the strength of the inference.

Participants

203 (Exp. 1) and 200 (Exp. 2) participants were drafted on Amazon’s Mechanical Turk and paid 80 US$ cent.[1] Payment was not contingent on any of their

[1] Mechanical Turk is a website where workers perform so-called ‘Human Intelligence Tasks’ (HITs) for financial compensation. It has been shown that the quality of data gathered through Mechanical Turk equals that of laboratory data (e.g., Buhrmester, Kwang & Gosling 2011, Schnoebelen & Kuperman 2010; Sprouse 2011).

responses. Only workers with an IP address from the United States and with a rate of accepted HITs of at least 90% were eligible for participation.

Materials

The materials in both Exp. 1 and 2 consisted of 16 vignettes (see Appendix A for the full material). Each story came with some background information and an utterance of a statement containing ‘some’ (Exp. 1) or ‘or’ (Exp. 2) by one of the characters in the story. For example:

> **Example story from Exp. 1**
> Lucy has to give a talk in front of a big audience of psychologists. She is going to criticize one of the dominant theories of schizophrenia. Afterwards, Jacob, who was in the audience, chatted with his neighbors.
>
> He tells Lucy: ‘Some of the people enjoyed your talk.’
>
> **Example story from Exp. 2**
> Danny and Alex reserved a squash court but Alex still has to buy a racket and a pair of shoes. Danny is talking to Alex’s girlfriend Jill who just went to the sports store with him.
>
> Jill says to Danny: ‘Alex bought a racket or a pair of shoes.’

Each story was associated with three control statements which were either certainly true, certainly false, or of uncertain truth value, given the background information. Moreover, each story was associated with four target statements gauging (i) the strength of inference, (ii) the relevance of the truth of the more informative statement for the hearer, (iii) the competence of the speaker, and (iv) the prior probability of the stronger statement. The four target statements associated with the examples above were:

> **Example target statements from Exp. 1**
>
> *Inference*: From what Jacob said we may conclude that not all of the people enjoyed Lucy’s talk.
>
> *Relevance*: It is important for Lucy to know whether all of the people enjoyed her talk.
>
> *Competence*: Jacob knows whether all of the people enjoyed Lucy’s talk.
>
> *Prior*: All of the people enjoyed Lucy’s talk.

Example target statements from Exp. 2

Inference: From what Alex's girlfriend said we may conclude that Alex did not buy both a racket and a pair of shoes.

Relevance: It is important for Danny to know whether Alex bought both a racket and a pair of shoes.

Competence: Alex's girlfriend knows whether he bought both a racket and a pair of shoes.

Prior: If Alex bought a racket, it is likely that he also bought a pair of shoes. / If Alex bought a pair of shoes, it is likely that he also bought a racket.

Statements *Inference*, *Relevance*, *Competence* (Exps. 1 and 2), and *Prior* (Exp. 1) were single statements. Statements *Prior* (Exp. 2) were pairs of symmetric conditional statements, where each targeted the intuitive probability that, given one disjunct, the other would be true as well. We reasoned that this makes for more natural statements and that it may give us more reliable measures than having participants rate a single statement containing 'and'.[2]

The stories were created to ensure sufficient variability across the three dimensions of interest (i.e., relevance, competence, and prior probability). We classified each story according to whether we felt it to be high or low on each dimension, thus making for eight types of stories. In both experiments, we had two vignettes for each type. For example, we expected the example story from Exp. 1 to score high on relevance, but low on competence and prior probability, and the example story from Exp. 2 to score high on all three dimensions. A full list of the 32 stories, together with our intuitive type-classification, can be found in Appendix A. [mf: insert appendices with materials]

[2] In order to ascertain that nothing hinges on this decision, we conducted a follow-up experiment in which we paid 70 participants on Amazon's Mechanical Turk 50 US$ cent to judge the stories from Exp. 2 followed by a control statement and the following target statement:

(i) It is likely that Alex bought both a racket and a pair of shoes.

Each participant saw six randomly sampled stories, which were presented without the statement containing 'or', just as in Exp. 2.

We excluded one participant for not identifying as a native speaker of English and another one for bad performance on the control questions, using the same criterion as for Exp. 2. Per-vignette means of the given ratings for both types of statements gauging prior probability were highly correlated ($r \approx 0.89, p < 0.0001$). For all of the analyses reported in the main text, nothing of substance changes if we include the ratings for (i) instead.

Procedure

The experiment started with instructions:

> In the following, you will be presented with 8 short background stories. Please read them very carefully. We ask you to rate 2 or 3 statements for each background story. Please indicate, using an adjustable slider, how likely you think a statement is true based on the background story.

Next, we presented a simple background story which was not used in the main experiment, followed by three annotated examples to illustrate the use of the slider bar. One example was clearly true, another clearly false, and the last uncertain.

