





Taking examples such as (3) and in particular, (4), seriously, recent work has argued that the lexical approach lacks explanatory adequacy in that it fails to account for the impact of information structure on projection. These authors have proposed more pragmatically oriented analyses of presuppositions and their projection behavior (reviving key aspects of earlier work by [Stalnaker 1974](#); henceforth the **pragmatic approach**). On this view, adopted in various forms by [Simons \(2001, 2007\)](#), [Beaver \(2010\)](#), [Simons et al. \(2010, 2017\)](#), [Roberts \(2012\)](#), [Abrusán \(2016\)](#), [Tonhauser \(2016\)](#), i.a., content will project if it is entailed or not at-issue, given the pragmatic context, commonly construed in terms of the Question Under Discussion [QUD] ([Roberts 1996, 2012](#)). On this kind of approach, it's not that a lexically encoded presupposition gets canceled or suspended in particular contexts; but rather, that in certain contexts, no presupposition is derived. There are a few prominent variations of this view. Below, we discuss the variations advanced by [Beaver \(2010\)](#), [Abrusán \(2011, 2016\)](#), [Simons et al. \(2017\)](#), and [Tonhauser \(2016\)](#).

For [Abrusán \(2011, 2016\)](#), the behavior of certain content as presuppositional crucially interacts with the information structure of a given utterance, such that backgrounded, non at-issue content ends up being presupposed. The default interpretation for sentences containing a factive predicate will be one where the embedded clause expresses the non at-issue content of the utterance, and is therefore presupposed. However, focusing part of the embedded clause has the effect of turning the embedded proposition into a secondary main point. Thus, the mechanism that otherwise would derive presuppositional status is blocked. Since the embedded proposition does not attain presupposed status, it does not project. In short, because focus is (at least in English) prosodically marked, whether or not the complement of a factive predicate will project depends on the prosodic contour of the utterance.

According to [Beaver \(2010\)](#), [Simons et al. \(2017\)](#), and [Tonhauser \(2016\)](#) on the other hand, the focus-sensitivity of factive presuppositions is accounted for in terms of focus leading the hearer to construe a particular QUD, defined as the Current or Congruent Question [CQ]. The claim is that the content of the embedded clause will project if it is entailed by the CQ.<sup>1</sup> [Tonhauser 2016](#) provides the following definition of the CQ, adapted from [Simons et al. 2017](#).

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<sup>1</sup> Although note that [Simons et al. \(2017: 192\)](#) end up invoking a more complex notion of QUD, involving also a Discourse Question, which “provides the topic of a segment of discourse and imposes relevance constraints on conversational contributions.” They thus hypothesize that in some instances “Projection of the content of the complement of an attitude verb occurs if the best explanation for relevance of the CQ to the DQ requires attribution of acceptance of that content to the speaker.” As pointed out by [Abrusán \(2016\)](#), for sentences taken out of context, this still requires the stipulation that the implicit CQ is veridical. We leave this issue to the side here.

- (5) The Current Question of an utterance is a privileged subset of the focus alternatives set of the uttered sentence (given a structural analysis of that sentence, including focus marking) which meets the following conditions:
- a. The proposition expressed is a member of the Current Question and
  - b. The Current Question has at least one additional member.
- (Tonhauser 2016: 952)

For instance, a sentence such as that in (6a), with narrow focus in the embedded clause, will give rise to the set of focus alternatives in (6b).

- (6) a. Perhaps John discovered that [Jane]<sub>F</sub> left town.  
 b. {p: for some entity *a*, John discovered that *a* left town}

In this case, the CQ for the utterance does not entail the proposition that Jane left town. Therefore, ‘Jane left town’ should not project. The existential claim that ‘someone left town’, however, *is* entailed by the CQ and projects. In contrast, a sentence such as (7a), with narrow focus on the factive predicate, will give rise to the focus alternatives set in (7b).

- (7) a. Sarah: Perhaps John [discovered]<sub>F</sub> that Jane left town.  
 b. {p: for some relation R, John R that Jane left town}

To the extent that the relations R in the focus alternatives set are all veridical (compare (8a) and (8b)), the CQ will entail p, and p will project. Tonhauser (2016) points out that although focus sets are contextually determined, it is still an open question what the most common focus sets are for different predicates in different contexts. The assumption on this account is that the relevant CQs for these types of sentences contain only veridical predicates.

- (8) a. Example veridical R: {*discover*, *know*, *be happy*}  
 b. Example non-veridical R: {*discover*, *think*, *speculate*}

Hence, this account predicts that with focus in the embedded clause, there should be *no* CQ that entails p, and p should therefore not be able to project.<sup>2</sup> With focus on the matrix predicate however, there exists at least one possible CQ that entails p, and thus, we expect projection to be more likely in this context.

<sup>2</sup> Although note that Simons et al. (2017: 192) state that “Projection of the content of the complement of an attitude verb occurs if the Current Question for the utterance entails this content.”—with the caveat that “this hypothesis presents one circumstance in which projection occurs: this is intentionally formulated with if and not iff.”

Before moving on to the current empirical studies, we present a novel theoretical account of the interaction of focus and factivity, building on aspects of both the lexical and pragmatic accounts.

