Triviality and interrogative embedding: Context-sensitivity, factivity, and neg-raising*

Clemens Mayr

Leibniz-Zentrum Allgemeine Sprachwissenschaft
mayr@leibniz-zas.de

May 25, 2018

Abstract

Why do predicates like *know* embed both declarative and interrogative clauses, whereas closely related ones like *believe* only embed the former? The standard approach following Grimshaw (*Linguistic Inquiry* 10:279–326) to this issue has been to specify lexically for each predicate which type of complement clause it can combine with. This view is challenged by predicates such as *be certain* which embed interrogative clauses only in certain contexts. To deal with this issue, this paper proposes (i) a novel unified semantics for declarative and interrogative embedding and (ii) a theory where embedding is constrained by semantic considerations. The reason for the apparent unembeddability of an interrogative clause under a given predicate is the resulting trivial meaning of the sentence. Such triviality manifests itself in unacceptability, and crucially it is affected by both the lexical meaning of the predicate and the polarity of the sentence as a whole.

1 Introduction

Since at least Hintikka 1975 the issue of why some proposition-taking predicates (PTPs) embed both declarative and interrogative clauses and why others only embed the former of the two has perplexed linguists. For instance, both *know* and *believe* embed declarative clauses as shown in (1a) and (2a).But only *know* also embeds interrogative clauses, as the contrast between (1b) and (2b) shows. From a pretheoretical perspective, this difference is unexpected. The meaning of *know* on standard treatments is the same as the one of *believe* modulo factivity.[1]

(1) a. John knows that Mary smokes.
b. John knows whether Mary smokes.

(2) a. John believes that Mary smokes.
b. *John believes whether Mary smokes.

A longstanding tradition dating back to Grimshaw 1979 holds that the patterns observed in (1) and (2) have to be stipulated. That is, PTPs—and predicates more widely—are lexically

*Thanks to be added later.

[1] As is custom, I will stay silent about possible further meaning components of *know*.

specified as to which type of complement clause they combine with, which is called s-selection. In other words, whether a PTP embeds an interrogative clause is claimed to be unpredictable.

As a consequence, the linguistic context should not affect embedding under a PTP. In light of data like (3), however, this prediction seems problematic (Adger and Quer 2001, Eckardt 2007). On the one hand, *be certain* is similar to *believe* in that it embeds declaratives but not interrogatives when occurring itself unembedded, as (3a) and (3b) show. When negated as in (3c), on the other hand, *be certain* straightforwardly embeds interrogatives.

(3) a. John is certain that Mary smokes.
b. ??John is certain whether Mary smokes.
c. John isn't certain whether Mary smokes.

The contribution of this paper is twofold. I first argue that all PTPs are in principle free to embed interrogative clauses. To this end I propose a novel unified semantics for PTPs allowing for both declarative and interrogative embedding. Specifically, PTPs are suggested to take propositional concepts as arguments. Furthermore, they contribute existential quantification over possible worlds (Spector and Egré 2015), interacting interestingly with factivity.

Second, I argue that the distribution of embedded interrogative clauses is largely determined by semantic considerations, avoiding the need for s-selection. In particular, the apparent impossibility of embedding is due to a trivial meaning assigned to the sentence by the interpretative component. A meaning is trivial if it either corresponds to a tautology or a contradiction (see Gajewski 2002, Chierchia 2006, 2013, Fox and Hackl 2006, Abrusán 2014 a.o.). In the present account two factors play a role in determining whether a meaning is trivial or not: (i) the particular lexical semantics of the PTP, and (ii) the polarity of the sentence as a whole. Interrogative embedding under PTPs like *believe* always results in a trivial literal meaning. This is due to the neg-raising property of such PTPs. Thus *believe* can never embed interrogative clauses. If the literal meaning of a sentence is non-trivial it does, however, not immediately follow that the sentence with the embedded interrogative clause is acceptable. I argue that such sentences are subject to a process of strengthening familiar from the literature on negative polarity items (NPIs) like *any* (Krifka 1995, Chierchia 2006, 2013). This process yields a trivial strengthened meaning for PTPs like *be certain* when occurring without negation but not when embedded under negation, even though the literal meanings are non-trivial in both cases. For PTPs like *know* neither the literal nor the strengthened meanings result in triviality. The reason for this is the factivity of *know*. Finally, this accounts for why (4b) is only acceptable if John predicted the correct answer (Karttunen 1977, Groenendijk and Stokhof 1984), even though *predict* in (4a) is not necessarily factive. Without factivity the strengthened meaning of (4b) would be trivial.

(4) a. John predicted that Mary smokes.
b. John predicted whether Mary smokes.

Since the paper is somewhat programmatic—more so than I would like it to be—there are many open threads and issues. I will point to these throughout the paper as best as I can. I believe, however, that it is useful to investigate how far one can push a semantic theory of selection. Therefore I opted to argue for a strong picture to bring out its limits most clearly.

The structure of the paper is as follows. In section 2, I discuss the issue that interrogative embedding poses for a theory of grammar in more detail. Section 3 introduces the core idea. To overcome its limitations, section 4 introduces the new semantics for interrogative embedding. Section 5 is devoted to the discussion of how triviality can be avoided with interrogative embedding. Section 6 deals with the notions of exhaustivity and triviality. Section 7 concludes the

paper.