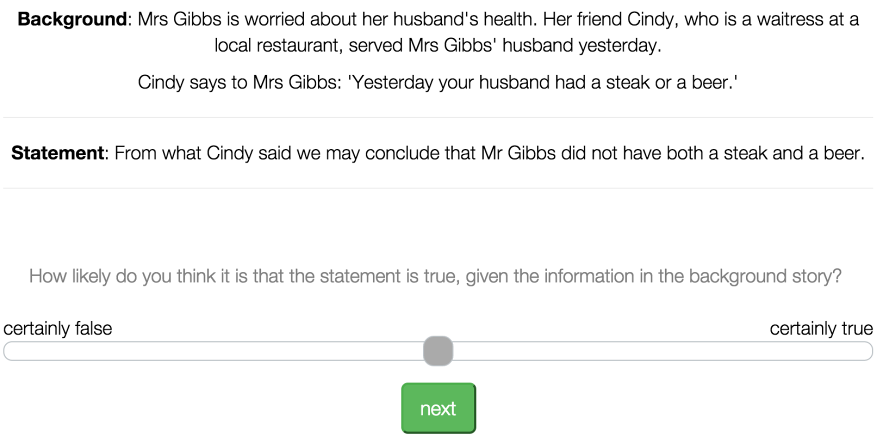
In the main part of the experiment, every participant saw eight randomly sampled stories, one of each story type, in random order. Each story was followed first by one random control statement and then the statement(s) associated with one of the four factors of interest (inference strength, relevance, competence, or prior probability). Each participant rated each of the four statement types exactly twice, but never in direct succession. When the prior statements were presented, only the background story was provided, but not the statement with 'or', so as to make sure that answers are based on expectations about worldly events alone, unmodulated by information based on pragmatic inferences from utterances. All other question types had the background story and the disjunctive statement with 'or' appear on the screen. The two prior statements in Exp. 2 were presented individually, one after the other, in random order.

Ratings of statements were elicited by asking "How likely do you think it is that the statement is true, given the information in the background story?" together with a continuous slider ranging from "certainly false" to "certainly true." An example of a trial from Exp. 2 is given in Figure 1.

3.1 Data preparation

We coded the slider-ratings as real numbers ranging from 0 ("certainly false") to 1 ("certainly true"). Ratings for the two conditional statements in the prior condition of Exp. 2 were averaged.

Seven participants were excluded from the analysis because they were not self-reported native speakers of English. We also removed another eleven participants for obviously deviant answers (e.g., blindly alternating between maximal



Background: Mrs Gibbs is worried about her husband's health. Her friend Cindy, who is a waitress at a local restaurant, served Mrs Gibbs' husband yesterday.

Cindy says to Mrs Gibbs: 'Yesterday your husband had a steak or a beer.'

Statement: From what Cindy said we may conclude that Mr Gibbs did not have both a steak and a beer.

How likely do you think it is that the statement is true, given the information in the background story?

Figure 1: Example of a trial [mf: insert pic with example from main text]

agreement and maximal disagreement).[3] Consequently, data from a total of 193 (Exp. 1) and 192 (Exp. 2) participants made it into our analysis. Unfortunately, there was a mistake in the formulation of two stories, one for each experiment. We removed all data for these stories for the analysis. (See Appendix A.)

In what follows, we discuss the results of Exps. 1 and 2 in turn, starting with Exp. 1, which tested the upper-bounded construal of 'some'.

Experiment 1: Results

Controls. Ratings for control statements are unsurprising. Means, averaged over all vignettes, for ratings of false (0.22), uncertain (0.39) and true statements (0.80) are pairwise different (two-population directed t-test: $t \approx -3.83, p < 0.001$ for false vs. uncertain; $t \approx -9.98, p < 0.001$ for uncertain vs. true).

Explanatory factors. Statements that targeted relevance, competence and prior probability were rated in accordance with our intuitive classification (see Figure 2, all high/low constrasts are significantly different).

[3] The formal criterion for exclusion was having a *deviance score* greater than a fixed threshold, where the deviance score of a participant is the sum of the absolute differences between the expected answers for all control questions (0, 0.5, or 1) and the subjects' answers. We set the threshold of exclusion to the mean plus twice the standard deviation. This exclusion criterion was also used in all other experiments.

