Projection variability across embedding operators and triggers

We present experimental data which suggests that **(i)** the projectivity of the content of attitude complements varies depending on the entailment-canceling operator used, and **(ii)** that this effect of entailment-cancelling operator between attitude predicates. Our finding of (ii) has not been previously observed and presents new theoretical challenges. The variability we found is gradient, confirming previous research that by-predicate variability is not determined by categorical lexical classes (Tonhauser et al. 2018; Degen and Tonhauser 2022), extending this result to by-predicate variability in interaction with embedding contexts. Existing theoretical accounts of projection across different entailment-canceling operators cannot explain the observed by-trigger differences (e.g., Heim 1983; van der Sandt 1992; Abrusán 2011; Schlenker 2021). To our knowledge, the only approach that considers interactions between predicates and embedding contexts is the traditional classification of factive versus semi-factive predicates (e.g., Karttunen 1971; Hooper and Thompson 1973; Djärv et al. 2018). Our experimental data suggests that any account of projection must consider interactions between triggers and embedding operators, and that this interaction cannot be fully determined based on categorical lexical classes. Instead, the projection variability reveals a more nuanced picture of lexical semantic/pragmatic properties which raises important questions for future research on projection.

Investigating Projectivity 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), 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.'*

Following the methodology and approach from Tonhauser et al. (2018); Degen and Tonhauser (2022), who find gradient differences in projection among different clause-embedding predicates, we talk about *projectivity* as the degree or frequency with which a projective interpretation is assigned. Contemporary empirical research rarely considers potential differences in projectivity from under these four operators, with very few exceptions and conflicting results: Smith and Hall (2014) investigated by-operator variation (negation, conditional) for various types of projective content, observing that the content of non-restrictive relative clauses and the preparatory content of *win* was more projective under conditionals than negation, while the projective content of epithets and the clausal complement (CC) of English *know* exhibited the opposite pattern. In contrast, Sieker and Solstad (2022), investigating projective variabiltiy of the CC German attitude predicates across the four operators in (1), they found no significant projection variability across operators, and did not report interactions by-predicate. In particular they did not find a difference between factive and semi-factive verbs, nor did they replicate Smith and Hall's (2014) result for the German counterpart of 'know' (*wissen*). This also raises the question whether these diverging results are due to differences between English and German or differences in the methods of investigation.

To investigate projection variability across operators and attitude predicates, we ran a series of experiments designed to investigate projection from under the four entailment-canceling operators in (1). Our experiment used 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 this

diagnostic to the contents of the complements of 20 English clause-embedding predicates, including purported factive predicates (e.g., *be annoyed, know, reveal*) and purported semi-factive predicates (e.g., *discover, see*). Given recent results that the CC of non-factive predicates is also projective (Degen and Tonhauser 2022), albeit to varying degrees, we also included 15 non-factive predicates.

Experiment: Methods and Expectations. Projection of the CC of the 20 attitude predicate was measured in four sets of experiments: The predicates were embedded under polar questions in Exps. 1, under negation (Exps. 2), under *perhaps* (Exps. 3), and in conditional antecedents (Exps. 4). (Each set of experiments contained three experiments differing in an at-issueness measure used in a separate block. We focus on the projection ratings here.) 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 the data from 2,682 self-reported native speakers of American English recruited on Prolific or Amazon's MT platform. Karttunen's generalization leads us to expect the CC of factive predicates to consistently receive relatively high projection ratings under all four operators, and the CC of semi-factive predicates to exhibit high projection ratings under negation and possibly lower ratings under the other operators.

Results. The results need to be rewritten to make the points (i) and (ii). Right now, they are too focused on the factive/semi-factive distinction. No wonder did the SALT-reviewers think that this is the main point of our abstract... We should also say that our results replicate the result of Degen & Tonhauser 2022 (Language) that projection is gradient, made there for interrogative embedding and here shown also for the other operators.

