

A diverse family (of sentences)

We present experimental evidence that the projectivity of attitude complements varies across different entailment-cancelling operators, and that this effect of entailment-cancelling operator differs between various attitude verb triggers. However, our findings about the interaction of operator and trigger do not support Karttunen's (1971) classification of factive vs. semi-factive verbs.

Projection across entailment-cancelling operators. Certain attitude ascriptions come with an inference to the truth of their complement, even if embedded under entailment-cancelling operators (shown for ‘*discover*’ in (1)), in which case the inference is said to *project* (e.g. Karttunen, 1971).

- (1) a. Modals: *'Perhaps Cole discovered that Julian dances Salsa.'*
 b. Negation: *'Cole didn't discover that Julian dances Salsa.'*
 c. Polar Questions: *'Did Cole discover that Julian dances Salsa?'*
 d. Conditionals: *'If Cole discovered that Julian dances Salsa, Logan will be joyful.'*

Previous work on projection showed that it is not a categorial property of lexical triggers (Tonhauser et al., 2018), but a gradient one, affected by various contextual factors (Simons et al., 2010; de Marneffe et al., 2012; Beaver et al., 2017; Degen and Tonhauser, 2021). In light of this, we expect that the heterogeneous entailment-cancelling operators in (1) affect projection differentially.

Karttunen (1971) proposed generalizations to this effect, distinguishing between *factive* verbs (*regret, forget, resent*) and *semi-factive* verbs (*discover, realize, see, find out, notice*), suggesting that factives always project, while semi-factives always project across negation, but not always in polar questions or conditionals. To provide a systematic way of distinguishing these classes, Djärv et al. (2018) suggest that they correspond to emotive and cognitive predicates, respectively. Regarding the effect of operators on projection, Smith and Hall (2014) find an effect of .. on ... (?) Here, we experimentally address the questions: **(i)** Is the projection of content affected by differences in entailment-canceling environments? **(ii)** Do these effects vary for different verbs (and in what way)?

Experimentally investigating projection, we used a response task to elicit judgments about how strongly a speaker would be committed towards the embedded clause (from Tonhauser, 2016). We presented sentences like in (1) as asserted by a named speaker (e.g. “**Daniel:** *‘Did Cole...?’*”). Participants then provided a certainty-rating in response to a prompt like: “*Is Daniel certain that Julian dances Salsa?*”, by moving a slider on a scale from ‘no’ (coded as 0), to ‘yes’ (coded as 1).

Design and Expectations. We compared certainty-ratings for the four entailment-canceling operators in (1), and 20 clause-embedding predicates (verb: *be annoyed, discover, know, reveal, see, acknowledge, admit, announce, confess, confirm, establish, hear, inform, prove, pretend, suggest, say, think, be right, demonstrate*). Based on the Karttunen-Dj  rv generalization about emotive factives vs. cognitive semi-factives, we would expect emotive factives (*be annoyed*), and verbs normally taken to be factive (*know*), to be highly projective in a way that is indifferent to the embedding context, and cognitive semi-factives (*discover, see*) to show higher projectivity ratings under negation compared to questions and conditionals.

Method. The study consisted of 12 experiments, all of which manipulated the factor verb for 20 items corresponding to the content of the complement clause. Experiments 1–3 used polar question embedding, expts. 4–6 used negation, 7–9 modals, and 10–12 conditionals, making the operator manipulation a between-subjects factor. We analyzed data from 2682 self-identified native English speakers participated online across the 12 experiments (recruited via Prolific and Amazon MTurk). Participants saw items Latin-squared and randomized with six control stimuli.

Results and Analysis. Pooling the data across our 12 experiments, we examined the effect on certainty-ratings of operator, and verb, as well as their interaction. Mean certainty-ratings by operator and predicate, and 95% bootstrapped confidence intervals are shown in **Figure 1**.

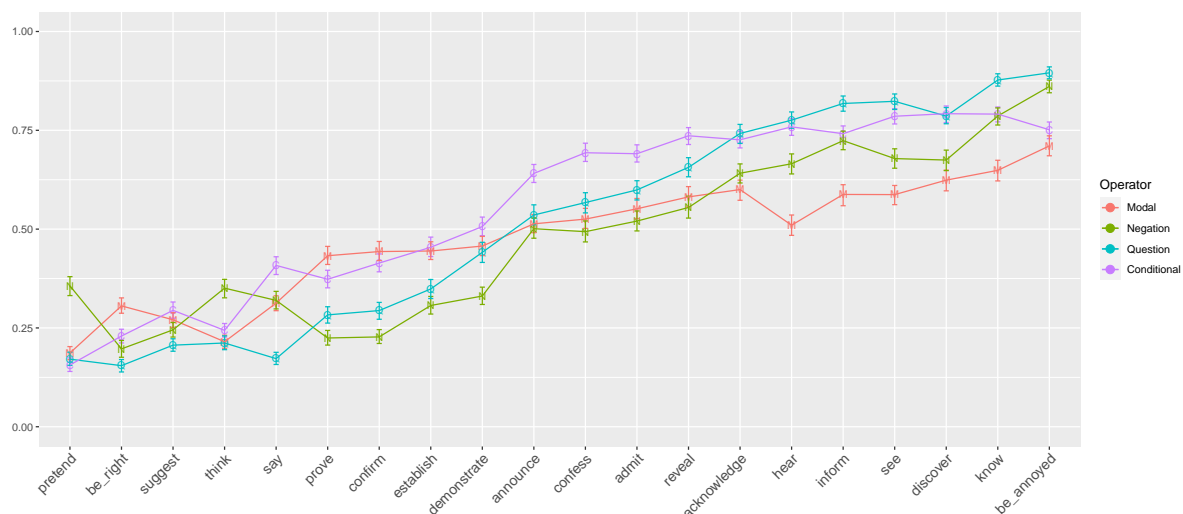


Figure 1: Mean certainty ratings by predicate and operator

The data was analyzed using a mixed effects linear regression (using `lme4`, `lmerTest` in R; Bates et al., 2015; Kuznetsova and Christensen, 2016; Team, 2014), with *be annoyed* and *negation* as reference levels, and random intercepts for participants and items. The mean for this baseline (intercept) is 0.867. We found highly significant main effects of operator for conditional (-0.116 , $p < 1.6e^{-13}$) and modal (-0.156 , $p < 2e^{-16}$), while the effect of question was only marginally significant ($+0.025$, $p < 0.1$). We also found many interactions of operator and verb across the board (where $p < 0.001$ in 43 cases, $p < 0.01$ in three, and $p < 0.05$ in one out of 57 possible interactions).

Notably, the interactions of:

- *discover* and *question*, *conditional*: significant positive interaction effects (can we really argue that for *discover*: $Q, C > N$, based on this? I am not really sure how to do this. what I would normally do instead is to look at the posterior samples in a bayesian model to compare each condition and see if they are really different, for $Q, C > N$)
- *know* and *question*, *modal*: how can we make argument from model output to differences seen in graph ($Q > C, N > M$)

Discussion and Conclusion.

- Main effect of operator: choice of operator has an effect on projectivity
- For *be annoyed*, no significant effect is found for *question* (vs *negation*), as would be expected based on Karttunen, but we do find unexpected differences between $N > C, M$
- for *discover*, we find $Q, C > N$, an effect in the opposite direction from expectation based on Karttunen
- *know* shows effects that would be incompatible with characterization as *factive* or *semi-factive*: $Q > C, N > M$. if *semi-factive*, we would expect $N > C, Q$, if *factive*, no difference would be expected

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