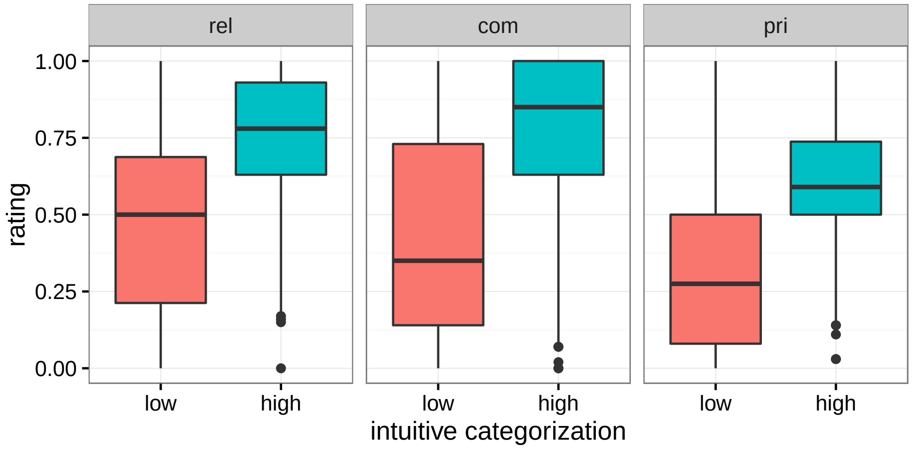


Figure 2: Ratings of statements according to intuitive pre-classification in Experiment 1

Figure 3 shows the relation of per-vignette mean implicature ratings and per-vignette mean ratings for the three explanatory factors. From visual inspection, it seems that REL and COM are unlikely good predictors of implicature strength, while low values of PRI seem to be correlated with high implicature ratings, as expected.

Main analysis. We want to explain ratings of the *Inference*-statement in terms of explanatory factors REL, PRI, and COM, which are the respective means of ratings of the corresponding statements for each vignette. Figure 4 gives the Bayes factors of regression models with our three explanatory variables as main factors. The best model only contains factor PRI and is made roughly six times more likely by the data than the two runner-ups which contain additionally REL or COM. Clearly, the data provides very strong evidence in favor of all models that include PRI, relative to those which do not.

Controls in Exp. 2. Control statements were rated as expected, indicating that participants understood the task in general and paid attention to the background stories. Means, averaged over all vignettes, for ratings of false (0.26), uncertain (0.48) and true statements (0.81) are pairwise different (two-population directed t-test: $t \approx -3.72, p < 0.001$ for false vs. uncertain; $t \approx -6.93, p < 0.001$ for uncertain vs. true).

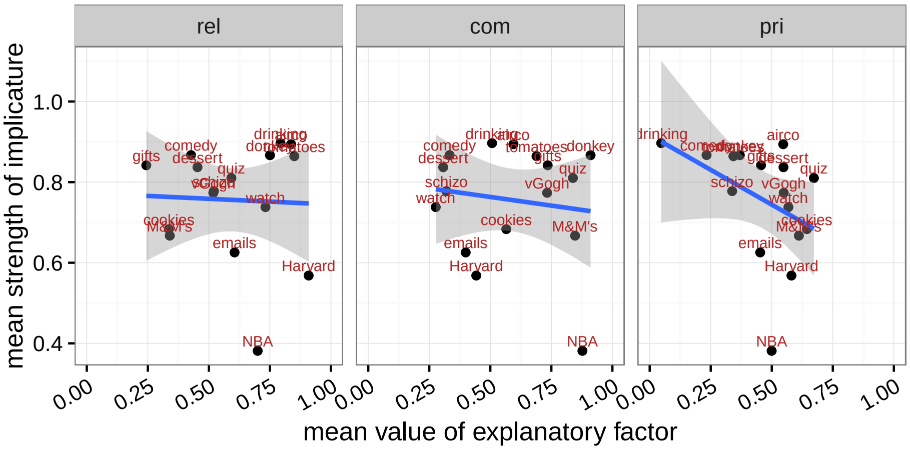


Figure 3: Per-vignette means of ratings of relevance, competence and prior statements vs. per-vignette means of implicature rating in Experiment 3

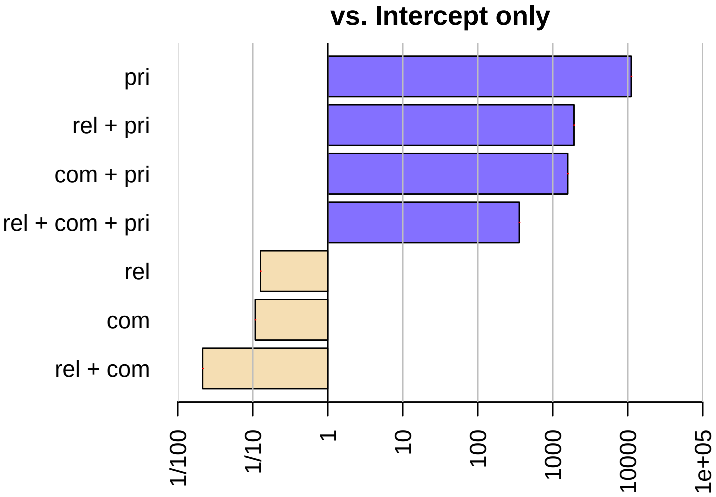


Figure 4: Bayes factor comparison of different main factor combinations, predicting the strength of scalar enrichment of *some* in Experiment 1.