2 Stating the problem

2.1 The responsiveness puzzle

There are predicates which embed both declarative and interrogative clauses such as *know* in (5), predicates which embed only declarative clauses such as *believe* in (6), and finally ones which embed only interrogatives such as *ask* in (7). Is there a principled reason for these observed differences?

(5) a. John knows that Mary smokes.
b. John knows whether Mary smokes.
c. John knows who smokes.

(6) a. John believes that Mary smokes.
b. *John believes whether Mary smokes.
c. *John believes who smokes.

(7) a. *John asks that Mary smokes.
b. John asks whether Mary smokes.
c. John asks who smokes.

One part of this question is more or less straightforward to resolve if three fairly standard assumptions are made: (a) declarative and interrogative denotations are to be distinguished in their types (e.g. Karttunen 1977), (b) declarative denotations cannot be turned into interrogative ones via some type-shifting operation (e.g. Uegaki 2015a), and (c) predicates like *ask* take as their first argument interrogative denotations (e.g. Chierchia 1992). Then (7b) and (7c) come out as interpretable, but not so (7a). I will refer to predicates like *ask* as rogative (Asher 1987, Lahiri 2002).[2]

Now, the standard position is that both *know* and *believe* take declarative denotations as arguments. This accounts for the acceptability of (5a) and (6a). Let us assume that declarative denotations correspond to propositions as is also standard—hence the term PTP—and that interrogatives denote questions, where we leave open for the time being what a question is. Since *know* can also embed interrogative clauses, it follows that there must be a way of turning questions into propositions. Again a fairly standard assumption is that *know* takes in (5b) and (5c)

[2]Whether these assumptions are all correct is not crucial at this point. What is important is that interrogative embedding under PTPs poses a puzzle that can be addressed independently of the one raised by (7). Clearly, eschewing either assumption (a), as done by Groenendijk and Stokhof (1982, 1984), or (b) as done by Uegaki (2015a), Theiler et al. (2016) would make the issue even more acute. Further rogative PTPs are the ones in (i) and in (ii). Note that the intended interpretation of *argue* is the one of arguing with one another rather than the one of arguing for something, as (iib) makes clear. That is, there seems to be a responsive and a rogative *argue*. In light of the observations made by Elliott et al. (2017) predicates of relevance like *care* might be further instances of this sort. See also footnote 8.

(i) a. *John *assessed / evaluated / investigated / wondered* that Mary smokes.
b. John *assessed / evaluated / investigated / wondered* whether Mary smokes.

(ii) a. *John and Mary *argued / debated* that Mary smokes.
b. John and Mary *argued / debated* whether Mary smokes.

the actual true answer to the question denoted by the interrogative, i.e., a proposition.[3] We could assume that this proposition is arrived at by applying an answer operator to the question (see Heim 1994, Beck and Rullmann 1999, Sharvit 2002 a.m.o.). But now we face a problem: why can we not apply the answer operator to the questions in (6b) and (6c) thereby turning them into a proposition that could function as the argument of *believe*?

I will refer to PTPs like *know* as responsive, again following Lahiri (2002), and to PTPs like *believe* as anti-rogative, following Theiler et al. (2016). We can then state the central puzzle addressed in this paper as in (8).[4]

(8) **The responsiveness puzzle**
Under what conditions is a PTP responsive?

2.2 The veridicality hypothesis and its problems

One reaction found in the literature with regards to the responsiveness puzzle is the claim that PTPs must be veridical in order to embed interrogative clauses (see Hintikka 1975, Berman 1991, Ginzburg 1995a,b, Egré 2008 a.o.). A PTP is veridical if it licenses the inference that the embedded declarative clause is true.[5] Veridicality distinguishes between *know* and *believe*, as shown in (9). By the veridicality hypothesis the former is correctly expected to embed interrogative clauses and the latter is correctly expected not to do so.[6]

(9) a. John knows that Mary smokes. $\rightsquigarrow$ *Mary smokes*
b. John believes that Mary smokes. $\not\rightsquigarrow$ *Mary smokes*

The veridicality hypothesis is supported by the fact that indeed veridical PTPs such as those in (10a) and (11a) embed interrogative clauses, as in (10b) and (11b), and by the further fact that

[3] I use the pretheoretical notion *the answer* ignoring for the moment the differences between the various kinds of exhaustive interpretations. See sections 4.1.1 and 6.1.

[4] To account for why only (ib) has the inference that John believes that Mary smokes, Uegaki (2015a) makes assumptions that could also account for (5) and (6): (a) Declaratives can denote propositions and questions, interrogatives only denote questions. (b) *Know* takes questions. This derives the acceptability of all of (5). (c) *Believe* takes propositions, making (6a) good. (d) Propositions cannot be shifted to questions, accounting for (6b) and (6c).

(i) a. John knows the rumor that Mary smokes. $\not\rightsquigarrow$ *John knows that Mary smokes*
b. John believes the rumor that Mary smokes. $\rightsquigarrow$ *John believes that Mary smokes*

Now, translating (ia) directly to a language like German mandates the use of the the acquaintance-based *kennen* over the knowledge-based *wissen*, as (ii) shows. Crucially, when embedding interrogatives or declaratives directly, the picture is reversed, as shown in (iii). This suggests that English *know* is ambiguous. Thus the pattern in (i) need not influence our conclusions about (5) and (6).