## 1.2 Current Proposal

In our novel account of how focus interacts with the triggering and projection of the inference that *p* is true, we assume a standard lexical account of presupposition triggering and projection. The lexical theory explains the attested large difference in inference types found in Experiment 2 (Section 3) between non-factive and factive predicates (the former come with lexically encoded presuppositions while the latter do not). We supplement this account with an explanation for the prosodic effect by claiming—based on results from Experiment 1 (Section 2), that differences in stress placement can give rise to **independent** pragmatic inferences which can influence the ultimate interpretation of an utterance. This explains the weak effect of focus found in Experiment 2. In particular, we claim that the final interpretation of an utterance is a synthesis of multiple inferences based on both lexically encoded content and pragmatic reasoning, which sometimes conflict with one another.

From the pragmatic account, we adopt the assumption that stress reflects the presence of particular CQs. Our proposal assumes that these CQs themselves give rise to particular inferences about the current state of the common ground (similar to presuppositional inferences about the presence of a proposition in the common ground). Depending on the nature of these inferences, they can provide support for or against the probability that the embedded proposition is held to be true. Thus, we assume that the certainty measure that we collect (i.e., to what extent participants assume that the speaker is committed to the truth of *p*) reflects the participants' estimation of the speaker's estimate of the probability that the embedded proposition is true. Such probabilities will be affected by the total sets of inferences and assertions generated by the speaker's utterance. This conjecture is supported by the experimental results reported in Section 2.

Applying this line of thought to the pragmatic effect, when stress is placed on the embedded subject, as in (9), this prosodically implicates a Question Under Discussion relating to the actor of the embedded event (e.g., 'Who left town: was it Anna or someone else?'). This implied question comes with its own inferences, given in (9c), namely (i) that someone has left town and (ii) that the identity of the leaver is not common ground.

- (9) Sentence: John might have discovered/believed that [Anna]<sub>F</sub> left town
- a. Factive inference from *discover*: 'Anna left town' is common ground.
  - b. Factive inference from *believe*: None.

- c. Inferences from the QUD ‘Who left town?’:
- (i) That someone left town is common ground.
  - (ii) That the identity of the person who left town is not common ground.

For *discover*, these inferences exist **along side** the projected presuppositional inference from the factive predicate (9a). The first inference that someone left town is consistent with the factive presupposition that Anna left town, but the uncertainty as to the identity of the leaver is **inconsistent** with the factive presupposition. The factive predicate lexically projects an inference that claims that the identity of the person who left town is already a part of the common ground, and the QUD gives rise to an inference that the identity of the leaver is unknown. The listener needs to reconcile these contradictory inferences, generally by decreasing certainty in the truth of either inference.

For *believe*, the same QUD inferences project, but in this case these inferences are stronger than the inferences that project from the *believe* alone (namely no inference at all) (9b). Listeners assume that with subject stress the speaker is committed to someone having left town. The proposition that Anna left town is more likely to be common ground once it is given that someone left town, than it is when it is open whether or not anyone left town at all. Thus, listeners can be more certain in the proposition that Anna left town when they derive an inference that the speaker is committed to *someone* having left town.

However, when focus is on the matrix predicate, no relevant inferences arise that may affect the inference that *p* is true.<sup>3</sup> As shown in (10c), the relevant QUD is “what cognitive/emotional relation (might) John have with the proposition ‘Anna left town’”. This gives rise to the inference that John has some relation to the embedded proposition. However, this inference is completely independent of the truth/falsity of the proposition ‘Anna left town’, and is thus predicted to have no influence on the certainty ratings given by listeners.

- (10) Sentence: John might have [discovered]<sub>F</sub>/[believed]<sub>F</sub> that Anna left town
- a. Factive inference from *discover*: ‘Anna left town’ is common ground.
  - b. Factive inference from *believe*: None.
  - c. QUD inferences: John has (or might have) some cognitive relationship to the proposition that Anna left town.

<sup>3</sup> Assuming (a) that the embedding operator, here *might*, is not part of the QUD, and (b) that the focus set for factive predicates includes only veridical relations, whereas that for non-factive predicates includes only non-veridical relations.

In the following two sections, we present experimental data testing our hypothesis about the interaction of prosodically mediated focus and factive presupposition projection.

## 2 Experiment 1 (QUD Experiment)

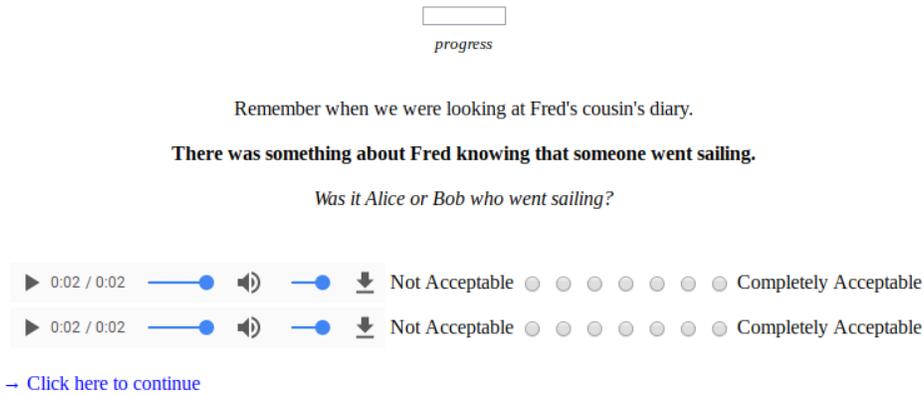
### 2.1 Design

Both our new account and the pragmatic account rely on the assumption that changes in stress evoke different QUDs and associated focus alternative sets (FAS). Our first experiment is designed to explicitly test the availability of various QUDs with different stress placement. In particular, we contrast stress on the matrix predicate (11a) with stress on the embedded subject (11b). The objective is to determine whether a QUD like ‘Who left town: was it Anna or someone else?’ is a more viable QUD with subject stress than matrix stress, as our model assumes (9)–(10). To accomplish this objective, we crossed the prosodic variation in responses (factive predicate stress vs. embedded subject stress) with three different types of contexts designed to elicit different QUDs (12).