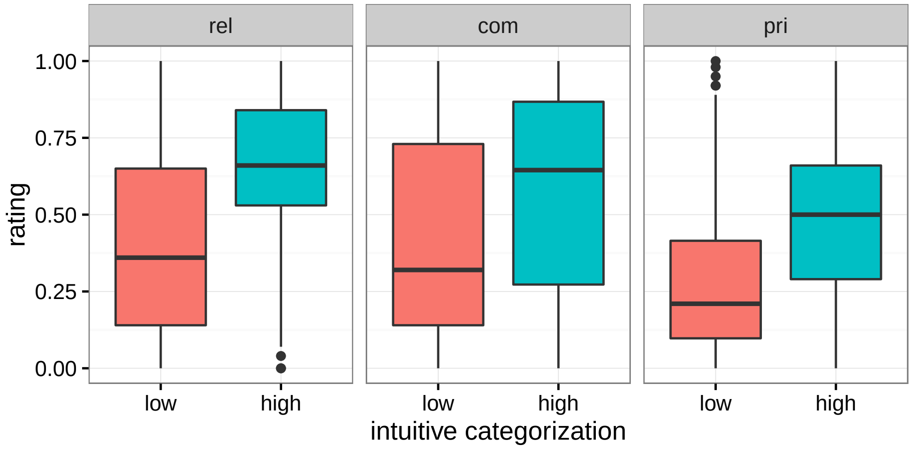


Figure 5: Ratings of statements according to intuitive pre-classification in Experiment 1

Explanatory factors. Ratings of relevant explanatory factors are not uniformly distributed across vignettes, but validate our intuitive pre-classification (see Figure 5, all high/low contrasts are significant).

Figure 6 shows the relation of per-vignette mean implicature ratings and per-vignette mean ratings for the three explanatory factors. From visual inspection, it seems that relevance and competence are not good predictors of implicature strength, while low prior plausibility seems to be correlated with high implicature ratings, as expected.

Main analysis. To check whether factors "relevance," "prior" and "competence" have an influence on the strength of exclusive readings, we compare regression models of different complexity. The dependent variable are ratings of the *Xor*-statement. Explanatory factors REL, COM, and PRI are, respectively, the means of the ratings, for each vignette, of the *Relevance*, *Competence* and *Prior* statements. We take a Bayesian approach to comparing regression models in terms of their Bayes factors (Rouder & Morey, 2012), as implemented in the *BayesFactor R*-package. This gives us a more nuanced picture of the relative evidence for models of different complexity, including information about how much, e.g., the absence of a factor in a model, is supported by our data.[4]

[4] All conclusions of theoretical relevance are also supported by more traditional, frequentist regression analyses in terms of significance of factors and model comparison by AIC.

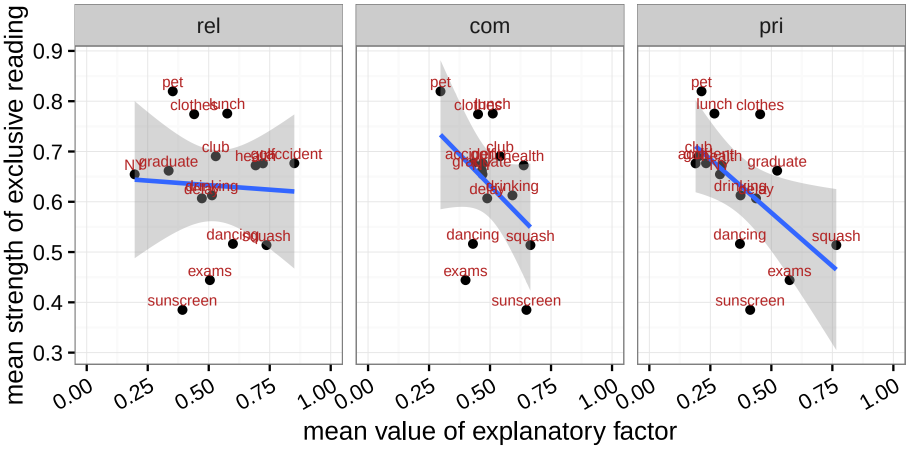


Figure 6: Per-vignette means of ratings of relevance, competence and prior statements vs. per-vignette means of implicature rating in Experiment 1

Figure 7 shows the Bayes factors of all regression models that can be built with our three explanatory variables as main factors. The graph gives the Bayes factor of each regression model, listed on the right, against the intercept-only model. A model with only REL as a main factor, for example, is roughly 8 times worse than the intercept-only model, suggesting that REL alone makes no useful contribution to harnessing the variance in *Xor*-ratings, but only makes for a more complex model. Single main factor COM does make a significant contribution, compared to the intercept-only model, but a model with single main factor PRI is more than 30 times more likely, given our data, than the model with just COM. The best model, by this standard, is a model with COM and PRI as main effects, but there is no substantial difference between this and the model with only PRI as a main factor.

