Projection differs across embedding operators

We present experimental evidence **(i)** that the projection of the content of attitude complements differs between entailment-canceling operators, and **(ii)** that this by-operator variation differs between attitude predicates. JT: I don't think point (i) is true when we aggregate across the predicates, no? And when we don't aggregate, point (i) is just point (ii). So perhaps we should just focus on point (ii)? I've written the theoretical discussion that way. The observed variation is not captured by contemporary projection analyses (e.g., Heim, 1983; vander Sandt, 1992; Abrusán, 2011; Schlenker, 2021) and does not align with the long-standing distinction of factive vs. semi-factive predicates (e.g., Karttunen, 1971; Hooper and Thompson, 1973; DjÃ€rv etal., 2018). Rather, the observed by-operator variation reveals a more nuanced picture of lexical semantic/pragmatic properties which raises important questions for future research on projection.

Projection across entailment-cancelling operators. Interpreters 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).

(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.'

Contemporary research rarely considers potential differences in projection from under these four operators, with very few exceptions and conflicting results:

- Smith and Hall (2014) observed that the content of non-restrictive relative clauses and the preparatory content of win was more projective under conditionals than negation, while the content of the clausal complement (CC) of English know and the projective content of epithets exhibited the opposite pattern. In contrast, **?** did not observe that the CC of German wissen 'know' was more projective under conditionals than negation.
- 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'.

To investigate whether these diverging results are due to differences between English and German or differences in the methods of investigation, 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 **?** (the 'certain that' diagnostic; see e.g., Tonhauser etal., 2018; DjÃ€rv 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 (**?**), 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.

Figure1 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 **Table1**) 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 Heim 1983, 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., Heim 1983; vander 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; **?**). 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.

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.

THIS IS OLD, FROM ABOVE: So far, there has been no experimental investigation of by-operator variation comparing factive and semi-factive predicates. However, DjÃ€rv etal. (2018) and Tonhauser etal. (2018) observed by-predicate variation in polar questions. DjÃ€rv etal. (2018), assessing acceptability of affirming the main clause while denying the CC, found higher ratings for be happy and appreciate (assumed to be factive) and be aware than realize (assumed to be semi-factive). Here, it is also not obvious how exactly this task relates to projection. Tonhauser etal. (2018) measured projection of the CC of a broad range of attitude predicates more directly, collecting ratings about speaker certainty about the CC. The observed differences did not match the expectations from Karttunen's classification (e.g., the CC of semi-factive realize was as projective as that of factive be annoyed and more than that of semi-factive discover).

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 etal. (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 **Figure2**: 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 exhibit 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.●

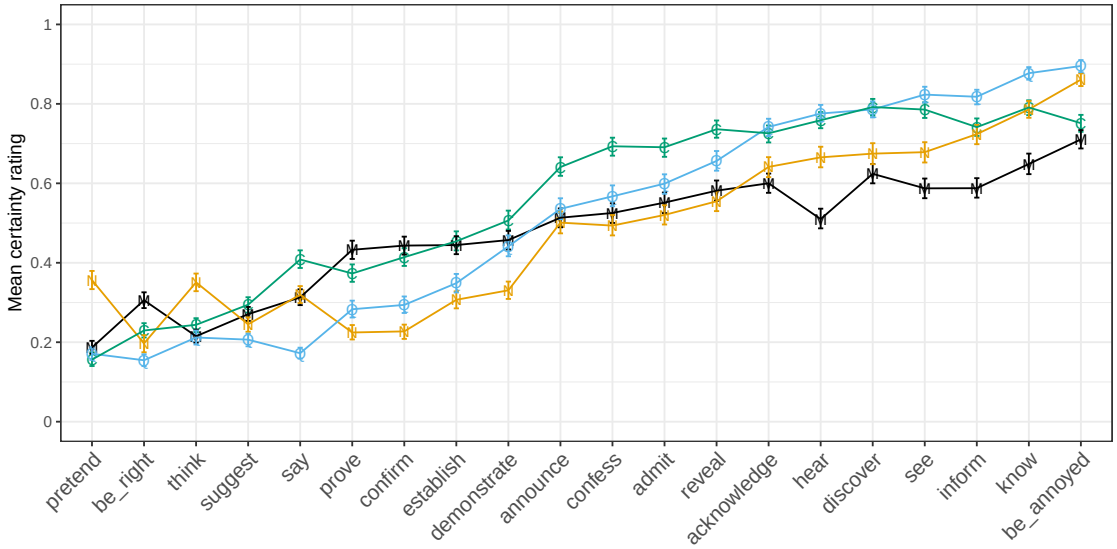

Figure1: Mean certainty ratings by predicate and operator with 95% bootstrapped confidence intervals. Embedding operator coded by letter and color: `N` (orange): negation, `M` (black): modals, `C` (green): conditional antecedents, `Q` (blue): polar questions.

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	***

Table1: 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`.

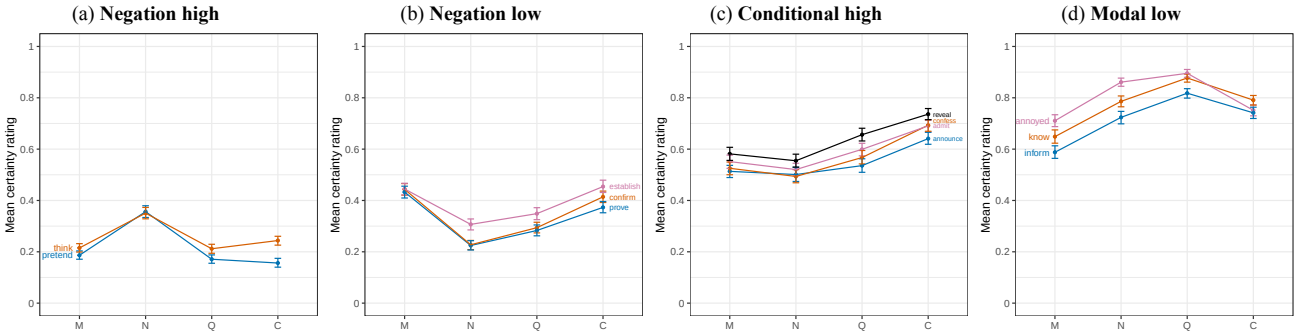

Figure 2: Mean certainty ratings by operator (`M`: Modal, `N`: Negation, `Q`: Polar Question, `C`: Conditional antecedent) with 95% bootstrapped confidence intervals, for some groups of predicates ('predicate patterns').

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