- (11) a. John might’ve [discovered]<sub>F</sub> that Anna left town.  
b. John might’ve discovered that [Anna]<sub>F</sub> left town.
- (12) Background: Remember when we were looking at John’s cousin’s diary...
- a. Control 1: Predicate stress (11a) ceiling condition  
**There was something about Anna leaving town.**  
*How did John find out about it?*<sup>4</sup>
- b. Control 2: Subject stress (11b) ceiling condition  
**There was something about John discovering that someone left town.**  
*Was it Anna or Aaron who left town?*
- c. Critical condition: by hypothesis (11a) < (11b)  
**There was something about someone leaving town.**  
*Was it Anna or Aaron who left town?*

The two control contexts were designed so that the intuitive QUD for each stress condition was targeted. The bolded lines were used as a natural way to generate the otherwise island-violating Subject stress control QUD (‘Was it Anna or Aaron who John discovered went sailing?’) The Predicate stress control (12a) backgrounded the embedded proposition and left open what the relationship was between the attitude

<sup>4</sup> The question in this condition varied by predicate type in order to make sure that the question was maximally compatible with the predicate.



**Figure 1** Screenshot of an experimental trial

holder and the embedded proposition. The Subject stress control (12b) backgrounded the attitude holder’s attitude to the embedded proposition and foregrounded the focus alternatives from the embedded proposition. Finally, the Critical condition (12c) targeted whether subject stress was a viable response in a context where the current QUD is only about the embedded proposition to the exclusion of the matrix subject (e.g. ‘Who left town: was it Anna or Aaron?’).

Figure 1 shows a screenshot of what a trial looks like. For each trial, the participants were presented with the initial line of the context. They then pressed a key twice to reveal the remaining two lines. Crucially, all of the contexts ended in a question, whose acceptability with respect to the different stress conditions was being tested. After all three lines of the context had been revealed, the participants pressed a key to reveal two sound files, representing the two stress conditions in (11), which they were told contained two possible answers to the question. Each sound file played automatically, and participants could not rate the sound files until they had listened to it. The participants had the option of replaying the sound files as many times as they wished. After listening to the sound files, they were asked to rate the acceptability of the two responses in the sound files as answers to the above question on a 7 point Likert scale ranging from "Not Acceptable" to "Completely Acceptable". We included the two sound files representing the two stress conditions with each question context explicitly to encourage participants to contrast the two stress conditions for each question context. Response times were not collected.

## 2.2 Participants

76 undergraduate students, recruited through the University of Pennsylvania’s Psychology department’s subject pool, participated in the study for course credit. The

participants were given a link to the experiment to take the experiment on their own over the internet. The experiment was implemented in Ibex.<sup>5</sup> It took approximately 10 minutes to complete. Some participants took the experiment twice. In these cases, only the first set of results were included in the analysis.

### 2.3 Materials

The auditory stimuli were recorded on a Blue Snowblue microphone in the Phonetics Lab in the Linguistics department at the University of Pennsylvania. The target sentences were produced by splicing together the recordings of the different matrix and embedded sentences to avoid any unintended prosodic variation. Each subject saw 12 items (4 of each context type) for which the rating on both stress patterns was gathered (giving a total of 24 ratings per subject). The experiment included a mix of non-factive, cognitive factive and emotive factive matrix predicates (each subject heard 6 factive and 6 non-factive items).<sup>6</sup> Each of the 12 items was shown in each context type between subjects.

The questions in the control contexts were manipulated to be maximally appropriate for the different predicates. In the Subject stress control, the context varied depending on the predicate used in the actual sentences. For the Predicate stress control, the question in the context varied between: ‘How did John feel about it?’, ‘Did John know that Anna left town?’, and ‘How did John find out about it?’ depending on the nature of the embedding predicate.

### 2.4 Predictions

We included the Control contexts to provide baselines for availability of a question. The Predicate stress control context was predicted to receive high ratings with predicate stress and low ratings with subject stress. The Subject stress control context was predicted to receive high ratings with subject stress and low ratings with predicate stress. In order for our explanation of prosodic effects on factive presupposition projection to be viable, the QUD represented by the Critical condition must be available in the subject stress condition and not available in the Predicate stress condition. Therefore, we predicted that the Critical condition context would receive low ratings in the predicate stress condition and high ratings in the subject stress condition (although probably not as high as in the Subject stress control context).

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<sup>5</sup> See <http://spellout.net/ibexexps/SchwarzLabArchive/THFactQUD/experiment.html?id=Archive> for an archived version of the experiment.

<sup>6</sup> The predicates included were: *been concerned*, *been disappointed*, *been hopeful*, *been informed*, *been upset*, *been worried*, *believed*, *discovered*, *hoped*, *loved*, *noticed*, and *said*.

## 2.5 Statistical Methods

We designed the experiment to encourage participants to contrast the two stress conditions. Our hypothesis relies on there being a difference in the availability of particular questions in the two stress conditions. Since every item included two ratings, the result from each item was reduced to the rating in the Predicate stress condition minus the rating in the Subject stress condition. This difference in their score represents the size and direction of the difference between the two conditions.