The main conclusion to be drawn from this analysis is that REL is a bad, COM an unnecessary, and PRI the best predictor of strength of exclusive readings.[5] Factor REL should be omitted for reasons of parsimony (every model with it is worse than the corresponding one with it), while COM can be omitted at no substantial loss (adding COM makes models better, but not substantially so, when PRI is present). Omitting PRI leads to a substantial decline in explanatory power.

Estimates of the posterior distributions over model parameter coefficients for

[5] This general conclusion is also vindicated by more complex analyses that would take interactions and random effects for participants into account.

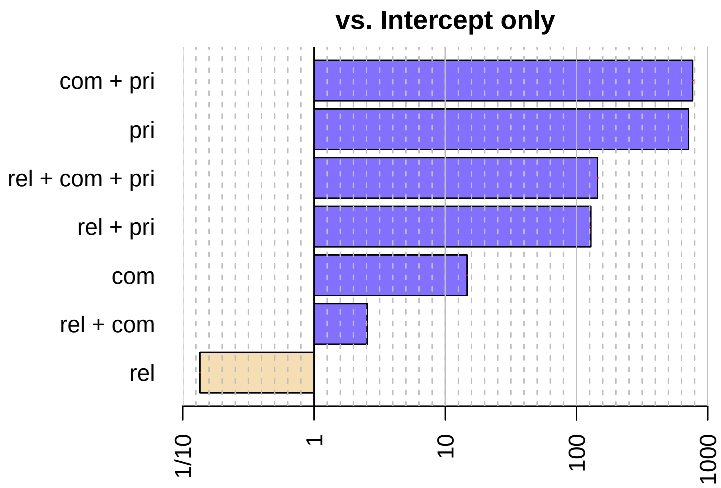


Figure 7: Bayes factor comparison of different main factor combinations. Notation like "com + pri" stands for a regression model with main factors COM and PRI.

the linear model that contains all three factors REL, COM and PRI are shown in Figure 8. Noteworthily, most credible values for coefficients for COM are negative. This is the same for all other models containing factor COM. This means that our data suggests that the more competent the speaker was felt to be, the lower the strength of the exclusive reading. This is the reverse of what we would expect from basically all pragmatic theories. In contrast, the impact of PRI is as expected: the more likely the conjunctive alternative, the less strong the exclusive reading is felt to be.

Discussion.

Prior plausibility of the conjunctive alternative seems to be the main explanatory factor of *Xor*-ratings. This is interesting since standard theories usually do not emphasize the role of prior plausibility. Moreover, it is actually surprising from the point of view of standard pragmatic theories of exclusive disjunction readings that relevance does not seem to play an explanatory role and that competence is correlated with *Xor*-strength in the "wrong direction," so to speak. [mf: more here? or rather later?]

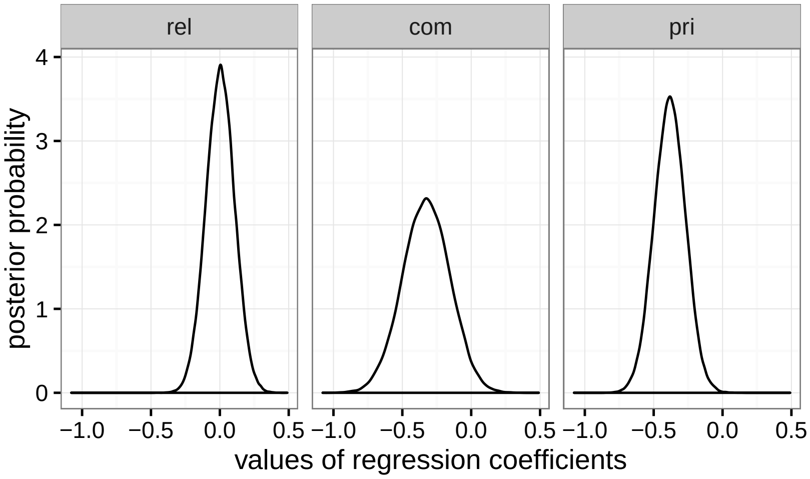


Figure 8: Density estimates of posterior over model parameter coefficients for a linear model with all three main factors.

Before drawing firm conclusions, we should address some potential worries about this design and the evidence that our results provide for or against theoretical positions. First of all, it could be objected that the way in which we measured factor PRI is inadequate. What matters, so a possible objection goes, is the prior plausibility of "*A* and *B*" not the mean of the plausibility of conditionals "if *A*, *B*" and "if *B*, *A*." Experiment 2 presents a follow-up that addresses this issue. Secondly, we should verify that our experimental measures of relevance, competence and prior do what we would like them to. In order to address this issue, Experiment 3 looks at scalar quantifier *some* in a parallel design to that of Experiment 1.

