Prosodic cues to presupposition projection[*]

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Abstract In English utterances with factive predicates, the content of the clausal complement of the predicate may project, i.e., taken to be a commitment of the speaker, even when the predicate is embedded under an entailment-canceling operator like negation or an epistemic possibility modal (e.g., Kiparsky & Kiparsky 1971; Karttunen 1971). Based on impressionistic judgments, Beaver (2010) and Simons, Beaver, Roberts & Tonhauser (to appear) suggested that whether the content of the complement of an utterance with a factive predicate projects may depend on the information structure of the utterance and, since information structure is prosodically marked in English, on the prosody of the utterance. This paper describes three perception experiments designed to explore the influence of the prosody of an utterance with a factive predicate on the projection of the content of the clausal complement. The results of these experiments suggest that the prosody of such utterances indeed provides a cue to listeners about whether the speaker is committed to the content of the complement, i.e., whether the content of the complement projects. The paper concludes with an analysis of the findings in the question-based analysis of projection advanced in Simons et al. to appear.

Keywords: presuppositions, factive predicates, prosody, Questions Under Discussion

1   Introduction

Projective content is utterance content that may be taken to be a commitment of the speaker (or the author, in written language) even when the content is introduced by an expression in the scope of an entailment-canceling operator (cf., Chierchia & McConnell-Ginet 1990; Potts 2005; Tonhauser, Beaver, Roberts & Simons 2013). The author of the blog post headline in (1), for instance, may be taken to be committed to the content of the complement (that the author is married with a kid) even though the complement clause that introduces this content is embedded under sentential negation, an entailment-canceling operator:

(1) My family doesn't know that I am married with a kid.[1]

Classical analyses of examples like (1), such as Heim 1983 and van der Sandt 1992, attribute the projective behavior of the content of the complement to the predicate. On such analyses, the content of the complement is specified by the predicate, e.g., *know* in (1), to be a presupposition, which means that the content of the complement must be entailed by or satisfied in (depending on the details of the analysis) the common ground of the interlocutors prior to the utterance being interpreted. As a consequence, the content of the complement is taken to be a commitment of the speaker. The fact that the content of the complement is not interpreted in the scope of the entailment-canceling operator, e.g., negation in (1), gives the impression of the content 'projecting over' negation. Predicates like *know* that presuppose the content of the complement are called 'factive predicates' (e.g., Kiparsky & Kiparsky 1971; Karttunen 1971).

It is well-known that the content of the complement of factive predicates is not always taken to be a commitment of the speaker (see, e.g., Karttunen 1971), i.e., does not always project over entailment-canceling operators. In the naturally occurring example in (2), for instance, the author is not taken to be committed to the content of the complement of the factive predicate *discover*, that the method is wombat-proof:

(2) They [the mattress springs] also work well to deter rabbits & foxes from digging into the chook-pen (Hen-run). Dig a shallow trench the width of a single mattress, then place the springs flat in the trench. [...] I haven't tried this with wombats, though, & if anyone discovers that the method is also wombat-proof, I'd really like to know!   (adapted from Beaver 2010: 79)

To account for examples like (2), classical analyses resort to 'local accommodation': the presupposed content of the complement can be accommodated in the local context of the embedding operator (the antecedent of the conditional in (2)), if adding the content of the complement to the common ground would lead to a contradiction, uninformativity or problems with binding (Heim 1983; van der Sandt 1992). In (2), for instance, the linguistic context leading up to the relevant utterance, in particular the utterance *I haven't tried this [method] with wombats*, strongly suggests that the author is not committed to the method being wombat-proof. Local accommodation of the content of the complement in the antecedent of the conditional is licensed in this example to avoid attributing a contradicting belief to the author.

Beaver 2010, a paper that has been circulated since 2002, advanced the idea that the prosodic realization of an utterance with a factive predicate influences whether the content of the complement projects. Beaver (2010: 95) proposed that "the crucial factor determining projection behavior is…the choice between an accented

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1 http://community.babycenter.com/post/a42276010

or deaccented propositional complement". To illustrate, consider the title of Beaver's paper in (3), a naturally occurring question with the factive predicate *noticed*:

(3) Have you ever noticed that your belly button lint colour is related to the colour of your clothing?   (title of Beaver 2010)

Beaver (2010: 97) suggested that "[i]f you read the title aloud, and stress "noticed" then" the content of the complement, that your belly button lint color is related to the color of your clothing, projects. But "if you do not accent "notice," and place the main accent within the complement" (*ibid.*), then the content of the complement does not necessarily project.

The examples in (4) serve to further illustrate the relation between the information structure of an utterance and the projection of the content of the complement. In these examples, angle brackets with a subscripted 'F' ([ ]$_F$) identify focused expressions (see, e.g., Rooth 1992). Beaver (2010: 93) suggested that (4a), in which the last word of the clausal complement of *discover* is narrowly focused, "does not imply that the student is guilty", i.e., the content of the complement is not a commitment of the professor. (4b), on the other hand, where the factive predicate *discover* is focused and the complement clause is deaccented, "conjures up an image of complicity between the all-knowing professor and the guilty student", i.e., here the professor is committed to the student's work being plagiarized.

(4) A professor to a student: (Beaver 2010: 93)

   a. If the T.A. discovers that your work is [plagiarized]$_F$, I will be [forced to notify the Dean]$_F$.

   b. If the T.A. [discovers]$_F$ that your work is plagiarized, I will be [forced to notify the Dean]$_F$.

In sum, Beaver (2010) proposed that the content of the complement of an utterance with a factive predicate projects if it is deaccented, but does not project if an expression in the clausal complement is narrowly focused. Beaver (2010) limited this claim to short complement clauses: "…when the factive complement is long, it is likely to contain some pitch accents. For the moment I make no claims about whether presupposition has any intonational correlates in the case of long factive complements" (p.95).

The claim that the prosodic realization of utterances with factive predicates influences the projection of the content of the complement was recently made again in Simons et al. to appear. In particular, Simons and her colleagues pointed out that when an expression in the clausal complement is narrowly focused, a content other than the content of the complement may project. To illustrate, consider the first sentence of B's utterance in the naturally occurring example in (5). If B utters this

sentence with prosodic prominence on *stormwater*, B is not taken to be committed to liking stormwater (the content of the complement clause), but only committed to liking *something*. As clarified in the next sentence, that something is fly-fishing for trout.

(5) A: When did you discover you liked stormwater?

   B: I didn't discover that I liked stormwater, I discovered that I loved fly-fishing for trout.[2]

In (6), a constructed example from Simons et al. to appear, the first sentence of B's utterance contains the factive predicate *find out* and the sentence is realized with prosodic prominence on *Harry*, as indicated by capital letters. An utterance of this sentence does not commit B to Harry having a graduation party, but only to *somebody* having such a party. That somebody, as clarified in the next sentence, is Harriet. Finally, in the naturally occurring example (7), the author is taken to be committed to the metabolite of Ketamine having *some* side effects, not to having no side effects (*NO* was capitalized in the original).