A Bayesian linear mixed effects model was fit using the `rStanarm` packages (Stan Development Team 2016) including context type, factivity of the predicate, factive type (cognitive vs. emotive) and their interaction as fixed effects. Intercept and context random effects were included for both participant and item. Context was coded with two variables: (1) the effect of having a question of the form ‘Was it X or Y who ...’, which was shared between the Critical and subject stress control context and (2) the effect of the difference between the Critical condition and the Subject stress control (i.e., the effect of the difference in framing for the context question).

## 2.6 Results and Discussion

Figure 2 shows the mean results from the experiment, while Table 1 shows the 90% posterior interval from the model. The 90% interval is the recommended summary statistic for the model, since there is a 95% chance that the parameter value is above the lower bound and a 95% chance that the parameter value is below the upper bound. Neither a main effect of factivity/factive type nor an interaction between either and the context manipulation was found (i.e., the model estimates that the effects are small and could go in either direction). The intercept shows that there was a substantial effect of stress condition in the Predicate stress control (namely the Predicate stress condition was rated ~3.3 points higher than the Subject stress condition). This effect was reversed in the Subject stress control and Critical condition, where the Subject stress condition was rated ~2.7 points higher. This effect was slightly (~0.4 point) smaller in the Critical condition, which indicates that (at least some) participants were sensitive to the context manipulation outside of the final question.

As discussed in the predictions, the crucial question investigated in this experiment was the availability of the Critical condition in the Subject stress condition. The results show that a QUD like ‘Who left town: was it Anna or someone else?’ is a viable QUD even in cases where ‘Anna left town’ is embedded under an attitude predicate. The fact that we found a slight difference between the Critical condition and the Subject stress control shows that participants were sensitive to the distinction

between a QUD of the form ‘Was it Anna or someone else who left town?’ versus ‘Was it Anna or someone else who John discovered left town?’.

	5% LB	Median	95% UB
Pred. Stress Control (Intercept)	2.96	3.3	3.62
Effect of Factivity	-0.33	0.1	0.54
Emotive vs. Cognitive	-0.97	-0.4	0.09
Effect of Question Type	-6.64	-6.0	-5.35
Effect of Critical Item	0.2	0.4	0.71
Factivity x Question Type	-1.06	-0.4	0.16
Factivity x Critical Item	-0.58	0.0	0.60
Factive Type x Question Type	-0.26	0.5	1.28
Factive Type x Critical Item	-0.53	0.2	1.00

**Table 1** 90% posterior intervals for effect sizes on difference score

### 3 Experiment 2 (Projection Experiment)

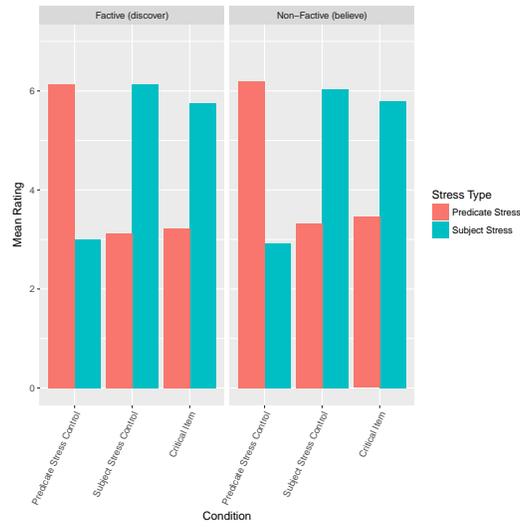
#### 3.1 Experimental background: Tonhauser 2016

In our second experiment, we explicitly test for the existence of a prosodic effect on factive presupposition projection. Before turning to our own experiment, we summarize a previous attempt to experimentally investigate this phenomenon and motivate our investigation.

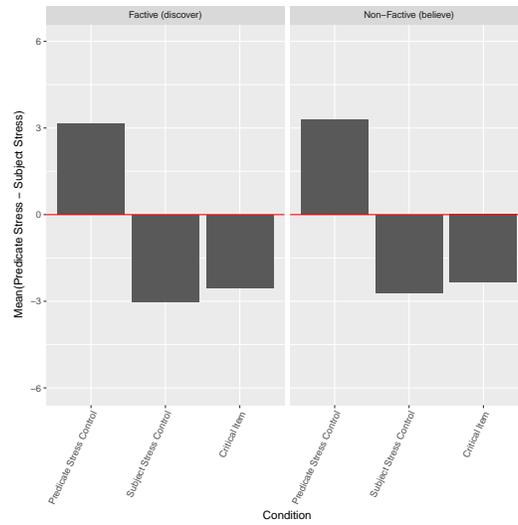
Tonhauser’s (2016) experiment was designed to test the predictions of the approach outlined in Section 1.1 for factive presupposition projection. In order to test the effect of information structure on projection, the experiment manipulated prosody by placing narrow focus on the factive matrix predicate or within the embedded clause, using items such as (13).

- (13) Dana (about Scott and Valeria)  
 [Context: overhearing a conversation at a party]
- a. Perhaps he [noticed]<sub>F</sub> that she is a widow. H\* on predicate
  - b. Perhaps he noticed that [she]<sub>F</sub> is a widow. L+H\* on pronoun
  - c. Perhaps he noticed that she is a [widow]<sub>F</sub>. L+H\* on content

The target sentences, which included a factive verb and the modal particle *perhaps* (*Perhaps he noticed that she is a widow.*) were presented aurally, as illustrated in Figure 3.