Results

Data preparation. Four participants were excluded from the analysis because they were not self-reported native English speakers. Another 6 participants were excluded for poor performance, by the same criterion as used with Experiment 1. All data from the remaining 193 participants entered into the analysis.

3.2 Discussion

We could conclude from this analysis that PRI is the key factor in our regression model comparison for predicting the strength of scalar inferences.[6] Factors REL and COM do not seem to carry extra explanatory power. This would suggest that the behavior of scalar *some* parallels that of disjunction *or* in terms of which factors seem to influence the strength of the putative implicatures.

There is, however, a particular oddity in our data. A look back at Figure 3 reveals that one vignette received a surprisingly low mean score for implicature strength, namely *NBA*. When we compare the ratings of the *notAll*-statement given for the *NBA* vignette with those given for each other vignette, we see that all of these fifteen pairwise comparisons shows a significant difference. No other vignette had that property in Experiment 3, and also no vignette from Experiment 1 was an "outlier" in this sense. Low implicature ratings for this vignette are particularly surprising, because it was intuitively classified as high relevance, high competence, and low prior. So, all explanatory factors should, by the standard theory, point towards high implicature rates. The observed ratings of these factors for this vignette accorded with intuition. Moreover, the NBA story had remarkably many participants answering that the likelihood of the implicature was exactly zero. Eight participants provided such a response; none did so for the next lowest-scoring item. Clearly, this case seems to stand out in some way.

Here is what we believe went wrong with this item. Consider the *notAll*-statement of this vignette:

> *notAll*
> From what Jason Barley said we may conclude that Greg Jones did not secure victory for his team during the last seconds of all of the decisive playoff matches.

Rather than directly modifying the noun phrase, the negation modifies the verb phrase and is separated by three constituents from the noun phrase. This may invite a reading, which was not intended, in which the negation modifies the verb rather than the noun phrase. In other words, it invites a reading of the complement of 'said' that can be paraphrased as 'Greg Jones failed to secure victory for his team during the last seconds of all of the decisive playoff matches.' We suspect

[6] This is also the case for more complex analyses that take interactions and random effects for participants into account: the model with only PRI as factor is the best, and every model that contains it is strongly favored by the data above any model that does not.

that participants arrived at this reading because of the amount of material between the negation and the noun phrase, which invited participants to instead have the negation modify the verb. Indeed, we found that ratings of exactly zero were overall much more frequent in cases of VP-negation than in cases of NP-negation. [mf: I don't understand the last sentence. Where did we find that? Should we really mention this? Should we go into the NP- vs. VP-negation thing in more detail? Otherwise, maybe drop this?]

In order to test our hypothesis that participants arrived at an unintended reading of the target statement, we conducted a small follow-up experiment in which we gathered implicature ratings for a statement that better expressed the intended reading than the one used in Experiment 3:

> From what Jason Barley said we may conclude that not all of the decisive playoff matches were secured during the last seconds by Greg Jones.

The follow-up consisted of the NBA story followed by three statements: two control statements and one target statement. The target statement was varied between the one used in Experiment 3 (see above) and the alternative one with NP-negation, and was varied between participants. 40 participants were drafted on Mechanical Turk and were paid $0.15 for their participation. They were instructed to, first, read the story carefully and, afterwards, indicate the likelihood of the corresponding statements on a seven-point Likert scale. We hypothesised that implicature ratings would be substantially higher for the modified statement than for the original one.

The normalised implicature ratings for the original statement were slightly lower than in Experiment 3 (0.25 versus 0.39). Crucially, however, the normalised implicature ratings for the modified statement were significantly higher and much more in line with what we observed for the other items (0.76, $t(29) = 4.28$, $p <$ .001). Since the two statements were synonymous on their intended readings, we consider this compelling evidence that participants in Experiment 3 arrived at an unintended reading of the target sentence and sufficient reason for discarding the item from our analysis.

Consequently, we reran the regression model comparison after excluding all data from the *NBA* vignette. The results are shown in Figure 9. The best model considers only factors COM and PRI. It is more than 6 times likelier, given the data, than the second best model, which also includes REL, which in turn is about 3.5 times likelier than the third model with single factor PRI. Figure 10 shows