(ii) Hans **weiß* / ✓*kennt* das Gerücht, dass Maria raucht.
Hans knows$_{know}$ / knows$_{acqu}$ the rumor that Maria smokes
'Hans knows the rumor that Maria smokes.'

(iii) Hans ✓*weiß* / **kennt*, dass / ob Maria raucht.
Hans knows$_{know}$ / knows$_{acqu}$ that / whether Maria smokes
'Hans knows that / whether Maria smokes.'

[5] More formally, a PTP P is veridical if and only if utterance in world w of sentence S with declarative sentence D embedded under P, i.e. [$_S$ X P D], licenses the inference that $[\![\mathbf{D}]\!](w) = 1$.

[6] $\rightsquigarrow$ indicates an inference licensed by the respective sentence without any commitment as to the specific type of that inference.

many non-veridical PTPs as in (12a) do not embed them, as in (12b). In the following, I give the polar case only when the *wh*-case behaves in parallel.

(10) John *deduced / discovered / discerned / disregarded / established / figured out / found out / forgot / foresaw / learned / noticed / overlooked / proved / recalled / remembered / sensed ...*

a. that Mary smokes. $\rightsquigarrow$ *Mary smokes*
b. whether Mary smokes.

(11) a. It *matters / is relevant / important* that Mary smokes. $\rightsquigarrow$ *Mary smokes*
b. It *matters / is relevant / important* whether Mary smokes.

(12) John *alleged / asserted / claimed / conjectured / proposed / suggested ...*

a. that Mary smokes. $\not\rightsquigarrow$ *Mary smokes*
b. *whether Mary smokes.

The following data, however, are in conflict with the veridicality hypothesis: on the one hand, there are PTPs such as in (13) and (14) which embed interrogative clauses yet are non-veridical (see Grimshaw 1979, Uegaki 2015a and also Lahiri 2002):[7] [8]

(13) a. John is *certain* / *conjectures* (*about) that Mary smokes. $\not\rightsquigarrow$ *Mary smokes*
b. John is *certain* / *conjectures* ??(about) whether Mary smokes.

(14) John *announced / confirmed / concluded / considered / contemplated / decided / declared / established / explained / guessed / heard / indicated / inferred / predicted / reported / told us ...*

a. that Mary smokes. $\not\rightsquigarrow$ *Mary smokes*
b. whether Mary smokes.

On the other hand, there are at least two veridical anti-rogative PTPs (Egré 2008):

(15) a. John *regrets* / *resents* that Mary smokes. $\not\rightsquigarrow$ *Mary smokes*
b. *John *regrets* / *resents* whether Mary smokes.

2.3 The lexical specification hypothesis and its problems

The responsive PTPs do not form a natural semantic class. It has thus been claimed that it is not predictable given formal semantic characteristics of a given PTP whether it is responsive (Grimshaw 1979, Uegaki 2015a). In particular, Grimshaw has advanced the view that predicates are specified lexically for so-called s-selectional properties (see also Chomsky 1965, Baker 1968). In addition, to specifying which categorial features complement clauses can have—so-called c-selection—they also specify which semantic features they can have. For instance assuming that $\pm D$ specifies whether a predicate can embed a declarative and $\pm I$ whether it can embed an interrogative clause, *know* would have as s-selectional specification $[+D, +I]$, *believe* would have $[+D, -I]$, and *ask* would have $[-D, +I]$. Similar s-selectional assumptions can be

[7] One might assume that the preposition in (13b) licenses the interrogative. Thereby *be certain* and *conjecture* might actually be in line with the veridicality hypothesis (see Egré 2008 and section 5.4.3).

[8] Beck and Sharvit (2002) argue that there are actually two different predicates *decide*, one rogative and the other one either anti-rogative or responsive. In that case *decide* should be removed from (14). But see Nathan (2005) for a different view, which is more in line with the picture to be drawn in section 5.1.1.

made about the other predicates discussed.[9]

Now, the lexical specification account makes two predictions. First, whether a PTP embeds a given clause type or not should be arbitrary and thereby subject to cross-linguistic variation; in particular, *random* variation, which is meant to describe the following state of affairs for our immediate purposes: a particular PTP has exactly the same lexical semantics in two languages, but in the first it would be anti-rogative whereas in the second it would be responsive. Second, the surrounding linguistic context should not affect the embedding possibilities under a given PTP. I discuss both predictions in turn now, focussing on the latter one in particular. I argue that there is reason to doubt their accuracy.

2.3.1 Cross-linguistic stability

Responsiveness is not as arbitrary as it might seem at first glance. For instance, the *know-believe* distinction is found in many languages. This is shown for German in (16), for Russian in (17), for French in (18), and for German Sign Language in (19). For similar observations regarding American Sign Language see Davidson and Caponigro (2016).