(6) adapted from Simons et al. to appear

   A: James just found out that Harry's having a graduation party, and I just can't understand why he's so upset about it.

   B: He didn't find out that HARRY's having a graduation party, he found out that HARRIET is having a graduation party.

(7) [The scientists] didn't discover that [the metabolite of Ketamine] has NO side effects. They discovered that it has no dissociative or hallucinatory side effects.[3]

Classical projection analyses need to appeal to local accommodation to account for the fact that the speakers/authors of the examples in (3), (4a) and (5) to (7) are not taken to be committed to the contents of the complements of the relevant sentences. Such analyses currently have nothing to say about why narrow focus on an expression in the clausal complement would result in the content of the complement not projecting, especially in examples where contextual information that warrants local accommodation is not available. Crucially, since only the content of the complement is lexically specified to be a presupposition, such analyses, as currently formulated, have nothing to say about the projection of the contents that are observed to project in these examples, namely that the speaker likes something,

2 http://science.unctv.org/content/whats-my-story-water-quality-engineer
3 http://sciencenewsjournal.com/antidepressant-compound-located-may-come-zero-side-effects/

in (5), that somebody is having a graduation party, in (6), and that the metabolite of Ketamine has some side effects, in (7).[4]

If prosody influences projection, as suggested in Beaver 2010 and Simons et al. to appear based on impressionistic judgments, then this influence constitutes a litmus test for theories of projection: theories that predict this influence are more empirically adequate than theories that do not. This paper describes three perception experiments designed to explore whether listeners attend to the prosody of utterances with factive predicates in interpreting whether the content of the complement projects. Experiments 1 and 2 were designed to explore the hypothesis that the content of the complement of an utterance with a factive predicate embedded under an entailment-canceling operator is less likely to project if an expression in the complement clause is narrowly focused than if the complement clause is deaccented, as suggested by Beaver (2010) and Simons et al. (to appear). Experiment 3 was designed to explore the hypothesis that the degree of prosodic prominence of the last content word of the complement clause has an influence on the projectivity of the content of the complement. The results of these experiments suggest that listeners attend to the prosody of utterances with factive predicates in identifying what they take the speaker to be committed to.

The paper proceeds as follows. In Section 2, I discuss Cummins & Rohde's (2015) experimental investigation of the influence of prosody on the projection of a range of presuppositions. Experiments 1 and 2 are described in Section 3 and Experiment 3 in Section 4. In Section 5, I analyze the experimental findings in the question-based analysis of projection developed in Simons et al. to appear. Section 6 concludes the paper.

2   Cummins & Rohde 2015

Cummins & Rohde's (2015) perception experiment 2 was designed to explore the hypothesis that the projection of a presupposition from an utterance with a presupposition trigger is sensitive to the Question Under Discussion (QUD, Roberts 2012) that the utterance addresses. The stimuli in their experiment were based on 20 negated sentences that each featured a different presupposition trigger: in addition to the factive predicates *regret, know, aware, happy, relieved* and *sorry*, presupposition triggers included the change of state predicates *stop, finish, return, return to, leave, arrive, restore* and *go back*, the implicative predicates *avoid, forget* and *manage*, and the iterative expressions *repeat, rewrite* and *again*. Utterances of the 20 stimuli sentences were recorded in two prosodic conditions, a "neutral" condition and a "focus" condition, with the prosodic realization of the stimuli in each condition

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4 The predictions of other analyses of projection with factive predicates (e.g., Schlenker 2008; Abrusán 2011) cannot be discussed here for reasons of space.

constraining the QUD differently (see pp.6f. for details). The prosodic realization of stimuli in the focus condition was described as "plac[ing] a pitch accent on the last word of the sentence" (p.7). The prosodic realization of the stimuli in the neutral condition was not further described.

Each participant listened to utterances of the 20 sentences, half in the focus condition and half in the neutral condition. For each of the 20 utterances, participants answered a question about the status of the relevant content. For instance, for utterances of the sentence in (8), participants were asked to respond to the question 'How likely is it that Bill argued with his boss?'. Responses were given on a 7-point Likert scale, with '1' labeled as 'unlikely' and '7' labeled as 'likely'.

(8)   Bill doesn't regret arguing with his boss.   (Cummins & Rohde 2015: 7)

Cummins and Rohde found that participants gave significantly lower ratings to utterances in the focus condition (mean: 5.97) than to utterances in the neutral condition (mean: 6.15). The results of their experiment thereby establish that the projection of a presupposition from an utterance with a presupposition trigger is sensitive to the QUD that the utterance addresses.

Discussion Cummins & Rohde's (2015) study is important for the purposes of the current paper because their study shows that the prosodic realization of an utterance with a presupposition trigger influences whether the presupposition is taken to project. These findings constitute an important step towards establishing what theories of projection need to be able to account for. Unfortunately, the conclusions we can draw from their study about the influence of prosody on projection are limited (as acknowledged by the authors on p.8) since the prosodic realizations of the stimuli were not described in detail. Furthermore, it appears that stimuli in a given condition may even had different prosodic realizations since the materials "were not constructed in such a way as to control their prosodic properties: the sentences were merely read by a native speaker who was trying to convey an intended meaning" (p.8). Since no information was provided about the meaning the native speaker was trying to convey for the stimuli in the two conditions, it is difficult to establish a systematic influence of prosody on presupposition projection from this study.

3   Experiments 1 and 2

Experiments 1 and 2 were designed to explore the hypothesis that the prosodic realization of an utterance with a factive predicate embedded under an entailment-canceling operator influences whether the content of the complement projects. Specifically, the two experiments explored the hypothesis that the content of the

complement is less likely to project if an expression in the complement clause is narrowly focused than if the complement clause is deaccented, as suggested in Beaver 2010 and Simons et al. to appear. Gradient ratings about whether listeners took the speaker to be committed to the content of the complement were collected using Amazon's Mechanical Turk service.[5]

3.1 Methods

3.1.1 Participants

Participants for Experiments 1 and 2 were recruited on Amazon's Mechanical Turk platform and paid 70 cents for their participation. Participants had US IP addresses and at least 99% of Human Intelligence Tasks (HITs) approved. The responses from participants who were not self-reported native speakers of American English were excluded, as were the responses from participants who gave an incorrect response to one or both control stimuli. In Experiment 1, 50 participants were recruited and responses from 3 participants were excluded. The remaining 47 participants (18 female, 29 male) ranged in age from 22-67 years old (median: 31 years). In Experiment 2, 55 participants were recruited and responses from 6 participants were excluded. The remaining 49 participants (17 female, 32 male) ranged in age from 21-57 years old (median: 34 years). One of these 49 participants had previously participated in Experiment 1.

3.1.2 Materials

The materials used in Experiments 1 and 2 were recordings of the 15 target sentences and the 2 control sentences shown in Table 1. The target sentences (D1 to N3) consisted of the entailment-canceling modal adverb *perhaps*, a factive predicate and a short complement clause consisting of a subject pronoun and a verb phrase. Five factive predicates occurred in the target stimuli: *discovered, realized, knew, was aware* and *noticed*. The control stimuli (based on sentences C1 and C2) were included to assess whether participants were paying attention.