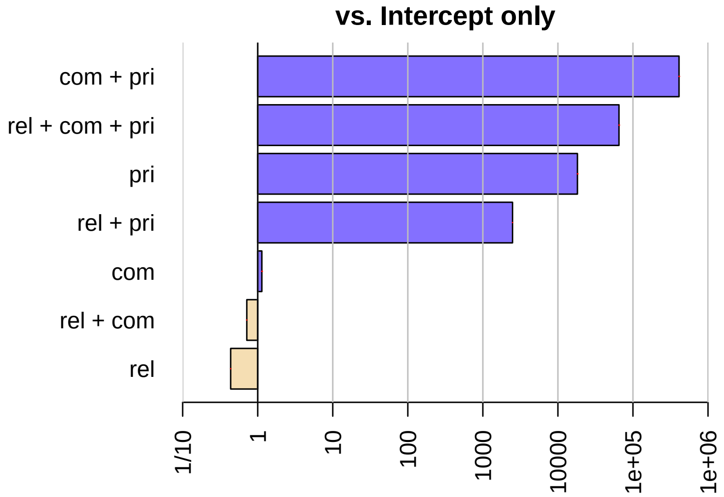


Figure 9: Bayes factor comparison of different main factor combinations, predicting the strength of scalar enrichment of *some* in Experiment 3 after excluding data from the "NBA" scenario.

posteriors over regression coefficients for that model with main effects Rel, Com and Pri. Unlike for the disjunction case in Experiment 1, the effect of factor Com on strength of scalar enrichment is as expected from standard theory: the more competent a speaker is felt to be, the stronger the scalar implicature reading.

In sum, we believe that there are good reasons to exclude the *NBA* vignette from our analysis, because of an unintended ambiguity in the *notAll*-statement. Doing so, reveals that factors Pri and Com contribute most to explaining the variance in implicature strength. Just as for disjunction, relevance seems to be a superflous factor, because any model without factor Rel is worse than the corresponding one where it is added. This suggests that the speaker expertise paradox [mf: terminology?] may be a real problem. While manipulations of competence do have the effects predicted by standard theories of scalar implicature for the case of *some*, this is not the case for disjunctive readings of *or*. There does seem to be a difference, which is, as such, already unexpected under standard conceptions.

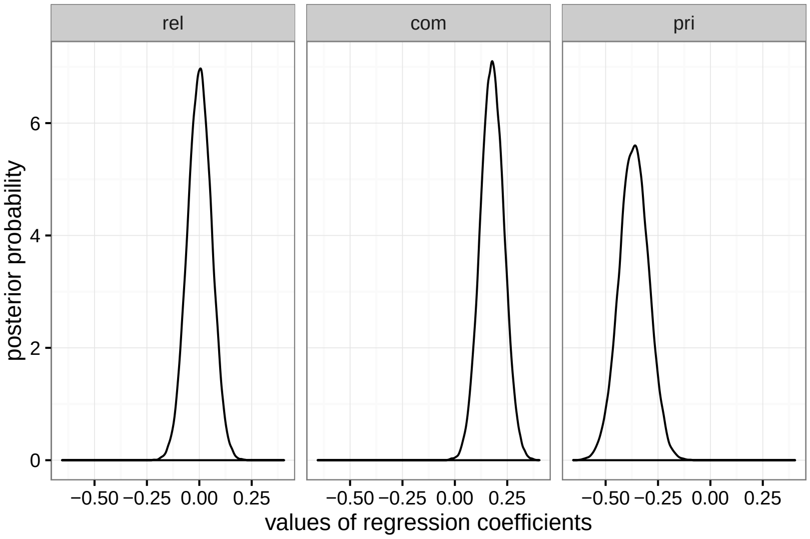


Figure 10: [mf: fill me]

4 Experiment 4

4.1 Design

Exclusive readings of disjunctions can also come about by exhaustifying individual disjuncts (see Section XYZ). This approach would predict that the strength of an exclusive disjunction reading of "*A* or *B*" should be positively correlated with the strength of exhaustive readings that statements of individual disjuncts "*A*" and "*B*" would receive in the same context. The purpose of Experiment 4 was therefore to collect data on the strength of exhaustive readings of such single-disjunct statements in the background contexts used in Experiment 1. We would then like to investigate whether strengths of exhaustive readings make for a reliable predictor of strength of exclusive readings across contexts.

4.2 Participants

Using the same selection criteria as before, 131 subjects were recruited via Amazon's Mechanical Turk and paid US$ 0.50 for participation.

4.3 Materials

Experiment 4 used the fifteen vignettes from Experiment 2 (that is excluding the erroneous “Bill’s orders” scenario). For each vignette we consider the speaker’s utterance of single disjuncts (see Appendix A). Concretely, where Experiment 1 had an utterance of a disjunction:

> *Utterance of disjunction*
> Jill says to Danny: ‘Alex bought a racket or a pair of shoes.’

Experiment 2 had two single-disjunct utterances by the same speaker:

> *Utterance of disjunct 1*
> Jill says to Danny: ‘Alex bought a racket.’
>
> *Utterance of disjunct 2*
> Jill says to Danny: ‘Alex bought a pair of shoes.’

Additionally, each vignette also had corresponding statements that subjects had to rate:

> *Exh1*
> From what Alex’s girlfriend said we may conclude that Alex did not buy a pair of shoes as well.
>
> *Exh2*
> From what Alex’s girlfriend said we may conclude that Alex did not buy a racket as well.