(16) a. Hans *weiß* / *glaubt*, dass Maria raucht.
Hans knows / believes that Maria smokes
b. Hans *weiß* / **glaubt*, ob Maria raucht.
Hans knows / believes whether Maria smokes

(17) a. Ivan *znaet* / *dumaet* čto Maša kurit.
Ivan knows / believes that Maša smokes
b. Ivan *znaet* / **dumaet* Maša li kurit.
Ivan knows / believes Maša whether smokes

(18) a. Jean *sait* / *croit* que Marie fume.
Jean knows / believes that Marie smokes
b. Jean *sait* / **croit* si Marie fume.
Jean knows / believes whether Marie smokes

(19) a. IX-A WEISS / GLAUBT IX-B RAUCHT.
(s)he knows / believes (s)he smokes
b. IX-A WEISS / *GLAUBT OB IX-B RAUCHT.
(s)he knows / believes whether (s)he smokes

Of course, one cannot conclude much from such a limited set of languages. But it is important

[9] Emotive factive PTPs as in (i) embed declaratives and *wh*-interrogatives but not polar interrogatives (Grimshaw 1979). The lexical specification analysis seems to have an advantage over the veridicality hypothesis here; given the apparent veridicality of the PTPs involved, no difference between (ib) and (ic) is expected on the latter view. The obvious response is to find an independent reason for why polar interrogatives cannot be embedded under emotive factive PTPs but *wh*-ones can be. A number of such suggestions exist in the literature (e.g. Guerzoni 2007, Sæbø 2007, Nicolae 2013, Romero 2015, Roelofsen et al. to appear). In principle, the present proposal is compatible with most of these. I will therefore largely ignore emotive factive PTPs in this paper but will briefly return to this issue in section 7. Related to but different from emotive factive PTPs are *regret* and *resent*, which do not embed any interrogatives, and are thus discussed in section 4.3.5.

(i) a. John *is amazed / happy / surprised / complains* that Mary smokes. ⇝ *Mary smokes*
b. *John *is amazed / happy / surprised / complains* whether Mary smokes.
c. John *is amazed / happy / surprised / complains* who smokes.

to see two things: (i) it is not clear at all which languages would not show the pattern above. And (ii) not only is the basic *know-believe* distinction found in many languages. Also, the more general pattern regarding the embedding of interrogative clauses under PTPs is not uncommon. For instance, both the veridical PTPs from (10) embedding interrogatives and the non-veridical PTPs from (12) not doing so exhibit the same behavior in German, as (20) and (21) show respectively (see Öhl 2007, Schwabe and Fittler 2009 for more discussion).

(20) Hans hat *ermittelt* / *entdeckt* / *herausgefunden* / *vergessen* / *erfahren* / *sich erinnert*,
Hans has deduced / discovered / figured out / forgot / learned / remembered
{**dass** / **ob**} Maria raucht.
that / whether Maria smokes

(21) Hans hat *behauptet* / *erklärt* / *vermutet* / *gefolgert* / *abgeleitet*, {**dass** / ***ob**}
Hans has alleged / asserted / conjectured / found / inferred that / whether
Maria raucht.
Maria smokes

Now, English and German are related, and similar observations could be made about other closely related languages. But it is important to appreciate the following. Even the parallels discussed here are surprising on Grimshaw's view. After all s-selection according to her is independent of the lexical semantics of the PTPs. It should thus also be historically unstable.

In other words, it is not clear that there is evidence for the kind of random cross-linguistic variation regarding clausal complementation that one would expect given the lexical specification hypothesis. While I must leave further investigation of this issue for future research, I want to point out once more that randomness is the key issue here. Even the cross-linguistic differences to be surely discovered thereby need not necessarily speak in favor of the lexical specification hypothesis. It might be that a PTP slightly varies in its lexical semantics across the languages considered thereby affecting the embedability of interrogative clauses.[10]

2.3.2 Context dependence

According to the lexical specification hypothesis each PTP specifies whether an interrogative clause is a possible complement or not. The surrounding linguistic context should not be able to affect this choice. The data in (22), repeated from (3) show that the PTP *be certain* contradicts this prediction. On its own *be certain* can embed declarative clauses as in (22a) but not interrogative ones as in (22b) (see for instance Egré 2008). With negation as in (23b), however, embedding of an interrogative markedly improves.

(22) a. John is certain that Mary smokes.
b. ??John is certain whether Mary smokes.
c. John isn't certain whether smokes.

Again, this pattern is observed across languages. It holds, for instance, in German (Eckardt 2007, Schwabe and Fittler 2009):

[10]For instance German *lernen* ('learn') unlike its English equivalent seems to almost lack the come-to-know reading when embedding declarative clauses. The prominent one is the being-taught reading, i.e. it is non-veridical. On this reading, interrogative clauses are difficult to embed, which is why it is absent from the list in (20). When embedding an interrogative, the come-to-know reading, however, becomes the prominent one. One might thus think that *lernen* corresponds to two different PTPs varying with the type of complement. If that was the case, the lexical specification hypothesis would not be supported. See also section 2.4 below.

(23) a. Hans ist (sich) sicher, dass Maria raucht.
Hans is SELF certain that Maria smokes
'Hans is certain that Maria smokes.'
b. ??Hans ist (sich) sicher, ob Maria raucht.
Hans is SELF certain whether Maria smokes
c. Hans ist (sich) nicht sicher, ob Maria raucht.
Hans is SELF not certain whether Maria smokes
'Hans isn't certain whether Maria smokes.'

