A diverse family (of sentences)
Projectivity differs across embedding operators—but not like you think

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. We find that verbs show patterns of between-operator projection behavior which group in interesting ways, but do not support Karttunen's (1971) longstanding classification of factive vs. semi-factive verbs, which has been assumed throughout the literature (e.g. Djärv et al., 2018) + OTHERS.

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.'*

Karttunen (1971) suggested that the entailment-cancelling operators in (1) affect projection differentially and proposed a generalization distinguishing *factive* verbs (*regret, forget, resent*) vs. *semi-factive* verbs (*discover, realize, see, find out, notice*): Factives always project, while semi-factives always project across negation, but not always in polar questions or conditional antecedents. Although widely assumed, experimental evaluations of this distinction have been little.

To provide a systematic way of distinguishing these classes, Djärv et al. (2018) suggest that they correspond to emotive and cognitive predicates, respectively. In a study assessing the acceptability of affirmative responses to a target utterance while explicitly denying a potentially projective inference (based on Cummins et al., 2012), they find that this kind of affirmative cancellation is more readily available for emotive than cognitive predicates, suggesting that the main clause content and projective content are logically more independent from each other for emotive predicates. Smith and Hall (2014), investigating the effect of operator on the projection of various types of projective content, find an effect on ratings of participant surprisal about the inferences in question, suggesting that inferences triggered by *know* and epithets project more from under negation than conditional antecedents whereas non-restrictive relative clauses show the opposite pattern.

In our work, we analyze measures from a task designed to measure speaker commitment more directly to address the questions: **(i)** Is projection affected by differences in entailment-canceling environments? **(ii)** Do these effects vary for different triggers (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-Djärv 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, originally designed to address a different research question, consisted of 12 experiments, all of which manipulated the factor `verb` for 20 items corresponding to to the content of the complement clause. Experiments 1–3 used polar question embedding, exps. 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 Discussion. 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**.
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. We found highly significant main effects of `operator`: For our baseline `be_annoyed`, both `conditional` and `modal` are clearly less projective than negation, thereby supporting the claim that the embedding context does matter. We also found many interactions of `operator` and `verb` across the board, suggesting that the effect of embedding context diffes by verb. Notably, *'discover'* is more projective in polar questions and conditional antecedents than under negation, patterning opposite to Karttunen's claims about semi-factives. For the emotive predicate *'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 `negation` > `conditional, modal`. *know* shows effects that would be incompatible with a characterization as either factive or semi-factive: `question` > `conditional, negation` > `modal`. If *'know'* is a factive predicate, no difference would be expected. If it is semi-factive, we would, again, expect higher projectivity under negation than in questions and conditionals.

Verb profiles. add discussion about verb classes here

Conclusion. add conclusion here

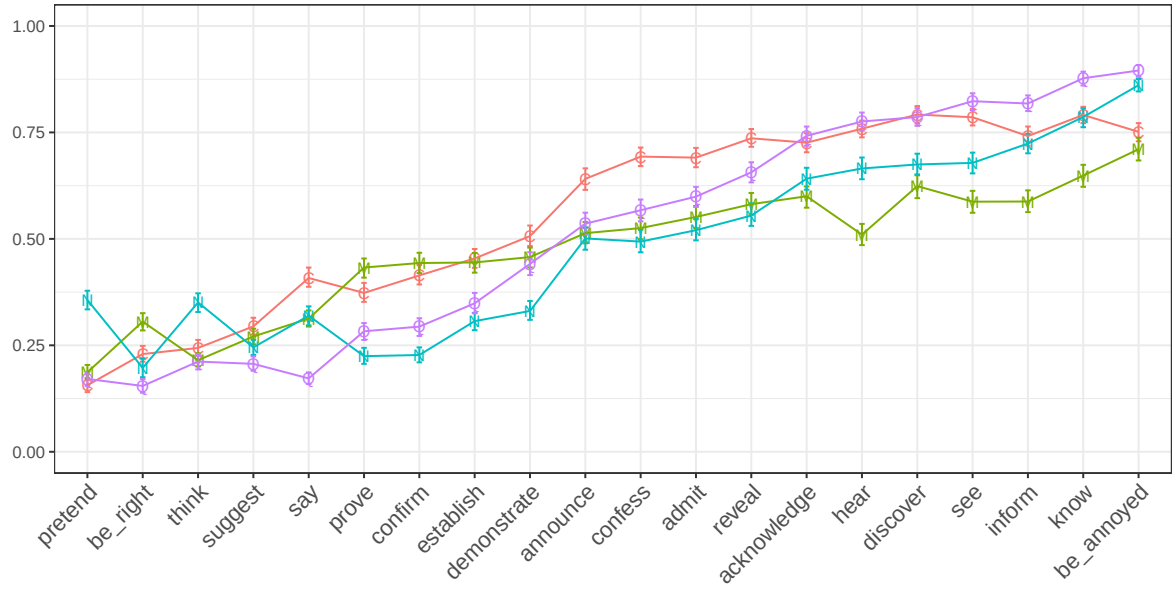

Figure 1: Mean certainty ratings by predicate and operator with 95% bootstrapped confidence intervals (y-axis), by verb (x-axis), and operator (color/grouping, where: `N` (blue): negation, `M` (green): modals, `C` (red): conditional antecedents, `Q` (purple): polar questions).

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