    Utterances of the 17 sentences in Table 1 were recorded with a female talker in a sound-attenuated room. The recordings were made with the built-in microphone of a MacBook Air laptop computer using the Praat software (Boersma & Weenink 2016) with a sampling rate of 44,100Hz. The talker was instructed to produce the target stimuli sentences in three prosodic conditions. In the first condition, henceforth referred to as the H*-on-predicate condition, the sentences were produced with a high

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5 The materials, data and the R code for generating the figures and analyses of the three experiments reported on in this paper are available at https://github.com/judith-tonhauser/SALT26-paper.

D1	Perhaps he discovered that she's a widow.	
D2	Perhaps she discovered that he's a father.	
D3	Perhaps she discovered that he's Canadian.	
R1	Perhaps he realized that she's wealthy.	
R2	Perhaps she realized that he had a virus.	
R3	Perhaps he realized that she was cheating on him.	
K1	Perhaps she knew that he was a criminal.	
K2	Perhaps he knew that she was married.	
K3	Perhaps she knew that he was wrong.	
A1	Perhaps she was aware that he's a vegetarian.	
A2	Perhaps she was aware that he was/is unreliable.	
A3	Perhaps she was aware that he had bad reviews.	
N1	Perhaps he noticed that she was missing something.	
N2	Perhaps she noticed that he had bad breath.	
N3	Perhaps he noticed that she was hungry.	
C1	I am tired.	
C2	I was invited to the party.	

Table 1   Sentences for target and control stimuli in the three experiments

tone pitch accent on the predicate (and no other pitch accents),[6] a low intermediate phrase accent and a low intonational phrase boundary (H* L-L% in the Tones and Break Indices (ToBI) annotation system, Beckman & Ayers 1997), as illustrated in the top panel of Figure 1.

In the second condition, the L+H*-on-content condition, the last content word of the complement clause[7] was produced with a complex pitch accent consisting of a low tone that preceded a high tone that was aligned with the stressed syllable of that word.[8] The sentence was realized without any other pitch accents and, again, a low intermediate phrase accent and a low intonational phrase boundary (L+H* L-L% in ToBI notation), as illustrated in the middle panel of Figure 1. In the third condition, the L+H*-on-pronoun condition, the pronoun of the complement clause was produced with a complex pitch accent consisting of a low tone that preceded a high tone that was aligned with the stressed syllable of that word. The sentence was

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6 The predicate was realized with a H* pitch accent rather than a contrastive L+H* pitch accent because of Beaver's (2010:95) claim that "if the factive verb is being contrasted with a non-presuppositional expression, there is no presupposition", i.e., the content of the complement does not project.

7 That content word was *cheating* in R3 and *missing* in N1.

8 In this condition, the clausal complement of stimulus A2 was erroneously produced in the present tense (…*he's unreliable*).
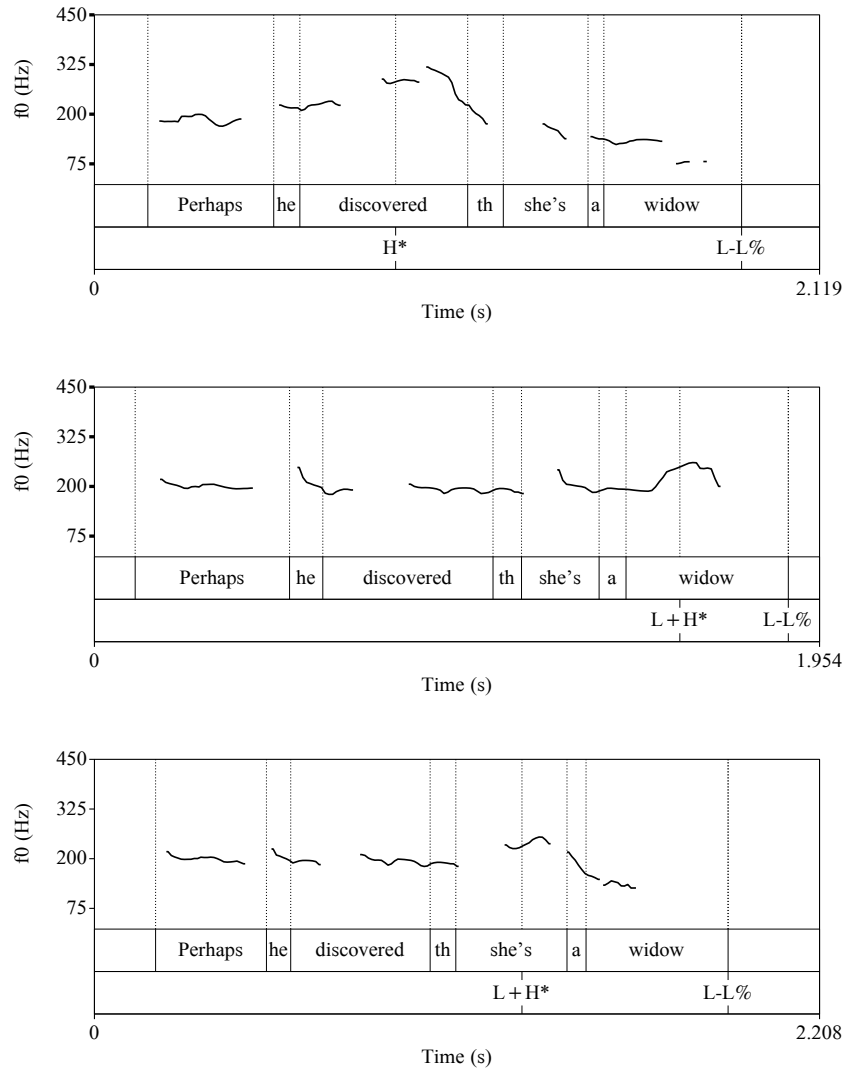
Figure 1   Target stimulus sentence *Perhaps he discovered that she's a widow* in the H*-on-predicate condition (top panel), the L+H*-on-content condition (middle panel) and the L+H*-on-pronoun condition (bottom panel)

realized without any other pitch accents and, again, a low intermediate phrase accent and a low intonational phrase boundary (L+H* L-L%), as illustrated in the bottom panel of Figure 1. The two control sentences were recorded with a H* on the last content word and a L-L% intermediate phrase accent/intonational phrase boundary.

Condition	duration (ms)		
	predicate	pronoun	last content word
H*-on-predicate	364	170	536
L+H*-on-content	322	158	557
L+H*-on-pronoun	301	272	527

Table 2   Experiments 1 and 2: Mean duration values

In English, stressed syllables that are realized with high tone pitch accents typically have longer durations than syllables that are deaccented (e.g., Eady & Cooper 1986). The stimuli used in Experiments 1 and 2 were submitted to a duration analysis. Duration values were obtained for the predicate, the pronoun of the clausal complement and the last word of the clausal complement. Table 2 shows the mean duration values of the relevant words across the three conditions. Pitch accented words were clearly longer than deaccented words.