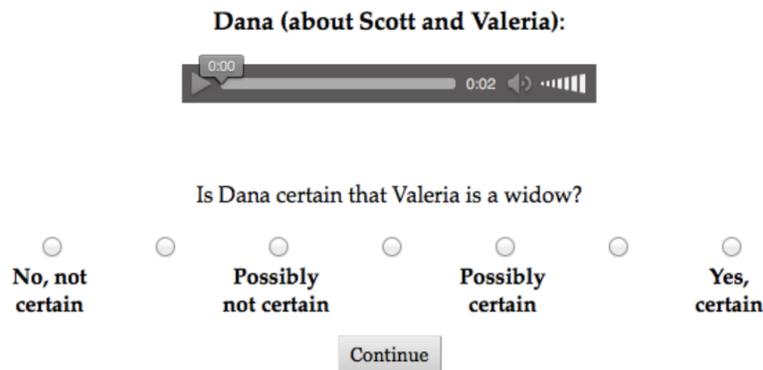


(a) Mean rating by condition



(b) Mean difference score by condition

**Figure 2** Rating graphs



**Figure 3** Tonhauser’s experimental set-up (Tonhauser 2016: 944).

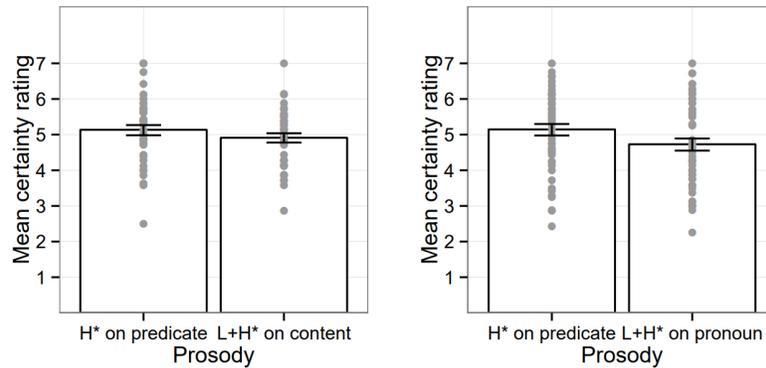
The predicates used were *discover*, *realize*, *know*, *be aware*, and *notice*. Two unembedded control sentences (*I am tired.* and *I was invited to the party.*) were also included to make sure that participants were paying attention.

The prediction was that narrow focus in the embedded clause would reduce projection. Projection was measured as the speaker’s commitment or certainty of the truth of the embedded proposition. Hence, after hearing the target sentence, the participants were presented with a question such as (14). The dependent variable was the participants’ rating of the speaker’s certainty on a 7-point likert scale (1=not certain—7=certain).

(14) Is Dana certain that Valeria is a widow?

Tonhauser found a significant difference between the predicate stress condition and both conditions with stress in the embedded clause, in the direction predicted by the QUD-based approach (focus on pronoun received lower ratings than predicate focus;  $\beta = -0.68$ ,  $p < .05$ , and focus on the content noun (e.g., *widow*) received lower ratings than predicate focus;  $\beta = -0.49$ ,  $p < .05$ ). The results are illustrated in Figure 4 from Tonhauser 2016: 945.

Tonhauser not only concludes from this that prosody *influences* projection for utterances with factive predicates embedded under an entailment canceling operator, but that the results provide evidence for the QUD-based analysis from Simons et al. (2017) outlined in Section 1.1—whereby information structure (here mediated by focus) *drives* projection. That is, the condition with narrow focus in the matrix clause will give rise to the CQ in (15a), which (given a domain of veridical relations R) entails p (predicting projection), and the conditions with narrow focus in the embedded clause will give rise to the CQs in (15b) and (15c), neither of which



**Figure 4** Graph of results from [Tonhauser \(2016: 945\)](#).

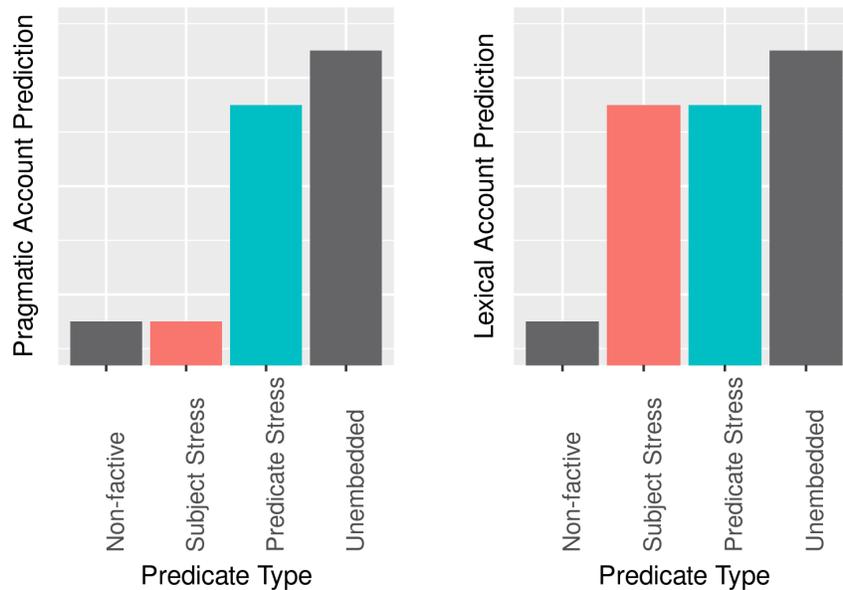
entails  $p$  (predicting non-projection). On the assumption that presuppositions are derived when a proposition is entailed by the CQ, only (15a) will generate a factive presupposition, and thereby project.