Figure 1 shows mean projection ratings for the 20 attitude predicates by embedding operator; predicates are ordered by their mean rating across all operators (*be annoyed* has the highest overall mean). We observe by-operator variation in projection means as well as differences across the predicates in by-operator variation: For instance, whereas the CC of *be annoyed* projects more from under negation (and questions) than conditionals and modals, the CC of *know* projects less from under negation than questions, but more from under negation than modals, and the CC of *discover* projects less from negation than conditionals and questions, and more from under negation than modals. These results (supported by linear mixed effects models, see **Table 1**) are unexpected based on Karttunen's (1971) distinction between factive and semi-factive predicates: The CC of the purportedly factive predicate *be annoyed* does not project invariably from all four operators, and the CC of the purportedly semi-factive predicate *discover* does not project more from under negation than the other three operators. The pattern observed for *know* is neither that of a factive nor a semi-factive predicate. Similar considerations apply to *see* and *reveal*, which are also considered (semi-)factive in the literature.

Discussion: Implications for projection analyses.

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 operator meanings. In **?**, for instance, the CC of (semi-)factive predicates projects to the global context, except when global projection 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., **??**, whose CCs are analyzed as presuppositions) and or entailed CCs that project unless at-issue with respect to the Question Under Discussion (e.g., **??**). A possible exception is the analysis of **?**, 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.

- Karttunen (1971) suggested that the CC of English factive predicates (e.g. *be annoyed, regret*) projects across all four operators, whereas that of English semi-factive predicates (e.g. *discover, realize, see, notice*) always projects from under negation, but not always from the other three operators. This suggestion does not find empirical support from the experiment reported on in **?** for German, where the CC of the factive predicates *bereuen* 'regret', *wissen* 'know', and *enthüllen* 'reveal' did not project more from under negation than that of the semi-factive predicates *entdecken* 'discover', *bemerken* 'notice', and *herausfinden* 'find out'.

Discussion: Empirical and theoretical implications.

We need to relate our results to those of Siekers and Solstad wrt the question of whether there is xling variation in projection from under different operators.

Our results—that projection is modulated by entailment-canceling operators and that there is by-predicate variation in the effect of operator on projection—have several empirical and theoretical implications. First, the results for the predicates typically considered (semi-)factive, (*viz. be annoyed, know, see, discover* and *reveal*), call into question the assumed distinction between factive and semi-factive predicates (see also Beaver, 2010). Future research appealing to these categories must clarify their definition. Second, claims about projection variability must be relativized to the entailment-canceling operator. While our data replicate the result from Tonhauser et al. (2018) that, in polar questions, the CC of *discover* is less projective than that of *know*, this result does not carry over to conditionals. Finally, our results provide further support (from negation, modals, and conditionals) for the result of Degen and Tonhauser (2022), that projection does not categorically distinguish 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.

Discussion: Novel research question. Can the observed interaction between predicate and operator in mean projection ratings be predicted from lexical semantic/pragmatic properties of the predicates, and, if so, how? This is a pressing question for future research, to which our data offer some tentative answers. We identify four major patterns. The predicates *pretend* and *think* exhibit the **'Negation high'** pattern, shown in panel (a) of **Figure 2**: We tentatively hypothesize that negation (but not the other operators) interacts with the semantic or pragmatic antiveridicality associated with these predicates. The inferential predicates *prove, confirm*, and *establish* exhibit a **'Negation low'** pattern, shown in panel (b): Here, we tentatively hypothesize that the veridical meaning component interacts with negation (but not the other operators), to result in lower projection ratings under negation. For *announce, confess, admit*, and *reveal*, the CC is most projective when embedded in conditional antecedents: This **'Conditional high'** pattern (c) may suggest that the discourse effect of a conditional interacts with the change-of-state communication predicates. Finally, the predicates *inform, know*, and *be annoyed* ex-

hibit a **'Modal low'** pattern (d). The lexical meaning of these predicates, whose CCs are among the most projective, appears to interact with the modal adverb *perhaps*, yielding lower projection ratings.