In Experiment 1, the interpretation of the target stimuli in the H*-on-predicate condition was compared to the interpretation of the target stimuli in the L+H*-on-content condition. Two lists containing 15 target stimuli were created such that each of the 15 target stimuli sentences occurred on both lists, either in the H*-on-predicate condition or in the L+H*-on-content condition (each list had 7 or 8 utterances in the two prosodic conditions). In Experiment 2, the interpretation of the target stimuli in the H*-on-predicate condition was compared to the interpretation of the target stimuli in the L+H*-on-pronoun condition. As in Experiment 1, two lists of 15 target stimuli were created such that each of the 15 target stimuli sentences occurred on both lists, either in the H*-on-predicate condition or in the L+H*-on-pronoun condition (each list had either 7 or 8 utterances in the two prosodic conditions). The two control stimuli were added to the four lists of the two experiments, for a total of 17 stimuli per list.

3.1.3   Procedure

In both experiments, each participant was randomly assigned to one of the two lists and presented with the 17 stimuli in random order. Participants were told to imagine that they are at a party and, upon entering the kitchen, they hear somebody say something about some other people. Participants were instructed to listen to each stimulus (as often as they wanted) and to answer the question presented with the stimulus. They gave their response on a 7-point Likert scale labeled at four points: No, not certain/1, Possibly not certain/3, Possibly certain/5, Yes, certain/7,
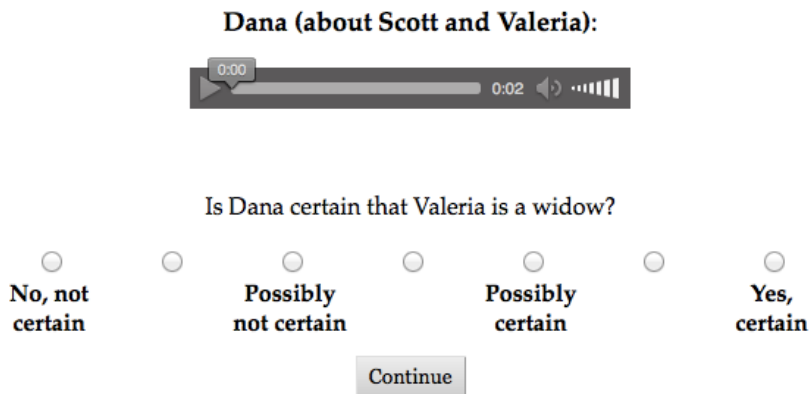
Dana (about Scott and Valeria):

Is Dana certain that Valeria is a widow?

No, not certain   Possibly not certain   Possibly certain   Yes, certain

Continue

Figure 2   Screenshot of the response task in Experiments 1 and 2

as shown in Figure 2. For the target stimuli, the question was about the content of the complement clause and for the two control stimuli the question was about the content of the main clause (i.e., 'Is [the speaker] certain that she is tired?', 'Is [the speaker] certain that she was invited to the party?'). A response lower than 6 to the control stimuli counted as incorrect.

At the end of the experiments, participants filled out a questionnaire about their age, their gender, their native language(s) and, if English is a native language, whether it is American English, as opposed to, e.g., Indian or Australian English. Participants were told that they would be paid no matter how they responded to these questions, to encourage them to answer truthfully.

3.2 Data analysis

The statistical analyses reported in this paper used ordinal mixed-effects regression models predicting response from the fixed effect of prosody and the following random effects structure: random by-participant intercepts, random-by-participant slopes for the fixed effect and random by-item intercepts. Results were obtained using the `ordinal` package (Christensen 2013) in R (version 3.2.0).

3.3 Results and discussion

The mean responses (with 95% confidence intervals) to the target stimuli in the two conditions of Experiments 1 and 2 are shown in the left and right panels of Figure 3, respectively. The participants' response means are shown as grey dots. As expected, in Experiment 1, stimuli in the L+H*-on-content condition received significantly
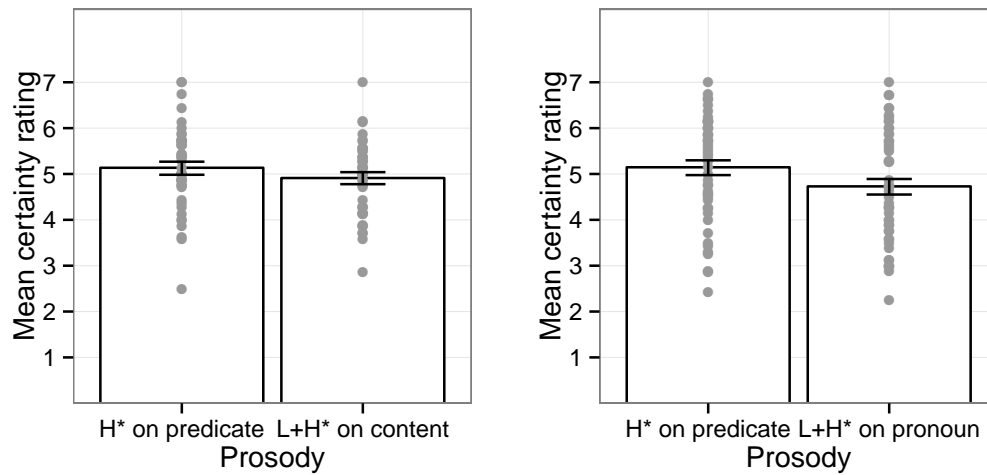
Figure 3   Mean responses (with 95% confidence intervals) and participants' means in Experiment 1 (left panel) and Experiment 2 (right panel).

lower responses than stimuli in the H*-on-predicate condition (β = -0.49, *SE* = 0.24, z = -2, $p < .05$). Likewise, in Experiment 2, stimuli in the L+H*-on-pronoun condition received significantly lower responses than stimuli in the H*-on-predicate condition (β = -0.68, *SE* = 0.27, z = -2.5, $p < .05$).

These results show that the projectivity of the content of the complement is influenced by the prosody of the utterance with the factive predicate. Specifically, listeners in Experiments 1 and 2 attended to the locations of pitch accents in identifying whether the speaker was committed to the content of the complement: when the utterance was produced with a L+H* pitch accent on an expression in the complement clause, the speaker was less likely to be taken to be committed to the content of the complement than when the utterance was produced with a deaccented complement clause and a H* pitch accent on the factive predicate. These results confirm the intuitions reported in Beaver 2010 and Simons et al. to appear.

As discussed in Section 1, the content of the complement of a factive predicate is classically analyzed as a presupposition. Examples in which the content of the complement is not a commitment of the speaker are attributed to local accommodation, which is licensed if projecting the content of the complement to the common ground leads to a contradiction, uninformativity or problems with binding. However, given that the contexts in which the stimuli of Experiments 1 and 2 were interpreted provided only minimal information about the interlocutors, these context cannot plausibly be assumed to license local accommodation of the content of the

complement. Thus, classical analyses, as currently formulated, can neither account for the influence of prosody on interpretation nor account for why the stimuli in Experiments 1 and 2 were able to receive non-projecting interpretations.