PTPs like *say*, *be convinced*, *be sure*, *be clear*, and *be important* exhibit a behavior parallel to *be certain*, as is shown by (24) and (25). Crucially, these PTPs are all non-veridical, just like *be certain*.[11]

(24) a. John *said* / *is convinced* / *is sure* that Mary smokes. $\not\rightarrow$ *Mary smokes*
b. ??John *said* / *is convinced* / *is sure* whether Mary smokes.
c. John *didn't say* / *isn't convinced* / *isn't sure* whether smokes.

(25) a. It is *clear* / *important* that Mary smokes. $\not\rightarrow$ *Mary smokes*
b. ??It is *clear* / *important* whether Mary smokes.
c. It isn't *clear* / *important* whether Mary smokes.

Agree is probably another such non-veridical PTP. It embeds declaratives without the use of a preposition. With interrogatives, however, a preposition can be used to license embedding and in the absence of negation actually must be used.[12]

(26) a. John and Bill agree (*on) that Mary smokes. $\not\rightarrow$ *Mary smokes*
b. John and Bill agree ??(on) whether Mary smokes.
c. John and Bill don't agree (on) whether Mary smokes.

Why would negation affect the embedding of interrogative clauses under non-veridical PTPs? Adger and Quer (2001) claim that *if*-interrogatives can be embedded under *admit* only in NPI-licensing contexts. We can therefore ask whether interrogative clauses as complements of *be certain* are similarly restricted. Typical contexts licensing NPIs like *any* apart from clausal negation are roughly downward monotonic: negative quantifiers, antecedents of conditionals, and restrictors of universal quantifiers (see Fauconnier 1979, Ladusaw 1979, Linebarger 1987, Krifka 1995, Giannakidou 1999, Chierchia 2004 a.m.o.). (27) shows that, indeed, both the restrictor and the scope of the negative quantifier *no* allow for interrogative embedding under *be certain*. See Eckardt 2007 for other downward monotonic quantifiers.

(27) a. No student who is certain whether Mary smokes met her.
b. No student who met Mary is certain whether she smokes.

However, with conditionals and universal quantifiers the parallel to NPIs breaks down. With conditionals speakers report that interrogative embedding under *be certain* is both possible in the antecedent, (28a) and the consequent, (28b).

[11] Notice that (25b) with *important* is acceptable on an interpretation like *It is important to know whether Mary smokes*. Arguably, on such an interpretation it is, however, *know* that licenses the interrogative. Alternatively, the latter interpretation might correspond to a rogative one.

[12] A google search for the string *agree whether* yields almost only results of the form *can't agree whether* and *don't agree whether*. In that respect, the situation is parallel to the one observed in (13) for *be certain*. See section 5.4.3.

(28) a. If John is certain whether Mary smokes, he met her.
b. If John met Mary, he is certain whether she smokes.

Similarly, with universal quantifier *every* there is no asymmetry. Embedding in the restrictor as in (30a) is as much possible as in the scope of the quantifier as in (30b) (but cf. Eckardt 2007). The absence of a difference in acceptability regarding interrogative embedding under *be certain* between negative environments, on the one hand, and downward monotonic environments more broadly, on the other hand, is experimentally supported by the data reported by van Gessel et al. (2017).

(29) a. Every student who is certain whether Mary smokes met her.
b. Every student who met Mary is certain whether she smokes.

Crucially though, indefinites do behave as expected on an NPI-based account. Neither the restrictor nor the scope easily allows for interrogative embedding under *be certain*:

(30) a. ??Some student who is certain whether Mary smokes met her.
b. ??Some student who met Mary is certain whether she smokes.

Thus, monotonicity appears to play a role in the embedding of interrogatives under *be certain*, but the parallel to NPIs is not perfect. More precisely, downward monotonic environments license interrogative embedding under *be certain*. Upward monotonic environments—like unembedded *be certain* and indefinites—do not do so, except for consequents of conditionals and scopes of universal quantifiers. As we will see in section 5.2.3 this suggests that the picture is more reminiscent of the licensing of scalar inferences more generally than of NPIs in particular.

It must also be mentioned that *wh*-interrogatives are somewhat better as complements of *be certain* even without negation than *whether*-interrogatives. That is, (31a) appears more acceptable than (22b). The basic contrast noted above, however, is still observed, because embedding under negation as in (31b) improves over (31a).

(31) a. ?John is certain who smokes.
b. John isn't certain who smokes.

Finally in contrast to embedding under *admit* as discussed by Adger and Quer (2001), there is no clear difference between *whether*- and *if*-interrogatives as complements of *be certain*. That is, without negation an *if*-interrogative is as unacceptable under *be certain* as a *whether*-interrogative:

(32) a. *John is certain if Mary smokes.
b. John isn't certain if Mary smokes.

As Eckardt (2007) points out this is to be expected given that German, as noted in (23b) and (23c) above, exhibits the same contrast with regards to interrogative embedding under *(sich) sicher sein* as found for English *be certain*. But German does not distinguish between *if* and *whether*. There is only one interrogative complementizer. As a consequence, the particular account offered by Adger and Quer (2001) for embedding under *admit* is unlikely to generalize to the data discussed in this section. I must leave *admit* for future research.