(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.* •

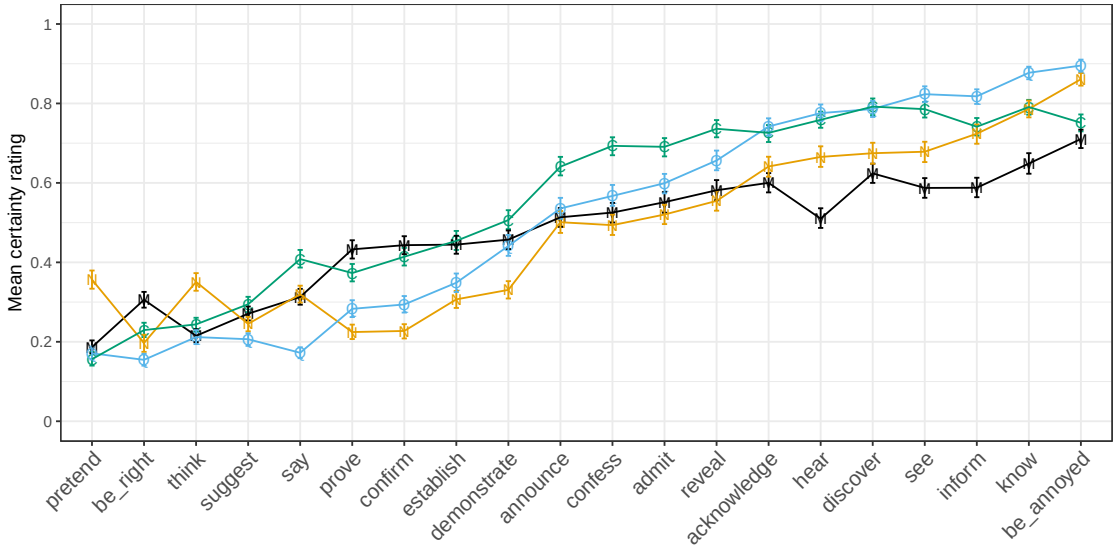

Figure 1: Mean certainty ratings by predicate and operator with 95% bootstrapped confidence intervals. Embedding operator coded by letter and color: `N` (orange): negation, `M` (black): modals, `C` (green): conditional antecedents, `Q` (blue): polar questions.

Model		Estimate	Std. Error	t-value	
#1	Intercept: **be annoyed**/negation	0.87	0.01	75.8	***
	operator: conditional	-0.12	0.02	-7.38	***
	operator: modal	-0.16	0.02	-10.04	***
	operator: question	0.02	0.01	1.74	n.s.
#2	Intercept: **know**/negation	0.79	0.01	69.24	***
	operator: conditional	-0.001	0.02	-0.08	n.s.
	operator: modal	-0.14	0.02	-9.2	***
	operator: question	0.08	0.01	5.72	***
#3	Intercept: **discover**/negation	0.68	0.01	59.48	***
	operator: conditional	0.11	0.02	7.11	***
	operator: modal	-0.06	0.02	-3.6	***
	operator: question	0.1	0.01	7.07	***

Table 1: Relevant parts of three linear mixed effects models that predict certainty ratings from a fixed effect of operator, predicate, and their interaction, with random effects for participant and CC. Models were fit with `lme4`, `lmertest` in R.

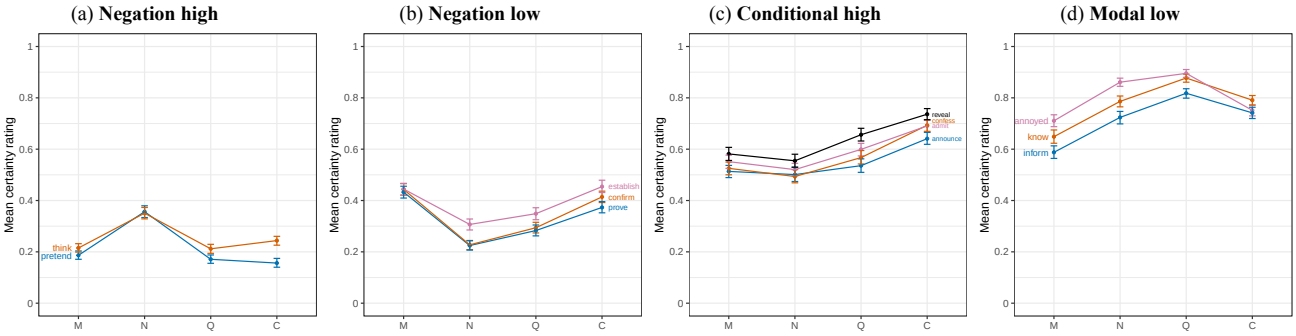

Figure 2: Mean certainty ratings by operator (`M`: Modal, `N`: Negation, `Q`: Polar Question, `C`: Conditional antecedent) with 95% bootstrapped confidence intervals, for some groups of predicates ('predicate patterns').

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