Experiments 1 and 2 established that listeners attend to the locations of pitch accents in utterances with factive predicates in identifying whether the speaker is committed to the content of the complement. Research on the interpretation of prosody has shown that listeners also attend to the type of pitch accent realized on an expression. Ito & Speer (2008), for instance, found that listeners are more likely to assign a contrastive interpretation to adjectives realized with a L+H* pitch accent than adjectives realized with a H* pitch accent (see also Watson, Tanenhaus & Gunlogson 2008). Such findings raise the question of whether listeners also attend to pitch accent type in identifying speaker commitment to the content of the complement. Experiment 3 addresses this question.

4 Experiment 3

Experiment 3 was designed to explore the hypothesis that the type of pitch accent realized on the predicate and the last content word of the clausal complement has an influence on whether the content of the complement projects. In this experiment, the predicate and the last content word of the 15 target sentences with factive predicates (see Table 1) were realized with pitch accents in both prosodic conditions. In the first condition, illustrated in (9a), the pitch accent on the predicate was relatively less prominent than the pitch accent on the last content word; in the second condition, illustrated in (9b), the pitch accent on the predicate was relatively more prominent than the pitch accent on the last content word.[9]

(9) a. Perhaps he disCOvered that she's a WIdow.
                    H*   (L+)H*   L-L%
     b. Perhaps he disCOvered that she's a WIdow.
              (L+)H*   !H*   L-L%

Since the less prominent pitch accent on the last content word in (9b) can signal that the content of the complement is information that the interlocutors already share (see, e.g., Ayers 1996: 27), the expectation is that when the last content word is more prosodically prominent, as in (9a), the speaker is less likely to be taken to be committed to the content of the complement than when the last content word is relatively less prosodically prominent, as in (9b).

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9 These realizations were attested in productions collected in an ongoing production experiment.

4.1 Methods

4.1.1 Participants

Participants for Experiment 3 were again recruited on Amazon's Mechanical Turk platform and paid 70 cents for their participation. The qualification requirements and exclusion criteria were the same as in Experiments 1 and 2. 55 participants were recruited and responses from 2 participants were excluded; the remaining 53 participants (20 female, 33 male) ranged in age from 21-64 years old (median: 32 years). 6 of these 53 participants had previously participated in Experiment 1 and (a different) 6 in Experiment 2.

4.1.2 Materials

In Experiment 3, the 15 target stimuli sentences shown in Table 1 were produced in two prosodic conditions, except that the clausal complement of stimulus A2 was in the present tense (...*he's unreliable*). The control stimuli were the same as in Experiments 1 and 2. For the stimuli in the first condition, the H*-(L+)H* condition, the talker was instructed to produce the sentences with a high tone pitch accent on the predicate and a high tone pitch accent on the last content word, followed by a low intermediate phrase accent and a low intonational phrase boundary. Some of the pitch accents on the last content word in this condition may however be considered L+H* pitch accents rather than H* pitch accents.[10] A sample stimulus in this condition is shown in the top panel in Figure 4. In the second condition, the (L+)H*-!H* condition, the talker was instructed to produce the stimuli with a high tone pitch accent on the predicate, a down-stepped high tone pitch accent on the last content word of the complement clause, a low intermediate phrase accent and a low intonational phrase boundary, as shown in the lower panel in Figure 4. Some of the H* pitch accents on the predicate may, again, be considered L+H* pitch accents.

The target stimuli of Experiment 3 were submitted to phonetic analysis. Duration values were obtained for the predicate and the last content word of the clausal complement, and F0 peak values were obtained for the pitch accent associated with the stressed syllables of these expressions. Table 3 shows the mean duration and mean F0 peak values of the relevant expressions.

The duration values of the predicates and last content words across the two conditions are roughly comparable, consistent with the fact that they are realized with pitch accents in both conditions. In the H*-(L+)H* condition, the F0 peak

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10 H* and L+H* are distinct accents in the ToBI system, but they are often confused in ToBI annotations (Syrdal & McGory 2000) and some authors consider the distinction between the two accents to be continuous rather than categorical (for discussion, see Ito & Speer 2008: 547f.).
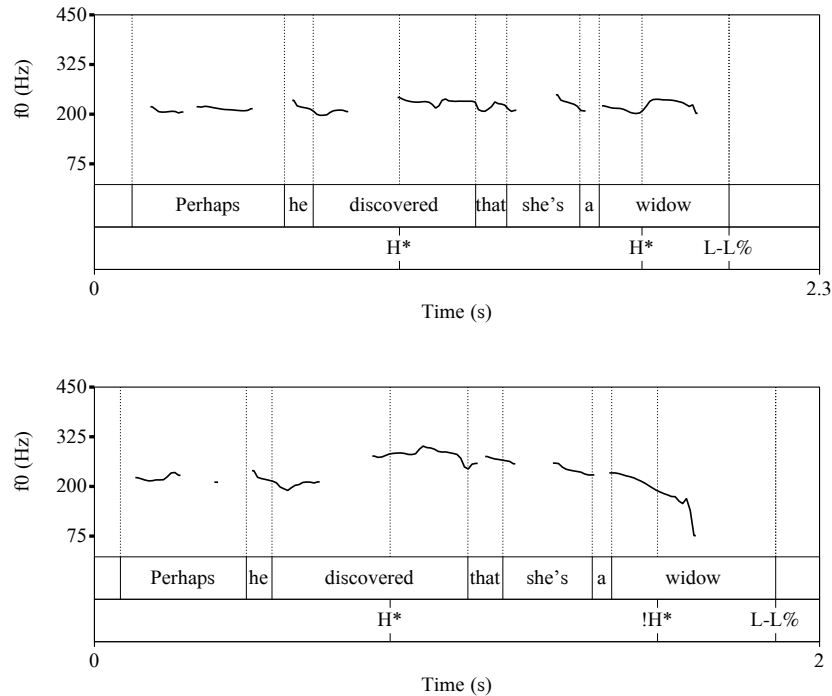
Figure 4   Target stimulus sentence *Perhaps he discovered that she's a widow* in the H*-(L+)H* condition (upper panel) and the (L+)H*-!H* condition (lower panel)

on the predicate is on average 19 Hz lower than the F0 peak on the last content word, whereas it is on average 52 Hz higher in the (L+)H*-!H* condition. These measurements are compatible with the pitch accent on the last content word being relatively more prosodically prominent than the pitch accent on the predicate in the H*-(L+)H* condition, and the pitch accent on the last content word being relatively less prosodically prominent than the pitch accent on the predicate in the (L+)H*-!H* condition. The fact that the predicate in the (L+)H*-!H* condition is on average 21 ms longer than in the H*-(L+)H* condition is compatible with the observation that some of the pitch accents on the predicate in the (L+)H*-!H* condition may be better analyzed as L+H* than as H* pitch accents. Likewise, the fact that the F0 peak on the predicate in the (L+)H*-!H* condition is on average 36 Hz higher than the F0 peak on the predicate in the H*-(L+)H* condition is compatible with the observation that some of the pitch accents on the predicate in that condition may be better analyzed as L+H* pitch accents than H* pitch accents.