- (15) a. { $p$ : for some relation  $R$ , John  $R$  that she is a widow} (13a)  
 b. { $p$ : for some entity  $a$ , John discovered that  $a$  is a widow} (13b)  
 c. { $p$ : for some property  $\pi$ , John discovered that she is a  $\pi$ } (13c)

She further argues that the classical analyses of projection ([Heim 1983 et seq.](#)), where presuppositions are lexically encoded on the factive predicate, are unable to predict the observed results.

Although [Tonhauser's](#) study demonstrates that information structure (mediated by prosody) indeed has an influence on presupposition projection, it is less clear that the results provide strong support for the claim that projection is in fact *driven* by the QUD. To begin with, the contrast observed between the embedded clause and matrix clause focus conditions was small. Secondly, and more critically, the experiment did not include any baseline conditions for projection and non-projection (i.e., unembedded sentences,<sup>7</sup> and sentences with non-factive clause embedding predicates, respectively). That is, if the construal of a particular CQ is what gives rise to projection (by either entailing or not entailing  $p$ ), then we would expect to see a distribution of responses like that in the left-hand graph in Figure 5. (Predicate Stress may lead to less projection than unembedded controls to the extent that non-veridical alternatives are considered for  $R$ .) On the other hand, if presuppositions are lexically encoded on certain (factive) verbs, then we would expect to see a distribution similar

<sup>7</sup> The two unembedded control sentences in [Tonhauser's](#) experiment were not included in the analysis.



**Figure 5** Predictions for (the strong versions of) pragmatic QUD-based (left) and lexically based (right) approaches to presupposition projection.

to that in the right-hand graph in Figure 5, where stress-placement inside vs. outside of the embedded clause has no effect on projection.

Without a baseline of comparison between cases where (the equivalents of) projection and non-projection respectively are uncontroversially expected, as reflected in straightforward judgments about the presence or absence of the relevant inference (that the speaker is committed to  $p$ ), it is difficult to assess the claim that [Tonhauser’s](#) results specifically provide evidence in favor of the QUD-based approach of [Simons et al. 2017](#). Hence, our experiment, reported below, crucially includes baseline conditions for projection and non-projection to assess more directly how the effects of prosody and potentially independent lexical factivity compare.

### 3.2 Design

The experiment closely followed [Tonhauser’s](#) design in order to maximize comparability, with some modifications (see Section 3.4). We used the same general set-up where the participants were told to imagine that they happened to overhear a conversation at a party, involving sentences similar to those used by [Tonhauser](#). The stimuli were presented aurally, and varied stress in the matrix clause (on the factive predicate) and the embedded clause (on the subject). Unlike [Tonhauser \(2016\)](#), we

did not include a third condition with stress on the embedded predicate (Tonhauser’s L+H\* on content condition; (13c)), given that Tonhauser only observed a very small difference between the two conditions with focus in the embedded clause, and that the two proposals considered here make the same predictions for the two embedded stress conditions. The dependent variable was the participants’ rating of the speaker’s certainty about whether the embedded proposition holds, measured on a 7-point likert scale. The participants were told that there is no right or wrong answer, but to simply choose the answer they preferred.

### 3.3 Participants

57 undergraduate students, recruited through the University of Pennsylvania’s Psychology department’s subject pool, participated in the study for course credit. They all reported being native speakers of English and having normal hearing. The participants were given a link to the experiment to take the experiment on their own over the internet. The experiment was implemented in Ibex.<sup>8</sup> It took approximately 10 minutes to complete.

### 3.4 Materials

In addition to the prosodic variation (factive predicate stress vs. embedded subject stress), the current experiment included three embedding conditions (factive matrix predicate vs. non-factive matrix predicate vs. unembedded), as in (16).

- |      |    |   |             |
|------|----|---|-------------|
| (16) | a. | John might’ve discovered that Anna left town. | Factive     |
|      | b. | John might’ve believed that Anna left town.   | Non-factive |
|      | c. | Anna left town.                               | Unembedded  |

The auditory stimuli used in this experiment were a superset of those used in Experiment 1 (Section 2). They were recorded on a Blue Snowblue microphone in the Phonetics Lab in the Linguistics department at the University of Pennsylvania. The target sentences were produced by splicing together the recordings of the different matrix and embedded sentences to avoid any unintended prosodic variation. As shown in (16), we also changed the embedding operator from *perhaps* to *might’ve*. This was done to avoid a potential metalinguistic interpretation of *perhaps*, along the lines of ‘I don’t know whether this answers your question, but perhaps the fact that he discovered that p is relevant’.<sup>9</sup>

<sup>8</sup> See <http://spellout.net/ibexexps/SchwarzLabArchive/THProsPs/experiment.html> for an archived version of the experiment.

<sup>9</sup> Thanks to Satoshi Tomioka for this point.

		Verbal
Unembedded		——
Cognitive Factive		discover, realize, notice
Emotive Factive		regret, love, resent
Non-factive		believe, hope, say
		—————
		Adjectival
Unembedded		——
Cognitive Factive		<i>be informed, be conscious, be aware</i>
Emotive Factive		<i>be happy, be disappointed, be upset</i>
Non-factive		<i>be hopeful, be worried, be concerned</i>

**Table 2** Factive and non-factive predicates used in the experiment (verbal and adjectival).

It has been observed in the presupposition literature going back to Karttunen (1971), that cognitive and emotive factives differ in several regards with respect to the status of the factive presupposition concerning the embedded content (see for instance Simons 2001, Abusch 2002, 2010, Chemla 2009, Romoli 2015, Abrusán 2016, and Djärv et al. 2017). Hence, the present study included both cognitive and emotive factive predicates. We also speculated that a difference between verbal (e.g., *discover*) and adjectival forms (e.g., *be aware*) could affect projection. Therefore, we balanced the number of verbal and adjectival predicates across the different embedding conditions. The full list of predicates is given in Table 2 (the color and font style will be used to refer to these categories in the rest of the paper).

