Projection variability of attitude complements across different operators

We present experimental data that the projection of the content of attitude complements **(i)** varies between entailment-canceling operators, and **(ii)** that this by-operator variation differs between attitude predicates. The observed variability is not captured by existing theoretical accounts of projection (e.g., Heim 1983; van der Sandt 1992; Abrusán 2011; Schlenker 2021), and suggests that an analysis must consider interactions between predicates and operators, which cannot be fully determined by lexical classes. Instead, our results reveal a more nuanced picture of lexical semantic and pragmatic properties, which raises important questions for future research on projection.

Projection across entailment-cancelling operators. Language users may infer that a speaker who utters an attitude ascription, as in (1), is committed to the content of the complement (CC, here: *Julian dances Salsa.*), even when it occurs under an entailment-canceling operator, like negation (1a), polar questions (1b), modals (1c), or conditionals (1d), in which case we say that it *projects*.

(1) a. **Negation:** *'Cole didn't discover that Julian dances salsa.'*
b. **Polar Question:** *'Did Cole discover that Julian dances salsa?'*
c. **Modal:** *'Perhaps Cole discovered that Julian dances salsa.'*
d. **Conditional:** *'If Cole discovered that Julian dances salsa, Logan will be joyful.'*

Current research only rarely examines projectivity differences across these operators, with conflicting findings. Karttunen (1971) proposed a distinction between English factive predicates (e.g., *be annoyed, regret*), where the CC projects across all four operators, and semi-factives (e.g., *discover, realize, see, notice*) where it only projects across negation. Comparing different types of contents, Smith and Hall (2014) found that the projective content of epithets and the CC of *know* is more projective under negation than conditionals, whereas that of non-restrictive relative clauses and *win* shows the opposite pattern. Sieker and Solstad's (2022) investigation of German purported factive and semi-factive predicates replicated Smith and Hall's (2014) result for the German *wissen* ('know'), but as part of an overall pattern of higher projectivity across negation than other operators. They found no interaction with predicate type, or evidence for the (semi-)factive distinction.

These studies all suggest comparatively high projectivity across negation, but the results diverge about interactions between operators and different types of contents. To investigate if this is due to variation between English and German, task-differences, or different contents being tested, we conducted a series of experiments designed to investigate projection across the four entailment-canceling operators in (1), using the same projection measure as Sieker and Solstad (2022) (the 'certain that' diagnostic; see e.g., Tonhauser et al., 2018; Djärv and Bacovcin, 2017; Mahler, 2020) and applied it to the CC of 20 English clause-embedding predicates, including factive predicates (*be annoyed, know, reveal*) and semi-factives (*discover, see*), as well as 15 non-factive predicates, due to recent findings that their complements are also projective, albeit to varying degrees (Degen and Tonhauser 2022). Our study aimed to replicate the projection variability across operators of various English projective contents reported in Smith and Hall (2014) for English attitude complements.

Method. Projection of the CC of the 20 attitude predicates was measured in four sets of experiments: The predicates were embedded in polar questions in Exps. 1, under negation (Exps. 2), under *perhaps* (Exps. 3), and in conditional antecedents (Exps. 4). (Each set contained three experiments using different at-issueness measure in a separate block. Here, we focus on the projection ratings.) In each experiment, participants read utterances like those in (1) and judged whether the speaker (who was named) was certain of the CC (e.g.: Is [the speaker] certain that Julian dances salsa?). Participants gave their response on a slider marked 'no' (coded as 0) at one end and and 'yes' (coded as 1) on the other. Each participant saw all 20 attitude predicates (each paired with a unique content from a set of 20 contents) under one operator. We analyze data from 2,682 self-reported native speakers of American English recruited on Prolific or Amazon's MT platform.

Results and Analysis. Figure 1 shows mean projection ratings for the 20 attitude predicates by operator; predicates are ordered by their mean rating across all operators (*be annoyed* has the highest overall mean). Our analysis reveals two key findings: **(i)** differences in projectivity across operators, and **(ii)** differences in by-operator variability between predicates. The first finding is supported by significant main effects of `operator` in the linear mixed effects models shown in **Table 1**. The second finding is supported by the three models having at least 34 significant interaction terms (out of 57 possible interactions of `operator` and `predicate`).