Condition	predicate		last content word	
	F0 (Hz)	duration (ms)	F0 (Hz)	duration (ms)
H*-(L+)H*	221	430	240	575
(L+)H*-!H*	257	451	205	584

Table 3   Experiment 3: Mean duration and mean peak F0 values

In Experiment 3, the interpretation of the target stimuli in the H*-(L+)H* condition was compared to the interpretation of the target stimuli in the (L+)H*-!H* condition. Two lists each containing 15 target stimuli were created such that the 15 target stimuli sentences occurred on both lists, either in the H*-(L+)H* condition or in the (L+)H*-!H* condition (each list had 7 or 8 utterances in the two prosodic conditions). The two control stimuli were added to the two lists, for a total of 17 stimuli per list.

4.1.3   Procedure

The procedure of Experiment 3 was identical to the procedure of Experiments 1 and 2 described in Section 3.1.3.

4.2   Results and discussion

The mean responses (with 95% confidence intervals) to the target stimuli in the two conditions of Experiment 3 are shown in Figure 5. The participants' response means are again shown as grey dots. As expected, stimuli in the H*-(L+)H* condition received significantly lower responses than stimuli in the (L+)H*-!H* condition (β = -0.3, SE = 0.15, z = -2, $p < .05$).

These results show that whether the content of the complement of utterances with factive predicate is taken to be a commitment of the speaker is influenced by the type of pitch accent realized on the predicate and the last content word of the complement. Specifically, listeners were more likely to take the speaker to be committed to the content of the complement when the pitch accent on the last content word was less prosodically prominent than the pitch accent on the predicate compared to when the pitch accent on last content word was more prosodically prominent than the pitch accent on the predicate. These results suggest that, in identifying speaker commitment to the content of the complement, listeners attend not only to the presence/absence of pitch accents on the predicate and the last content
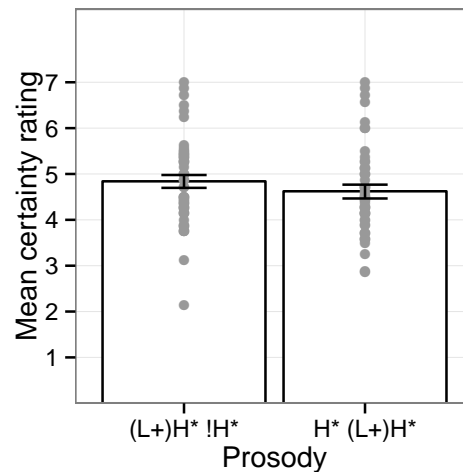
Figure 5 Mean responses (with 95% confidence intervals) and participants' means in Experiment 3

word (Experiments 1 and 2) but also to the type of pitch accent realized on these expressions.

5 Accounting for the influence of prosody on projection

The results of the three perception experiments provide evidence for the influence of prosody on projection. In particular, the three experiments show that the prosody of an utterance with a factive predicate embedded under an entailment-canceling operator influences whether the content of the complement projects: listeners attend both to the locations of pitch accents (Experiments 1 and 2) and to the types of pitch accents (Experiment 3). These results establish the need for a theory of projection that predicts the influence of prosody on projection. As discussed above, classical analyses of presupposition projection, as currently formulated, do not predict the influence of prosody on projection. This section explores how the results of the three experiments can be captured in the question-based account of projection presented in Simons et al. to appear.

5.1 Simons et al. to appear

The account of projection developed in Simons et al. to appear assumes that the focus marking of an uttered sentence (regardless of whether focus is marked prosodically,

morphologically or syntactically) constrains the question addressed by that utterance. This assumption is empirically motivated by the observation that utterances must be congruent with the questions they address (e.g., Paul 1880, 1919; von Stechow 1990; Rooth 1992). The question-answer pairs in (10a) and (10b) illustrate question-answer congruence: J's utterance in (10a), with *Turkish* prosodically prominent, is congruent with M's question in (10a), but not with M's question in (10b), and vice versa for J's utterance in (10b), where *David* is prosodically prominent.

(10)   David, Mandy, Craige and Judith are having lunch at a place that serves Turkish, Lebanese and Irish coffee.

    a. M: What kind of coffee does David like?

       J: David likes TURkish coffee.

    b. M: Who likes Turkish coffee?

       J: DAvid likes Turkish coffee.

Question-answer congruence is straightforwardly modeled in an alternative semantics framework (cf., Rooth 1985, 1992), which analyzes both the focus semantic meaning of the answer and the meaning of the question in terms of alternatives. In such a framework, the meanings of the questions in (10a) and (10b) are sets of propositions that are answers to the questions, as shown in (11a) and (12a), respectively. The focus semantic meanings of the answers in (10aJ) and (10bJ) are focus alternatives sets, i.e., sets of propositions derived by abstracting over the focused expressions, as shown in (11b) and (12b).

(11)   a. $[\![(10\text{aM})]\!]^{M,g}$ = {David likes Turkish coffee, David likes Lebanese coffee, David likes Irish coffee}

    b. $[\![(10\text{aJ})]\!]^{M,g}$ = {David likes Turkish coffee, David likes Lebanese coffee, David likes Irish coffee, David likes cold coffee,... }

(12)   a. $[\![(10\text{bM})]\!]^{M,g}$ = {David likes Turkish coffee, Craige likes Turkish coffee, Mandy likes Turkish coffee, Judith likes Turkish coffee}

    b. $[\![(10\text{bJ})]\!]^{M,g}$ = {David likes Turkish coffee, Craige likes Turkish coffee, Mandy likes Turkish coffee, Judith likes Turkish coffee, Adam likes Turkish coffee,... }

The observation that answers are congruent with the questions they address is modeled by requiring the meaning of the question to be a subset of the focus alternatives set of the answer. For instance, the answer in (10aJ) is congruent with the question in (10aM) because the meaning of the question, given in (11a), is a subset of the meaning of the answer, given in (11b). But the answer in (10aJ) is not

congruent with the question in (10aM) because the meaning of the question, given in (12a), is not a subset of the meaning of the answer.

An utterance that is not made in response to an interrogative utterance (an explicit question) is taken to address an implicit question (see, e.g., Roberts 2012). Consequently, given question-answer congruence, the focus marking of an utterance that addresses an implicit question provides a cue to the question that the utterance addresses. This idea is already found in Halliday 1967: 208: "[a] specific question is derivable from any information unit except one with unmarked focus". For instance, Halliday argues (p.207f.) that *JOHN painted the shed yesterday* implies the question *Who painted the shed yesterday* or the question *Did Mary paint the shed yesterday?* whereas *John PAINTed the shed yesterday* implies the question *What did John do to the shed yesterday?* or *Did John mend the shed yesterday?*. Experimental evidence that listeners can identify questions that utterances with prosodically marked focus address is provided in Most & Saltz 1979.