4.4 Procedure

The procedure followed that of Experiment 2 very closely. After reading (slightly amended) instructions and seeing examples for the use of the slider bar, each participant was presented with six randomly sampled vignettes. Subjects read the background story, followed with an utterance of disjunct 1 or 2, randomly chosen. Subjects first rated a random control question and then rated the *Exh1* or *Exh2* statement, depending on which utterance was shown to them.

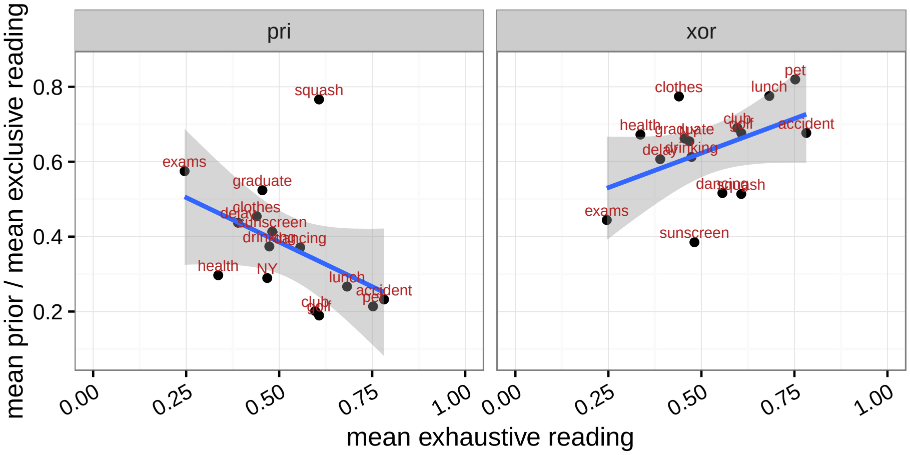


Figure 11: Means of ratings of *Exh*-statements from Experiment 4 (x-axis) vs. means of ratings of *Prior*-statements and *Xor*-statements from Experiment 1 (y-axis)

4.5 Results

Data from one subject was discarded because English was not the self-reported native language. Another four subjects were removed for bad performance on the control questions, using the same criterion as before.

Figure 11 shows the per-vignette means of the ratings of the *Exh*-statements plotted against the corresponding mean ratings of the *Prior*- and *Xor*-statements from Experiment 1. There is no significant correlation between *Prior*-ratings and *Exh*-ratings ($r \approx -0.44$, $p \approx 0.1$), suggesting that our measures of prior expectations and exhaustive strength do not coincide. Adding the per-vignette mean *Exh*-ratings as an additional explanatory factor EXH to the regression model comparison, we obtain the picture given in Figure 12. A model using single factor PRI to predict *Xor*-ratings is about 8.5 times more likely than a model using single factor EXH. That means that our data provides evidence for the assumption that prior expectations are a better explanatory factor of exclusive readings than the strength of exhaustive readings.

4.6 Discussion

- something about awareness?

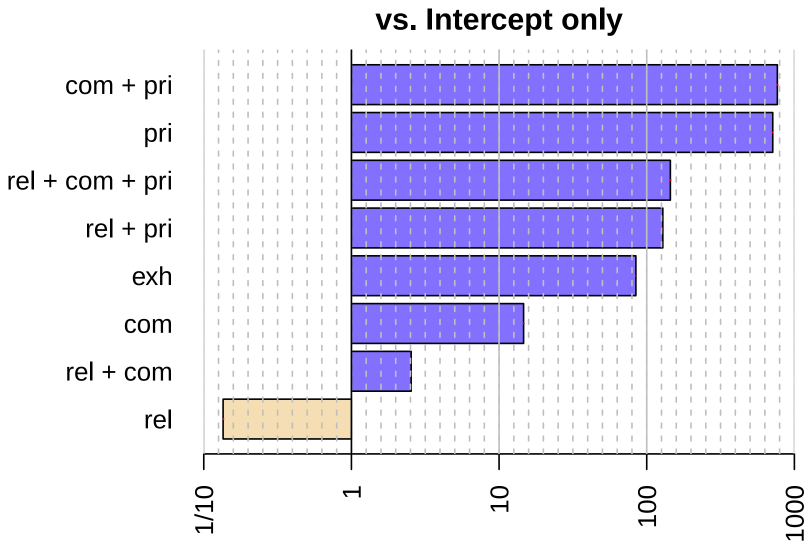


Figure 12: Bayes factor comparison of different main factor combinations, predicting the strength of exclusive disjunction readings with additional factor EXH from Experiment 4.

5 General discussion

- there are more factors that influence implicature strength, obviously:
  - intonation, speaker-specific adjustments, . . .
- what about relevance theory?

A Material for Experiments 1, 2 and 4

Stories from Exp. 1 **1.**
[mf: fill me]

B Material for Experiment 3

[mf: fill me]

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