Implicit questions-under-discussion raise expectations only in at-issue main clauses

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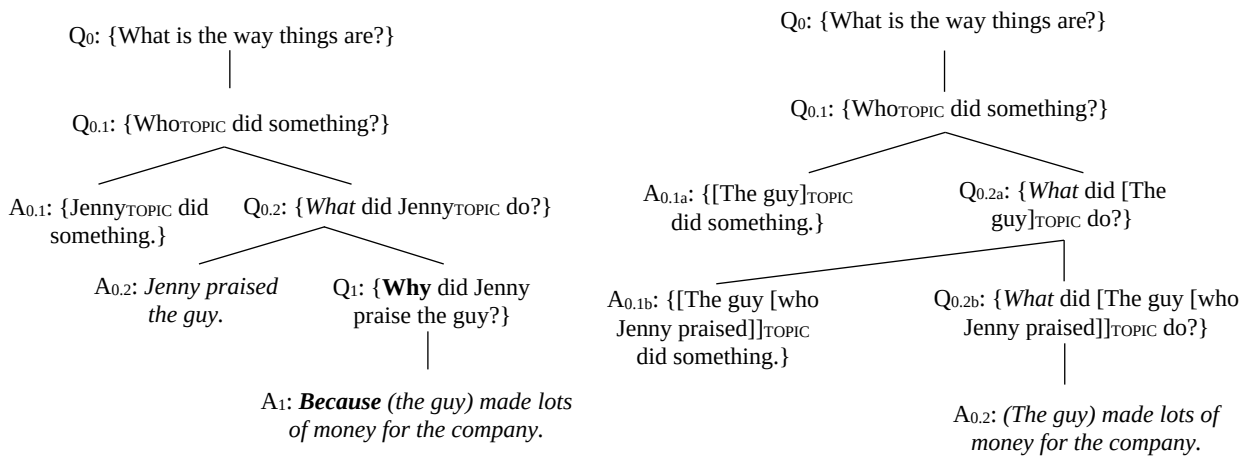
When processing discourse, comprehenders use contextual cues incrementally to predict upcoming coherence relations. A variety of studies have reported that implicit causality (IC) verbs can bias discourse interpretation and elicit expectations for upcoming causal coherence relations between sentences, as well as main and relative clauses (RCs) (e.g., *Jenny praised the guy who made lots of money for the company.* ⇝ 'priased the guy *because* he made lots of money') [1][2]. However, all these studies examined IC verbs in at-issue main clause, and it remains unclear whether IC verbs embedded in non-at-issue restrictive RCs [3], can similarly bias causal main-RC relations (e.g., *The guy who Jenny praised made lots of money for the company*). The current study aims to address this question within an incremental Question-under-Discussion (QUD) framework, where discourse is structured by a series of questions (i.e., QUDs) [4]. While QUDs in narrative discourse are *What*-type questions by default, IC verbs are more likely to raise *Why*-type questions (e.g., *Why did Jenny praise the guy?*) [7], raising expectations for upcoming causal relations. Moreover, the QUD-based analysis suggests that topics are non-at-issue and contained in the denotation of the question [5][6]. When embedded in restrictive subject RCs, IC verbs are also included in topics, and cannot raise *Why*-type QUDs as main IC verbs (Fig. 1). To examine this framework, we conducted a comprehension task and a self-paced reading task. We manipulated Verb Type (IC verb, non-IC verb) and Verb Position (Main, RC), and predicted that readers were more likely to obtain causal interpretations and expectations for upcoming coherence relations when IC verbs are in main clauses because only IC verbs in at-issue main clauses can trigger *Why*-type QUDs in both offline and online processing.

Study 1: Comprehension. 24 experimental stimuli, adapted from [1], were manipulated in terms of Verb Type (IC verb, non-IC verb) and Verb Position (Main, RC) (Table 1). Items were counterbalanced and intermixed with 48 fillers. 24 monolingual English speakers were recruited via Prolific and were instructed to respond to comprehension questions probing the potential causal relationships between (non-)IC verbs (e.g., admire$_{IC}$/talk to$_{non\text{-}IC}$) and events (e.g., built a successful career in sales) in target sentences, using a 7-point Likert scale (1=100% No, 7=100% Yes). A cumulative link mixed model revealed a significant interaction (Est=0.76, SE=0.35, z=2.16, p<.05), with causal relations most likely in the Main IC verb condition. Pairwise comparisons via *emmeans* confirmed that the effect of Verb Position in IC conditions (Est=0.82, SE=0.18, p<.001) was larger than in non-IC conditions (Est=0.49, SE=0.19, p<.05) (Table 2), suggesting that main IC verbs are more likely to trigger a causal inference than RC IC verbs in offline processing.