For the moment it suffices to note three things: (i) the prediction of the lexical specification account that linguistic context cannot affect clausal embedding is too strong. (ii) The way linguistic context affects clausal embedding is systematic and tracks the licensing of NPIs to

some extent but not completely. (iii) The embedding patterns appear to be cross-linguistically surprisingly stable. In light of this it is worth considering possible alternative accounts.

2.4 Two types of veridicality

Recall now (33) repeated from (14) above. Given that the non-veridical PTPs in (33) embed interrogatives, I suggested that the solution to the responsiveness puzzle is likely to be unrelated to the property of veridicality.

(33) John *announced / confirmed / concluded / considered / contemplated / decided / declared / established / explained / guessed / heard / indicated / inferred / predicted / reported / told us* ...

a. that Mary smokes. $\not\rightsquigarrow$ *Mary smokes*

b. whether Mary smokes. $\rightsquigarrow$ *John P-ed the true answer to "Does Mary smoke?"*

There is a curious fact about the PTPs in (33), which I have not mentioned yet (Baker 1968, Boër 1978, Karttunen 1977, Groenendijk and Stokhof 1984, Berman 1991 a.o.): each PTP in (33) when embedding an interrogative requires that the subject of the matrix clause stand in the relation denoted by the PTP to the true answer to the question denoted by the interrogative. That is, for (33b) to be true with *announce*, for instance, John must have announced that Mary smokes if that is what is the case but must have announced that she does not smoke if that is what is the case. In other words, it does not suffice for John to have announced some answer. Rather he must have announced the actual true answer whatever it is (see Groenendijk and Stokhof 1984, Lahiri 2002, Spector and Egré 2015 a.o.). In the following, I will refer to this property of the PTPs involved in (33) as another type of veridicality, as is standardly done. To distinguish the two types of veridicality, I will call the already familiar type *d(eclarative)-veridicality* from now on, and the new type *i(nterrogative)-veridicality*.[13]

Thus a PTP like *announce* is i-veridical but not d-veridical. Interestingly, the PTPs from (10a) and therefore also *know* are i-veridical and d-veridical:

(34) John *deduced / discovered / discerned / disregarded / established / figured out / found out / forgot / foresaw / learned / noticed / overlooked / proved / recalled / remembered / sensed* ...

a. that Mary smokes. $\rightsquigarrow$ *Mary smokes*

b. whether Mary smokes. $\rightsquigarrow$ *John P-ed the true answer to "Does Mary smoke?"*

Ignoring the exceptions of *regret* and *resent* for the moment, the data in (33) might be taken to support the initial veridicality hypothesis. Assume that d-veridicality is sufficient for interrogative embedding and that d-veridicality entails i-veridicality. Assume furthermore that the PTPs in (33) are ambiguous between d-veridical and non-d-veridical versions. In absence of other factors licensing interrogative embedding, the d-veridical version would then have to be chosen when embedding an interrogative giving rise to i-veridicality as in (33).[14]

I-veridicality also sets the PTPs in (33) apart from other non-veridical PTPs such as *be certain* and *conjecture* in (35), repeated from above. (35b) is true as long as John stands in the relation denoted by the PTP to some answer to the question denotation, i.e., he need not

[13] A PTP P is i-veridical if and only if utterance in world w of sentence S with interrogative Q embedded under P, i.e. $[_S$ X P Q], licenses the inference that $[\![\mathbf{P}]\!]$(the true answer in w to $[\![\mathbf{Q}]\!]$)$([\![\mathbf{X}]\!])(w) = 1$.

[14] In this respect it should be noted that interrogative embedding tracks semantic properties of PTPs like d-veridicality to a considerable extent as shown by White et al. (2017).

be certain about the actual true answer in the case of *be certain*. This means that the PTPs are neither d- nor i-veridical, even when embedding an interrogative with the help of a preposition.

(35) a. John *is certain / conjectures* (*about) that Mary smokes. $\not\rightarrow$ *Mary smokes*
b. John *is certain / conjectures* ??(about) whether Mary smokes.
$\not\rightarrow$ *John P-ed the true answer to "Does Mary smoke?"*

Consider next cases of context dependent interrogative embedding under negation. Even in this case the PTPs remain non-veridical. Obviously, John does not believe the true actual answer to the embedded interrogative in the example in (36). Given that the example is unacceptable in the context, we can conclude that its truth-conditions do not just require that John do not stand in the be-certain-relation to the true answer to *whether Mary smokes*. Rather they seem to require that John do not stand in the be-certain-relation to any possible answer to *whether Mary smokes*. These truth-conditions are not fulfilled in the context, and thereby the sentence comes out as degraded.

(36) **Context:** *Mary smokes, but John believes she does not smoke.*
#John isn't certain whether Mary smokes.

(37) makes a parallel point for *say*.

(37) **Context:** *Mary smokes, but John said she does not smoke.*
#John didn't say whether Mary smokes.

In light of all these observations, I propose the modified veridicality hypothesis in (38). According to this hypothesis it is sufficient for a PTP to be d-veridical in order to embed an interrogative clause. But even d-veridicality is not a necessary condition. Non-veridical PTPs like *be certain* can embed interrogatives by either occurring in certain contexts or with the help of prepositions. (38) is not necessarily an exhaustive list.