With these assumptions about the relationship between focus and the question addressed by an utterance in mind, Simons et al. (to appear) proposed the following for the projection of the content of the complement of attitude predicates, including factive ones:

(13)   Projection of the content of the complement of an attitude verb occurs if the Current Question for the utterance entails this content.[11]

<div align="right">(Simons et al. to appear)</div>

The Current Question of an utterance is defined as follows (see also Beaver & Clark 2008):

(14)   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:

   (i)   The proposition expressed is a member of the Current Question and

   (ii)   The Current Question has at least one additional member.

<div align="right">(adapted from Simons et al. to appear)</div>

To illustrate, consider again B's response in the example in (6), given in (15), with focus marking on the subject noun phrase of the clausal complement:

(15)   He (James) didn't find out that [HARRY]$_F$'s having a graduation party. . .

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11 The *if* here is intended: the content of the complement may also project for other reasons than being entailed by the Current Question.

The focus alternatives set of this utterance, which is calculated by abstracting over the focus-marked subject of the clausal complement, is a set of propositions of the following form:[12]

(16)   {p: for some entity a, James found out that a is having a graduation party}

The Current Question of the utterance in (15) is a contextually-restricted subset of (16). Under the assumption that only humans have graduation parties and from the observation that *find out* is veridical (i.e., entails the truth of the clausal complement), it follows that every proposition in the Current Question entails that somebody is having a graduation party. Simons et al. (to appear) define the entailments of a question as those propositions that are entailed by all the alternatives in the meaning of the question. By this definition, the Current Question of (15) entails the proposition that somebody is having a graduation party, but not the proposition that Harry is having a graduation party. By the projection hypothesis in (13), a speaker who utters (15) is thus predicted to be taken to be committed to somebody having a graduation party, but not to Harry having one.

In sum, the question-based account of projection developed in Simons et al. to appear predicts that prosody influences projection in English: prosody provides a cue to focus and focus, in turn, constrains the Current Question, whose entailments project. The next two sections discuss how this question-based account of projection accounts for the results of the three experiments.

5.2   Accounting for the results of Experiments 1 and 2

To start, consider the three sentences in (17a-c): as argued below, the assumed prosodic prominences (indicated by capital letters) and foci (indicated by [ ]$_F$) are compatible with the prosodic realizations of *Perhaps he discovered that she's a widow* in the H*-on-predicate, L+H*-on-content and L+H*-on-pronoun conditions, respectively, of Experiments 1 and 2.

(17)   a. Perhaps he [disCOvered]$_F$ that she's a widow.
       b. Perhaps he discovered that she['s a WIdow]$_F$.
       c. Perhaps he discovered that [SHE]$_F$'s a widow.

The focus alternatives sets of the three sentences in (17a-c) are given in (18a-c), respectively:[13]

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12 See Simons et al. to appear for arguments for why negation is not included in the domain over which the focus alternatives set is calculated.

13 I assume here that the epistemic modal adverb is not part of the domain over which the focus alternatives set is calculated.

(18)   a. $\{p$: for some relation R, he R that she's a widow$\}$

      b. $\{p$: for some property P, he discovered that she $P\}$

      c. $\{p$: for some entity a, he discovered that a is a widow$\}$

The Current Questions that the three sentences in (17) address are subsets of these focus alternatives sets. It is straightforward to see that the content of the complement of *Perhaps he discovered that she's a widow* – that she's a widow – is not entailed by the Current Questions that (17b) and (17c) address: not all of the propositions in the sets in (18b) and (18c) entail that she's a widow. For instance, the set in (18b) contains the proposition that she's a baby, which does not entail that she's a widow. Since the content of the complement is not entailed by the Current Questions that (17b) and (17c) address, (13) does not predict that the content of the complement projects from utterances of these sentences.

The focus alternatives set in (18a), on the other hand, is compatible with Current Questions that entail the content of the complement, as well as with ones that don't. Crucially, if the relations R in the Current Question are contextually restricted to veridical ones, as in (19a), then the Current Question of (17a) entails the content of the complement, which is therefore predicted by (13) to project from an utterance of (17a). If, on the other hand, the relations R in the Current Question include non-veridical ones, as in (19b), then the Current Question of (17a) does not entail the content of the complement, which is therefore not predicted by (13) to project.

(19)   a. $\{$he discovered that she's a widow, he knew that she's a widow, he was happy that she's a widow$\}$

      b. $\{$he discovered that she's a widow, he thought that she's a widow, he speculated that she's a widow$\}$

Without further context, it is impossible to identify how the focus alternatives set of an utterance of (17a) is restricted and, hence, which alternatives are included in the Current Question of (17a). What is crucial, however, is that (17a) has Current Questions that entail the content of the complement, whereas (17b) and (17c) do not. Simons et al.'s account therefore predicts that (17a) is more likely to receive a projecting interpretation than (17b) and (17c).

The prosodic realizations of the stimuli of Experiments 1 and 2 are compatible with the focus markings of the sentences in (17). In particular, stimuli in the H*-on-predicate condition realized a H* pitch accent on the predicate, which is compatible with focus marking of the predicate, as in (17a); stimuli in the L+H*-on-content condition realized a L+H* pitch on the last content word of the clausal complement, which is compatible with focus marking of the verb phrase of that complement, as in (17b); and stimuli in the L+H*-on-pronoun condition realized a L+H* pitch on the pronoun of the clausal complement, which is compatible with focus marking

of that pronoun, as in (17c). If the stimuli in Experiments 1 and 2 were interpreted with these foci, then Simons et al.'s (13) predicts that stimuli in the H*-on-predicate condition are more likely to receive projecting interpretations than stimuli in the L+H*-on-content or L+H*-on-pronoun conditions. And this prediction is correct, as shown in Section 3.

The experimental results also show, however, that the stimuli in the L+H*-on-content and L+H*-on-pronoun conditions were not always taken to mean that the speaker was not committed to the content of the complement. One possible explanation for this finding is that these stimuli may be compatible with focus markings other than those discussed above. Stimuli in the L+H*-on-content condition, for instance, may be compatible not just with the verb phrase of the clausal complement being focused, but also with the entire complement clause or the verb phrase of the matrix clause being focused. Consider the possibility in (20a), in which the complement clause is focused. The corresponding focus alternatives set in (20b) consists of propositions that vary with respect to what he discovered.

(20) a. Perhaps he discovered that [she's a WIdow]$_F$.
      b. {p: for some proposition q, he discovered q}

It is plausible to assume that the Current Question that (20a) addresses may be restricted to those alternatives in the focus alternatives set in (20b) for which the propositions q that he stands in the 'discover' relation to are true propositions. (See Simons et al. to appear: §4.3 for an argument.) Interpreting an utterance of (20a) relative to this Current Question would lead a hearer to take the speaker to be committed to the content of the complement, since that content is one of the true propositions in the Current Question.