Study 2: Self-paced Reading. 56 Prolific-recurited monolingual English speakers performed a region-by-region SPR task on the same 24 experimental items in Study 1 and 48 fillers. Fig. 2 shows model estimated log-transformed reading times on the pre-critical, critical, and spillover regions. By region linear mixed effects models revealed a main effect of Verb Position (Est=0.12, SE=0.03, t=3.99, p<.001) and an interaction (Est=-0.09, SE=0.04, t=-2.42, p<.05) on the critical region. Pairwise comparisons via *emmeans* showed that verb position only significantly affected RTs in the IC conditions (Est=-0.12, SE=0.03, p<.001), but not in the non-IC conditions (Est=-0.02, SE=0.03, p=.44). The results indicate that only main IC verbs facilitated online processing by raising relevant *Why*-QUDs and expectations for upcoming answers.

Discussion & Conclusion. The two experiments demonstrate that readers are more likely to make use of main IC verbs, but not RC IC verbs and non-IC verbs, to establish main-RC causal relations in both offline and online processing. The distinction between main IC verbs and RC IC verbs is arguably due to their (non-)at-issue nature. The SPR study also suggests that readers can generate expectations from matrix IC verbs in real-time, resulting in faster processing. These findings align with the expectation-driven QUD processing model, showing that the QUD framework can capture the incremental and probabilistic features of sentence processing [7]. They also support the QUD-based analysis we proposed, and follow-up study may examine this analysis in more contexts with other types of QUD triggers (e.g., Non-Actuality Implicature [8]).



(a) *(b)*

Figure 1. Compact QUD trees for (a) *Jenny praised the guy who made lots of money for the company* and (b) *The guy who Jenny praised made lots of money for the company*. The IC verb (i.e., *praise*) incrementally raises a *Why*-type QUD in tree (a) (bolded), but not in tree (b).

Intro		Andrew looked over the crowd that*had assembled in the company lounge.*
Matrix	*Non-IC*	He **talked to** the woman who*had built a successful career in sales.*
Matrix	*IC*	He **admired** the woman who*had built a successful career in sales.*
RC	*Non-IC*	The woman who he **talked to***had built a successful career in sales.*
RC	*IC*	The woman who he **admired***had built a successful career in sales.*
Wrap up		She arrived at the conference room*just in time for her next meeting.*
Comprehension question		Did Andrew admire/talk to the woman because she had built a successful career in sales?

Table 2. Sample experimental items. Asterisks mark boundaries of regions in Exp 2, and the critical region is underlined.

	Est	SE	z	Pr (> |t|)
Verb Type	-3.56	0.47	-7.53	<.001***
Verb Position	-0.69	0.21	-4.50	<.001***
Interaction	-0.76	0.35	2.16	.031*
Contrast: matrix – RC				
	Est	SE	z	Pr (> |t|)
IC	0.82	0.18	4.63	<.001***
Non-IC	0.49	0.19	2.31	.021*

Table 2. Output of CLMM model and post-hoc pairwise comparisons of Exp 1.

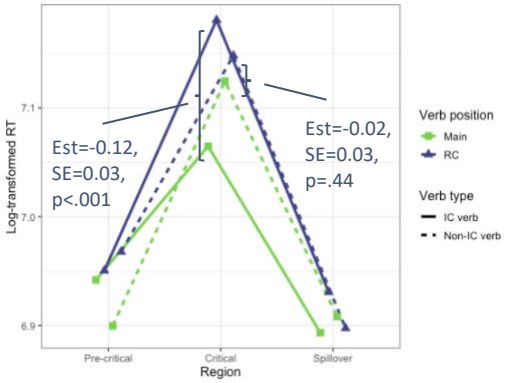


Figure 2. Estimated log-transformed reading times in four conditions in Exp 2.

Reference: [1] Hoek, J., Rohde, H., Evers-Vermeul, J., & Sanders, T. (2020). *Language, cognition and neuroscience.* [2] Hoek, J., Rohde, H., Evers-Vermeul, J. & Sanders, T. J. (2021). *Cognition*. [3] Gibson, E., Desmet, T., Grodner, D., Watson, D., & Ko, K. (2005). *Cognitive Linguistics*. [4] Zimmermann, M., von Heusinger, K., & Onea, E. (2019). *Questions in Discourse: Volume 2: Pragmatics.* [5] Roberts, C. (1996/2012). *Ohio State University Working Papers in Linguistics*. [6] Riester, A. (2019). In *Questions in discourse*. [7] Kehler, A., & Rohde, H. (2017). *Discourse Processes*. [8] Delogu, F., Jachmann, T., Staudte, M., Vespignani, F., & Molinaro, N. (2020). *Discourse Processes*.