(38) **The modified veridicality hypothesis**
A PTP P embeds interrogative clause Q if
a. P can be d-veridical, or
b. P cannot be d-veridical and
(i) P is embedded in an NPI-licensing context, or
(ii) P is embedded in the scope of a universal quantifier or the consequent of a conditional, or
(iii) P occurs with a preposition.

In the following section I lay the groundwork that will let me account for the responsiveness puzzle on the basis of the hypothesis in (38).

3 A polarity system for interrogative embedding[15]

Focusing on the case of interrogative embedding under *be certain* in NPI-licensing contexts, the obvious question to ask at this point is how the pattern in (39) can be seen as parallel to the more familiar one in (40) with the NPI *any*.

[15]This section is based on and crucially extends Mayr 2017.

(39) a. John isn't certain whether Mary smokes.
b. ??John is certain whether Mary smokes.

(40) a. John didn't see any girl.
b. *John saw any girl.

One of the main contending views regarding NPIs goes as follows:[16] first, *any girl* in (40) denotes an existential quantifier over girls. In (40a) the existence of girls seen by John is therefore negated. Second, the sentence has alternatives about particular girls such as *John didn't see Mary* for (40a) and *John saw Mary* for (40b). Third, each sentence in (40) is strengthened by adding the negations of its logically non-weaker alternatives to its meaning, i.e., those alternatives not entailed by it. This leads to a contradiction without but not with negation, accounting for the pattern in (40) (see Heim 1984, Kadmon and Landman 1993, Krifka 1995, Chierchia 2006, 2013, Crnič 2014 a.m.o.).

In the following, I argue that something similar is happening in the case of (39). Here it is the PTP that contributes existential quantification (Spector and Egré 2015, Theiler et al. 2016), while the non-weaker alternatives are contributed by the embedded interrogative clause (Klinedinst and Rothschild 2011). If anything, it is therefore the PTP *be certain* in combination with the interrogative that constitutes an NPI, rather than a single lexical item. Strengthening relative to these alternatives accounts for the pattern in (39).

I begin with a very simple system, which derives the part of the modified veridicality generalization from (38) above about NPI-licensing contexts. I then show that without modification this also captures the part of the hypothesis about d-veridicality. As a side-effect it immediately accounts for the *know-believe* distinction. When the system introduced below is modified in section 4, the three ingredients just mentioned will remain.

3.1 Deriving context dependence for *be certain*

Assume for *be certain* Hintikka's (1969) universal semantics for propositional attitudes, as in (41).

(41) $[\![\textbf{be certain}]\!] = \lambda p_{st}.\lambda x_e.\lambda w_s.\forall w'[w' \in Dox_{x,w} \rightarrow p(w') = 1]$

Be certain applied to a proposition p asserts that p is true in all of the subject's doxastic alternatives. This means p is true in all the worlds doxastically accessible to the subject from the world of evaluation w. In yet other words, in all worlds compatible with the subject's beliefs in w p is true.

Consider now the sentences in (39) again. Assume for the moment that the denotation of the embedded interrogative is as in (42). This is an existential quantifier ranging over a set of propositions, i.e., over a question denotation in the sense of Hamblin (1973) and Karttunen (1977). The set contains the positive and the negative answer to the polar interrogative. In the following, I abbreviate this set as Q'—that is, $\{\lambda w.$ Mary smokes in w, $\lambda w.$Mary doesn't smoke in $w\} = Q'$.

(42) $[\![\textbf{whether Mary smokes}]\!]$
$= \lambda Q_{\langle st,t\rangle}.\lambda w_s.\exists p[p \in \{\lambda w'.\text{M smokes in } w', \lambda w'.\text{M doesn't smoke in } w'\} \wedge Q(p) = 1]$
$= \lambda Q_{\langle st,t\rangle}.\lambda w_s.\exists p[p \in Q' \wedge Q(p) = 1]$

[16] To be sure, other views exist. For instance, work building on Giannakidou (1999) more or less denies the picture sketched below. Given that interrogative embedding is not fully parallel to NPI-licensing, however, her criticism is not expected to carry over to the present proposal.

Now, since the denotation of *be certain* requires a proposition as argument, it cannot apply to (42). Assume therefore, following Lahiri (2002), that the embedded interrogative must take scope over the entire clause, which gives the LFs in (43a) and (43b) for (39a) and (39b), respectively. The operator Exh is discussed below.[17]

(43) a. $[_{S'_1}\ \text{Exh}_{Alt}\ [_{S_1}\ \text{not}\ [[\ \text{whether Mary smokes}\ ]\ \lambda p[\ \text{John is certain}\ p\ ]]]]$
b. $[_{S'_2}\ \text{Exh}_{Alt}\ [_{S_2}\ [\ \text{whether Mary smokes}\ ]\ \lambda p[\ \text{John is certain}\ p\ ]]]$

For (43a), on the one hand, its literal meaning before the contribution of Exh is factored in corresponds thus to (44a). This says that there is no proposition in Q' which is true in all of John's doxastic alternatives. (43b), on the other hand, has as its denotation (44b) saying that there is a proposition in Q' that is true in all of John's doxastic alternatives.