The 48 test items involved a speaker (Sarah), uttering a sentence about some other people (John and Anna). Each item had variations in all 8 conditions; [factive predicate vs. embedded subject] × [cognitive factive matrix predicate vs. emotive factive matrix predicate vs. non-factive matrix predicate vs. unembedded], as illustrated in (17). Each subject saw all conditions across items, but the different lexical content in the embedded clause associated with an item was only shown in one condition, counter-balanced across subjects using a latin-square design.

- (17) a. Cognitive, Subject Stress:  
Sarah: John might've discovered that [Anna]<sub>F</sub> left town.
- b. Cognitive, Predicate Stress:  
Sarah: John might've [discovered]<sub>F</sub> that Anna left town.



Is Sarah certain that Anna left town?

No, not certain        Yes, certain

**Figure 6** Task used in the current experiment.

- c. Emotive, Subject Stress:  
Sarah: John might've regretted that [Anna]<sub>F</sub> left town.
- d. Emotive, Predicate Stress:  
Sarah: John might've [regretted]<sub>F</sub> that Anna left town.
- e. Non-Factive, Subject Stress:  
Sarah: John might've believed that [Anna]<sub>F</sub> left town.
- f. Non-Factive, Predicate Stress:  
Sarah: John might've [believed]<sub>F</sub> that Anna left town.
- g. Unembedded, 'Subject Stress':  
Sarah: [Anna]<sub>F</sub> left town.
- h. Unembedded, 'Predicate Stress':  
Sarah: Anna left town.

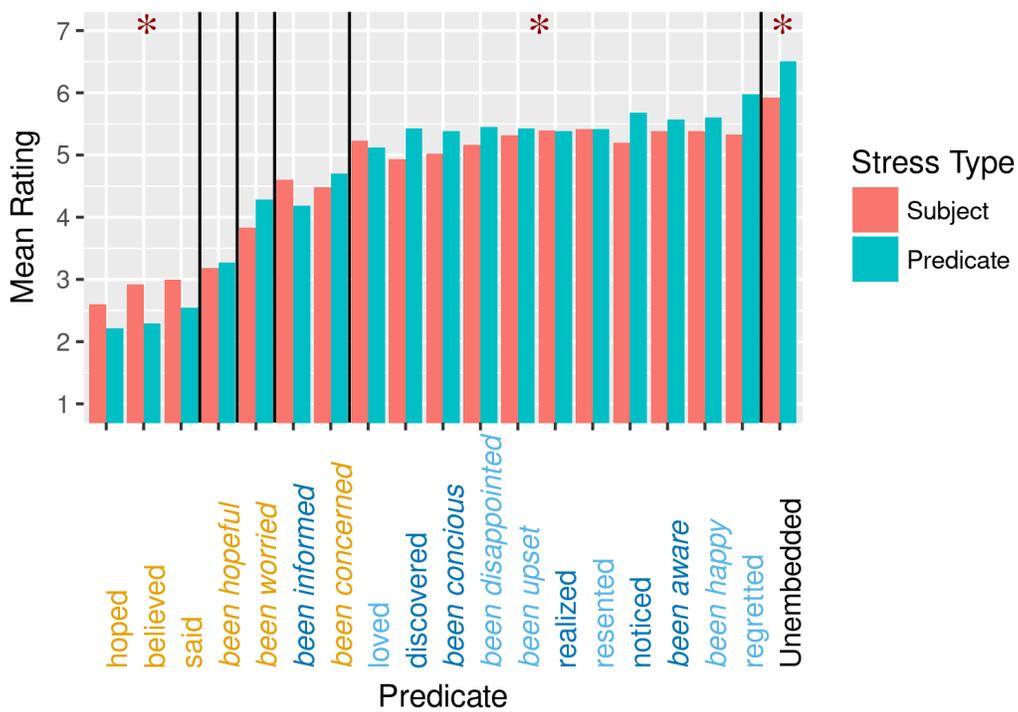
As in Tonhauser's study, the target sentence was followed by a question such as ((18)), asking about the speaker's commitment to *p*.

(18) Is Sarah certain that Anna left town?

The set up of the experiment is illustrated in Figure 6.

### 3.5 Statistical methods

To test our predictions, we used two different statistical methods: Conditional Inference Trees and Bayesian Mixed Effects Models. The Conditional Inference Trees were used to test whether there was significant clustering of stress conditions and embedding predicates on the basis of certainty ratings. They were fit using the *partykit* package in R (Hothorn & Zeileis 2015 and Hothorn et al. 2006).



**Figure 7** Mean certainty ratings by embedding predicate and stress condition (grouping and significance from Conditional Inference Tree)

Bayesian Linear Mixed Effects models were used to test whether there was an effect of stress on subjects’ perception of the speaker’s certainty in the embedded proposition. A 90% credible interval is reported, which provides the range of parameter values such that there is a 95% chance that the value is above the bottom of the range and a 95% chance that the value is below the top of the range. Significance corresponds to zero not being a plausible parameter value. The Median (found in Table 3) gives the best estimate of the effect size, i.e., the number of points changed on the scale in that condition. The model was fit with the *rstanarm* package in R (Stan Development Team 2016) and included only random intercepts (more complex random effect structures did not converge).