The models in **Table 1** also illustrate some specific differences across predicates in by-operator variation (suing different reference levels for `predicate`): For instance, the CC of *be annoyed* projects more from under negation (and questions) than conditionals and modals, while the CC of *discover* projects less from negation than conditionals and questions, and more from under negation than modals. Additionally, we did not replicate the result from Smith and Hall (2014); Sieker and Solstad (2022), that the CC of *know* projects more from negation than conditionals. Instead, we found that it projects less from under negation than questions, but more from under negation than modals, while the difference between negation and conditionals is not significant here. With many interaction effects of `operator` and `predicate` throughout, our results also differ from Sieker and Solstad (2022), who did not find such interactions for the German attitudes they investigated.

Discussion: Empirical implications and lexical properties. Since our study used the same projection diagnostic, and a similar set of contents as Sieker and Solstad (2022), the different results indicate potential cross-linguistic variation in projection variability, suggesting a set of questions for future research. However, in line with their study, our findings contradict Karttunen's (1971) distinction between factive and semi-factive predicates: The CC of (factive) *be annoyed* does not project invariably from all four operators, and the CC *discover,* which is considered semi-factive, does not project more from under negation than the other three operators. The pattern we observed for *know* does not fit into either category, thus questioning the defined difference between factive and semi-factive predicates (see also Beaver, 2010). Future research appealing to these categories must clarify their definition. Additionally, claims about projection variability must be relativized to the entailment-canceling operator. Finally, our results provide further support (from negation, modals, and conditionals) for the result of Degen and Tonhauser (2022), that projection does not categorically differentiate between (semi-)factive and non-factive predicates: The CCs of *inform* and *acknowledge*, for instance, are at least as projective as that of some (semi-)factive predicates. In spite of a lack of categorical distinctions about the projection behavior of our verbs, we can find some interesting initial generalizations over lexical properties, indicated in **Figure 2**.

Theoretical Implications. Our results—that projection is modulated by entailment-canceling operators and that there is by-predicate variation in the effect of operator on projection—are not captured by contemporary projection analyses, for several reasons. The first reason is that contemporary analyses do not lead us to expect interactions with different types of entailment-cancelling operators. In Heim 1983, for instance, the CC of (semi-)factive predicates projects to the global context, except when that would produce an inconsistency, in which case the CC is accommodated to the local context of the operator. While it is conceivable for the meaning of the operator to systematically interact with the possibility of local accommodation, no such interaction has been spelled out. The second reason is that many contemporary analyses do not make predictions for the projection of the CC of many of the 20 predicates, as they are limited to (semi-)factive predicates (e.g., Heim 1983; van der Sandt 1992, whose CCs are analyzed as presuppositions) and or entailed CCs that project unless at-issue with respect to the Question Under Discussion (e.g., Abrusán 2011; Simons et al. 2017). A possible exception is the analysis of Schlenker 2021, which predicts the potential for projection for CCs that are contextually entailed. In the full talk, we discuss how this analysis might be able to capture the gradient projection observed in our experiment. The third reason is

that contemporary projection analyses do not make sufficiently fine-grained distinctions between different clause-embedding predicates (but only between whether the CC is a presupposition or entailed). Consequently, they do not make predictions about the by-predicate variation in the effect of operator on projection.

(Selected) References: Beaver (2010). Have you noticed that your belly button lint colour is related to the colour of your clothing? *Presuppositions and Discourse: Essays offered to Hans Kamp.* • **Degen & Tonhauser (2022).** Are there factive predicates? An empirical investigation. *Language.* • **Djärv & Bacovcin (2017).** Prosodic effects on factive presupposition projection. *Semantics and Linguistic Theory.* • **Djärv, Zehr & Schwarz (2018).** Cognitive vs. emotive factives: An experimental differentiation. *Proceedings of Sinn und Bedeutung.* • **Karttunen (1971).** Some observations on factivity. *Research on Language & Social Interaction.* • **Mahler (2020).** The social component of projection behavior of clausal complements. *Linguistic Society of America.* • **Smith and Hall (2014).** The relationship between projection and embedding environment. *Proceedings of the 48th Meeting of the Chicago Linguistics Society.* • **Tonhauser, Beaver, & Degen (2018).** How projective is projective content? Gradience in projectivity and at-issueness. *Journal of Semantics.* •

