Probabilistic accounts of the proviso problem: experimental evidence

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Background. The proviso problem (Geurts 1996) concerns presupposition projection from the consequent of a conditional sentence of the form *"if A then B(P)"*. The theoretical challenge is to explain when and how the presupposition projects as a conditional or unconditional inference:

(1) *If John is a scuba diver, he will bring his wetsuit ⟶ If John is a scuba diver, he has a wetsuit*
(2) *If John wants to impress his girlfriend, he will bring his wetsuit ⟶ John has a wetsuit*

Lassiter (2012) proposed a probabilistic solution to the proviso problem based on the satisfaction theory of presupposition projection (Karttunen 1974, Heim 1983). He postulates that a presupposition is licensed if its probability exceeds a certain threshold parameter θ in the local context: pr(P) > θ. For a presupposition in the consequent, this corresponds to the conditional probability threshold in the global context: pr(P|A) > θ. When A and P are independent or negatively dependent (pr(P) ≥ pr(P|A) > θ), the unconditional probability also exceeds θ, which licenses the unconditional presupposition. However, in cases of positive dependence (pr(P) < pr(P|A)) we cannot infer pr(P) > θ, and therefore the unconditional presupposition is not licensed.

The binding theory within the Discourse Representation Theory (DRT, van der Sandt 1992, Kamp et al. 2010) provides an alternative account of presupposition projection. It treats a presupposition as an anaphor that searches for an antecedent through a hierarchy of local contexts, resulting in several potential interpretations, in our case two – with the conditional and unconditional projection. To select between those interpretations (world states), we suggest employing the Rational Speech Act framework (RSA, Goodman & Frank 2016). RSA includes a model of a literal listener, whose posterior probability of a world state S given an utterance U is proportional to the prior probability of that state, pr(S), provided that U is true in S according to the semantic interpretation function [[U]](S). In our case, these prior probabilities are pr(P) and pr(P|A).

$$pr_{L_0}(S|U) \propto pr(S) \cdot \left[\left[U\right]\right](S)$$

Experiments. We conducted two experiments to assess presupposition projection in conditionals to test predictions of the theories. In Experiment 1, a norming study (n = 320; Prolific), participants evaluated how likely it is that a person with a particular description owns a particular object:

(3) *A random (person | guitarist | artistic person | married person | tone-deaf person) has a guitar.*

The experimental stimuli included 40 objects of possession. Each object was paired with four possible owners corresponding to different levels of conditional probability that the person owns the object: *very high*, *high*, *independent,* and *low*. Using the description *"a random person,"* we also estimated the unconditional probability of owning each object. We checked whether the probabilities exhibited a monotonic pattern: the *very high* and *high* conditional probabilities exceeded the unconditional one, the *independent* probability was approximately equal to it, and the *low* conditional probability fell below it. We then selected 12 of the 40 objects that followed this pattern. Figure 1 presents the results (prior probabilities averaged across all 12 objects).

In Experiment 2 (n = 400; Prolific), participants were presented with sentences of the following form, where a possessive noun phrase (*"his guitar"*) triggers an existential presupposition:

(4) *If Peter is (a guitarist | artistic | married | tone-deaf), his guitar is good-sounding.*
   a. *Peter has a guitar.*
   b. *If Peter is (a guitarist | artistic | married | tone-deaf), he has a guitar.*

Participants then used a slider to indicate which assumption the speaker was more likely to have made: (4a) or (4b). We did not ask whether participants themselves infer (4a) or (4b) or consider them as true to avoid interference with participants' own background beliefs.

If the likelihood of the unconditional presupposition depends on a fixed threshold (Lassiter 2012), the magnitude of the difference between probabilities should not affect projection. Specifically, if the conditional probability exceeds the unconditional one, we cannot infer pr(P) > θ, and only the conditional presupposition is licensed; otherwise, both of them are. Hence, the theory predicts no contrast between the *high* and *very high* conditions, nor between the *independent* and *low* conditions. Conversely, our DRT + RSA account predicts such contrasts because it is sensitive to the degree of difference between probabilities, since the probability to select either interpretation is proportional to their prior probabilities. The higher the conditional probability, the more frequently the interpretation with the conditional presupposition should be selected.

Figure 2 shows the average rate of conditional presupposition interpretations across conditional probability levels. A mixed-effects regression model (Bates et al. 2015) revealed a significant difference between the first two levels: conditional presuppositions are more likely in situations with *very high* conditional probability than in those with *high* conditional probability ($\beta = -0.057$, $SE = 0.019$, $z = -3.04$, $p = 0.006$), which supports our account. However, no significant difference was detected between the last two levels ($\beta = -0.046$, $SE = 0.023$, $z = -2.00$, $p = 0.074$), which provides no clear evidence against the probabilistic satisfaction theory.

Discussion. In this study, we investigated whether presupposition projection patterns in conditional sentences can be explained by the probabilistic satisfaction theory (Lassiter 2012) or by an alternative DRT + RSA account. The results revealed a mixed pattern, providing partial support for both theories. Although the effect size of the *high* vs. *very high* contrast is relatively small, it is compatible with the DRT + RSA approach. Figure 3 shows the predictions of the literal listener RSA model based on the prior probabilities from Figure 1. The predictions for the first three conditions broadly align with the experimental results. The only notable deviation occurs in the *low* condition, where the experimentally obtained value is significantly higher than predicted by the model and is compatible with the probabilistic satisfaction theory.

We quantitatively confirm previous studies (Romoli et al. 2011, Domaneschi et al. 2016, Çağırıcı 2022) that showed that positive dependence increases the likelihood of conditional presupposition projection. However, we did not find enough evidence to conclude that the pattern extends symmetrically to cases of negative dependence, which, to our knowledge, have not previously been investigated systematically. One promising direction for future work is to investigate whether RSA models of projective content that incorporate common ground and QUD-based reasoning (Qing et al. 2016, Warstadt 2022) can help resolve this puzzle.

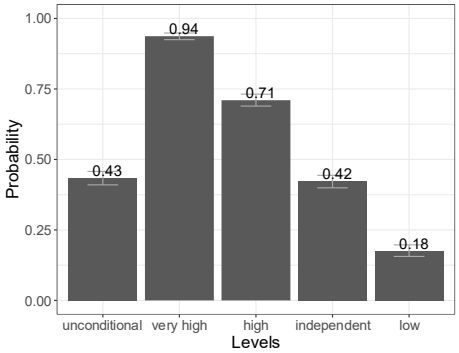


Figure 1. Prior probabilities

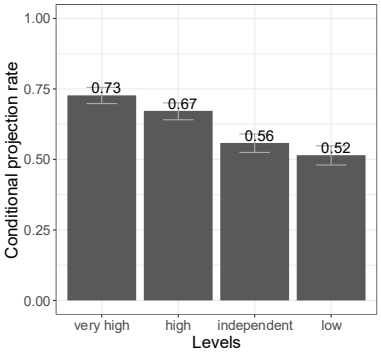


Figure 2. Projection results

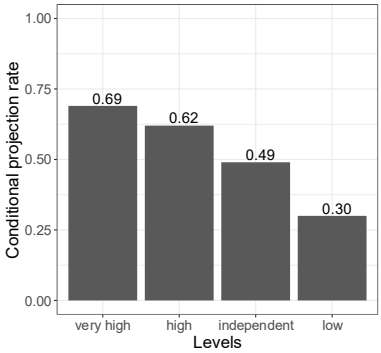


Figure 3. Model predictions

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