### 3.6 Results

The Conditional Inference Tree (see Figure 7) clustered (most) factives together as a single group (blue font on x-axis). The only exception was *be informed*, which

	5% LB	Median	90% UB
Factives (Intercept)	5.0	5.2	5.4
Non-Factive Diff.	-2.0	-1.9	-1.7
Unemb. Diff.	0.6	0.7	0.9
Fact. Pred. Stress	0.03	0.2	0.3
N.F. Stress. Interact.	-0.5	-0.3	-0.04
Unemb. Stress Interact.	0.2	0.4	0.6

**Table 3** Parameter estimates from the Bayesian Mixed Effects Model

patterned with some of the adjectival non-factives.<sup>10</sup> Adjectival non-factives (orange, italics) were gradually ranked higher than the verbal non-factives (orange, plain text), but lower than the factives (blue). Factives and verbal and adjectival non-factives were rated below the unembedded conditions (black), although the factives (even with subject stress) were much closer to the unembedded conditions than to the verbal non-factives (orange, plain text).

Stress was shown to have a significant effect within the factive category, which was supported by the mixed effect analysis, for which all credible values according to the Bayesian model were positive (meaning that being in the predicate stress condition reliably led to higher certainty ratings). However, the magnitude of the difference between the factive and non-factive category (model estimate of 1.9 points) was an order of magnitude larger than the difference between predicate and subject stress (model estimate of 0.2).

In addition to the expected effect of stress in the factive category, there was also a reliable effect of stress with both the verbal factives and in the unembedded condition. In the unembedded condition, the effect of stress was stronger than with factives, and in the same direction (stress on the subject led to decreased ratings). However, for verbal non-factives, the effect of stress was in the **opposite** direction: subject stress led to increased ratings.

#### 4 Discussion

Our experiment successfully replicated the results from [Tonhauser 2016](#): stress on the embedded subject leads to decreased certainty ratings for the factive inferences introduced by the presupposition triggers under investigation. However, we crucially find that this effect is substantially smaller than the difference associated with the

<sup>10</sup> See [Anand & Hacquard 2014](#) for an argument that its verbal counterpart *inform* is non-factive, contra [Schlenker 2008](#).

traditional lexical distinction between factive and non-factive predicates, with the latter patterning overall very closely to unembedded content.

Thus, the inclusion of baseline comparisons for projection and non-projection in our second study puts the overall results in a very different perspective. The relatively small size of the effect of prosodic stress on factives, in combination with the finding that we still find substantially higher certainty ratings for factives in the subject stress conditional, compared to non-factive predicates, argues against strong versions of pragmatic accounts of projection, i.e., that pragmatic factors are the **cause** of the factive/non-factive distinction. More specifically, it directly argues against the claim that such causal pragmatic effects are driven by prosodic signals of the QUD. Nevertheless, the existence of a robust (if small) effect of prosody on judgments of certainty about whether the speaker is committed to the embedded content still requires an explanation, even if a lexical approach to presupposition triggering and projection is adopted.

When looking at the impact of stress, we found that our prosodic manipulation actually had an effect for all predicate types. One surprising lexical contrast with regards to the prosodic effects was a gradient difference between verbal and adjectival non-factives. Adjectival non-factives (to varying extents) showed more projection-like behaviour than verbal non-factives. For factives and unembedded clauses, stress on the embedded clause subject **decreased** certainty in comparison to either stress on the matrix predicate (for factives) or no marked stress (for unembedded clauses).<sup>11</sup> For verbal non-factives, the effect of stress was in the opposite direction, stress on the embedded subject **increased** certainty in comparison to stress on the matrix predicate. While these stress effects were significant, they were an order of magnitude smaller than the lexical differences mentioned above.

We take these findings to support the novel account of how focus interacts with factive presupposition triggering outlined in Section 1.2. On this account, the QUD inferences generated by focus-placement in the embedded clause will either strengthen (for non-factives) or weaken (for factives) the inference that the speaker is committed to the embedded proposition. In the case of stress on material from clauses embedded under *non-factive* predicates, the QUD inferences supplement the lack of a factive inference from non-factive predicates by giving rise to an existence inference: focus on the embedded subject generates a CQ that entails that for *some individual*, the embedded predicate holds. Here, the existence inference generated by focus is stronger than any inferences from the non-factive predicate (i.e., no inference at all). Thus, prosody can give rise to effects resembling a weak factive

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<sup>11</sup> We interpret the effect in the unembedded condition as being due to at least some participants interpreting stress on the subject as a question. This interpretation is corroborated by comments left by two participants at the end of the experiment. We therefore leave this to the side for the remainder of the discussion.

presupposition. In the case of stress on material from clauses embedded under *factive* predicates however, this type of QUD inference contradicts the factive inference. Here, the existence inference generated by focus in the embedded clause is weaker than the truth inference generated by the factive predicate. Thus, this contradictory QUD inference can then weaken the inference drawn from the lexically factive predicate. However, it does not eliminate the factive inference entirely.

## 5 Concluding remarks

Prosodically mediated pragmatics does impact the interpretation of presupposed content in the context of embedding operators. However, this effect is not strong enough to account for the existence or non-existence of presupposition triggering and projection. We propose that presupposition projection as a process is unaffected by the prosodic contour of an utterance. Instead, we take these results to favor a traditional lexical account of factive presupposition generation and projection, thus straightforwardly capturing the large scale differences between predicate types. To account for the (small) effects of prosody, we propose an independent pragmatic process of inference resolution, where the ultimate interpretation of an utterance is derived from the synthesis of multiple inferences.

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