Another possible explanation for the finding that stimuli in the L+H*-on-content and L+H*-on-pronoun conditions were not always taken to mean that the speaker was not committed to the content of the complement is that the cue from the meaning of the factive predicate, that the content of the complement projects, is stronger than the cue from prosody, that the content of the complement does not project. Recall that on classical analyses, discussed in Section 1, the content of the complement is lexically specified by the predicate to be a presupposition. While Simons and her colleagues don't assume that this content is conventionally specified to project (see, e.g., Simons 2001), they do recognize that this content has a strong tendency to be taken to be a commitment of the speaker. It is possible that the prosodic cues to non-projection are more difficult to recognize than the cues to projection from the meaning of the predicate.

In sum, Simons et al.'s (to appear) hypothesis in (13) that utterance content projects if it is entailed by the Current Question that the utterance addresses correctly predicts that the content of the complement of stimuli in the H*-on-predicate

condition is more likely to be taken to be a commitment of the speaker than the content of the complement of stimuli in the L+H*-on-content and L+H*-on-pronoun conditions. However, whether the content of the complement projects is not fully determined by Simons et al.'s (to appear) proposal because the hypothesis in (13) is formulated as a conditional, not as a bi-conditional, and because the prosodic realization of an utterance only provides a cue to focus, but does not determine it.

5.3   Accounting for the results of Experiment 3

In Experiment 3, the stimuli in the two conditions featured pitch accents on the factive predicate as well as on the last content word of the clausal complement. Since the stimuli had more complex prosodic realizations than the stimuli in Experiments 1 and 2, these stimuli are potentially compatible with several information-structural analyses. In this section, I entertain an analysis according to which the prosodically more prominent expressions indicate the foci of the utterances: that is, stimuli in the H*-(L+)H* condition are focused on the verb phrase, as shown in (21a), and stimuli in the (L+)H*-!H* condition are focused on the predicate, as shown in (21b). The pitch accents realized on the non-focused expressions could be attributed to these expressions not being given in the context of utterance or due to prosodic structure (see, e.g., Ladd 2008).[14]

(21)   a.   Perhaps he disCOvered that she['s a WIdow]_F.
        b.   Perhaps he [disCOvered]_F that she's a WIdow.

The focus alternatives sets of the sentences in (21a-b) are given in (22a-b), respectively:

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14 A more tenuous possibility is that the factive predicate in the H*-(L+)H* condition and the last content word in the (L+)H*-!H* condition are contrastive topics (Roberts 2012; Büring 2003). Roberts (2012) takes contrastive topics to be realized with a (L+)H* pitch accent, followed by a low intermediate phrase accent and a high intonational phrase boundary (L-H%). Liberman & Pierrehumbert (1984: 173ff.) showed that the difference between the F0 peak of the first pitch accent and the F0 peak of the second pitch accent was greater in sentences in which a contrastive topic preceded a focus than in sentences in which a focus preceded a contrastive topic. The stimuli of Experiment 3 partially match these descriptions. First, in both conditions, both the predicate and the last content word were realized with high tone pitch accents. Second, the pitch accent on the last content word was relatively more prominent than the pitch accent on the predicate in the H*-(L+)H* condition, and relatively less so in the (L+)H*-H* condition. Third, the difference between the F0 peak of the first pitch accent (on the predicate) and the F0 peak of the second pitch accent (on the last content word) was greater in the (L+)H*-!H* condition than in the (L+)H*-!H* condition. Crucially, however, the utterances in the two conditions were realized as a single intonational phrase. If the stimuli were to be taken to realize contrastive topics and foci, the focus alternatives sets of the stimuli would be as in (22), with the predictions as discussed.

(22) a. {p: for some property P, he discovered that she P}   = (18b)

   b. {p: for some relation R, he R that she's a widow}   = (18a)

As discussed for (18b) above, the propositions in the focus alternatives set in (22a) do not entail the content of the complement, that she's a widow. As a consequence, Current Questions that are contextual restrictions of the set in (22a) do not entail the content of the complement either. In contrast, and as discussed for (18a) above, there are Current Questions for (21b) that are subsets of the focus alternatives set in (22b) and entail the content of the complement. Thus, given the assumed foci, (21b) is compatible with Current Questions that entail the content of the complement and (21a) is not. Simons et al.'s hypothesis in (13) therefore predicts that the content of the complement of utterances like (21b) may project whereas no such prediction is made for utterances like (21a). Thus, if the stimuli in the (L+)H*-!H* condition of Experiment 3 were taken to have the focus marking as in (21b) and the stimuli in the H*-(L+)H* condition were taken to have the focus marking as in (21a), then Simons et al.'s account predicts that stimuli in the (L+)H*-!H* condition are more likely than stimuli in the H*-(L+)H* condition to receive an interpretation in which the content of the complement is taken to be a commitment of the speaker. This prediction is correct, as shown in Section 4.

   Recall, however, that an utterance with a pitch accent on the last content word of the clausal complement is also potentially compatible with focus marking of the entire complement clause. As discussed for (20a) above, such utterances may be taken to address Current Questions that do commit the speaker to the truth of the content of the complement. Thus, if the clausal complement was taken to be focused for stimuli in the H*-(L+)H* condition, then the content of the complement is taken to be a commitment of the speaker. The results of Experiment 3 seem to suggest that such interpretations of the stimuli in the H*-(L+)H* condition are less accessible than interpretations according to which only the last content word is focused, as illustrated in (21a). Whether that is a case, and why, remain questions for future research.

5.4 Summary

Simons et al. (to appear) proposed that utterance content projects if it is entailed by the Current Question of the utterance or if the Current Question entails that the content is true. Since the Current Question is taken to be a contextually restricted subset of the focus alternatives set of the utterance, and since focus is prosodically marked in English, Simons et al.'s account predicts that prosody influences projection, correctly so, as suggested by the results of the three experiments discussed in Sections 3 and 4. As discussed in this section, Simons et al.'s hypothesis that

utterance content projects if it is entailed by the Current Question of the utterance correctly predicts that listeners are more likely to take the speaker to be committed to the content of the clausal complement of utterances in which the predicate is focused than of utterances in which an expression in the clausal complement is focused. At the same time, because of the non-deterministic relationships between the prosody of an utterance and focus marking, and between focus marking and the Current Question, Simons et al.'s account does not fully predict the experimental findings.

6 Conclusions

The content of the complement of a factive predicate is classically analyzed as a presupposition, i.e., as content that is taken to be a commitment of the speaker, unless doing so would result in a contradiction, uninformativity or problems with binding (Heim 1983; van der Sandt 1992). This paper has provided experimental evidence for claims made in Beaver 2010 and Simons et al. to appear based on impressionistic judgments that the prosody of utterances with factive predicates influences whether the content of the clausal complement is taken to be a commitment of the speaker. Since the experimental task was set up in such a way that taking the speaker to be committed to the content of the complement does not result in a contradiction, uninformativity or problems with binding, analyses of presupposition projection like that in Heim 1983 or van der Sandt 1992 do not predict the observed influence of prosody on projection. While the question-based analysis of projection developed in Simons et al. to appear does correctly predict an influence of prosody on projection, the discussion of the experimental findings in the context of their account has shown that the account is not yet fully predictive.

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