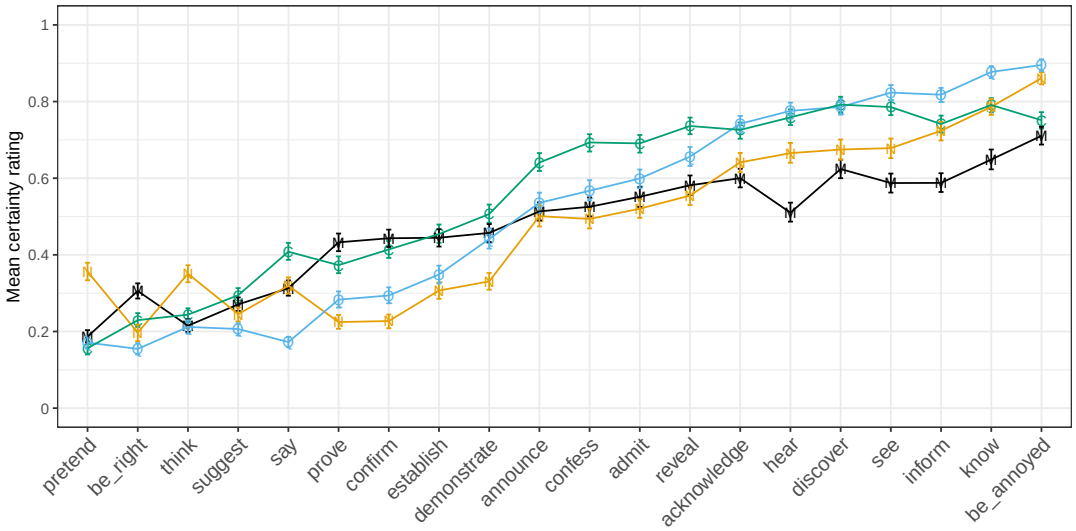

Figure 1: Mean certainty ratings by predicate and operator with 95% bootstrapped confidence intervals. Embedding operator coded by letter and color: `N` (orange): negation, `M` (black): modals, `C` (green): conditional antecedents, `Q` (blue): polar questions.

Model		Estimate	Std. Error	t-value	
#1	Intercept: **be annoyed**/negation	0.87	0.01	79.86	***
	operator: conditional	-0.12	0.02	-7.36	***
	operator: modal	-0.16	0.02	-10.01	***
	operator: question	0.02	0.01	1.72	n.s.
#2	Intercept: **discover**/negation	0.68	0.01	62.70	***
	operator: conditional	0.11	0.02	7.11	***
	operator: modal	-0.06	0.02	-3.63	***
	operator: question	0.10	0.01	7.08	***
#3	Intercept: **know**/negation	0.79	0.01	72.97	***
	operator: conditional	0.00	0.02	-0.06	n.s.
	operator: modal	-0.14	0.02	-9.18	***
	operator: question	0.08	0.01	5.67	***

Table 1: Excerpt of the output from three linear mixed effects models; with fixed effects of operator, predicate, and their interaction; random effect: participant intercepts. Models were fit with `lme4`, `lmertest` in `R`. All three models also had at least 34 highly significant interaction terms of `operator` and `predicate` with $p < 0.001$ (Not shown here).

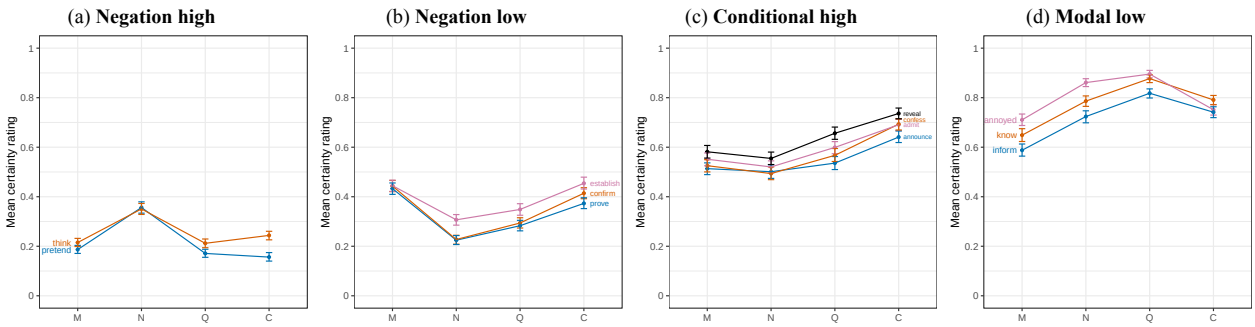

Figure 2: Mean certainty ratings by operator (`M`: Modal, `N`: Negation, `Q`: Polar Question, `C`: Conditional antecedent) with 95% bootstrapped confidence intervals, for some groups of predicates ('predicate patterns').

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