(44) a. $[\![\mathbf{S}_1]\!]^g = \lambda w.\neg\exists p[p \in Q' \wedge \forall w'[w' \in Dox_{J,w} \rightarrow p(w') = 1]]$
b. $[\![\mathbf{S}_2]\!]^g = \lambda w.\exists p[p \in Q' \wedge \forall w'[w' \in Dox_{J,w} \rightarrow p(w') = 1]]$

Consider next the alternatives to the denotations in (44). For the moment I stipulate them to constitute sets of propositions satisfying the following requirement: each member corresponds to the denotation one would get by replacing the embedded interrogative in (39) with one of its answers in the set Q'. Since the answers are propositions *be certain* can be applied directly. The first proposition in (45) says, for instance, that not in all of John's doxastic alternatives Mary smokes.

(45) a. $[\![\mathbf{S}_1]\!]^{alt} = \{\lambda w.\neg\forall w'[w' \in Dox_{J,w} \rightarrow \text{Mary smokes in } w'],$
$\lambda w.\neg\forall w'[w' \in Dox_{J,w} \rightarrow \text{Mary doesn't smoke in } w']\}$
b. $[\![\mathbf{S}_2]\!]^{alt} = \{\lambda w.\forall w'[w' \in Dox_{J,w} \rightarrow \text{Mary smokes in } w'],$
$\lambda w.\forall w'[w' \in Dox_{J,w} \rightarrow \text{Mary doesn't smoke in } w']\}$

Finally, exhaustification applies to the propositions derived in (44a) and (44b) to strengthen them. That is, the former is exhaustified relative to its alternatives in (45a), and the latter relative those in (45b). This is done with the help of the Exh-operator defined in (46) (see Groenendijk and Stokhof 1984, Krifka 1995, van Rooij and Schulz 2004, Chierchia 2006, 2013, Fox 2007, Spector 2007, Chierchia et al. 2012 a.m.o.). Exh takes a proposition p—the prejacent S_1 or S_2—, asserts it and states that all propositions which are not Strawson-entailed by p are false. In the following $\Rightarrow$ indicates regular entailment, and $\Rightarrow_S$ Strawson-entailment. In the particular case at hand and more generally whenever a sentence is presuppositionless, Strawson-entailment reduces to regular entailment. For more discussion, see section 3.2.1.[18]

(46) $[\![\mathbf{Exh}_{Alt}]\!] = \lambda w.p(w) = 1 \wedge \forall q \in Alt[p \not\Rightarrow_S q \rightarrow q(w) = 0]$

Now notice that the denotation of the prejacent S_1 of Exh in (43a), i.e., (44a), entails each of its alternatives in (45a). If none of the propositions in Q' is such that it is true in all of

[17] The details of all this will change in section 4.2. Given Spector and Egré's (2015) innovation, the denotation of the interrogative will not be a quantifier and scoping will not be necessary. It will thereby automatically be in the scope of negation, which for the moment is stipulated in the LF in (43a).

[18] Entailment and Strawson-entailment (von Fintel 1999) are defined as follows:

(i) a. For any $p, q \in D_{st}$, p entails q, $p \Rightarrow q$, iff for all $w \in W$ such that $p(w) = 1$, $q(w) = 1$.
b. For any $p, q \in D_{st}$, p Strawson-entails q, $p \Rightarrow_S q$, iff for any presupposition r of q and all $w \in W$ such that $p(w) = r(w) = 1$, $q(w) = 1$.

John's doxastic alternatives, then it follows both that John is neither certain that Mary smokes nor that she does not smoke. As a consequence Exh does not negate any of the alternatives, and the strengthened interpretation of (39a) is equivalent to its literal one without Exh—that is, $[\![\mathbf{S}'_1]\!]^g$ is equivalent to $[\![\mathbf{S}_1]\!]^g$ in (44a). This corresponds to the intuitive interpretation of sentence (39a). To see this, consider it in context (47) from (36). It is unacceptable because the truth-conditions in (44a) require John to be uncertain about all of the propositions in Q', contradicting the context. Notice that (47) provides strong evidence for the assumption that there is existential quantification over answers involved. If the truth-conditions where about the true answer, the sentence should be acceptable.

(47) **Context:** *Mary smokes, but John believes she does not smoke.*
#John isn't certain whether Mary smokes.

Consider next the denotation of the prejacent S_2 of Exh in (43b) given in (44b). Each of its alternatives in (45b) entails it. For instance, if John is certain that Mary smokes, then there is a proposition in Q' that is true in all of John's doxastic alternatives. Consequently, Exh negates each of the alternatives and conjoins them with the denotation of the prejacent yielding (48).

(48) $[\![\mathbf{S}'_2]\!]^g = \lambda w.\exists p[p \in Q' \wedge \forall w'[w' \in Dox_{J,w} \rightarrow p(w') = 1]] \wedge \neg\forall w'[w' \in Dox_{J,w} \rightarrow$ Mary smokes in w'] $\wedge \neg\forall w'[w' \in Dox_{J,w} \rightarrow$ Mary doesn't smoke in w']

(48) is clearly a contradiction. Following Gajewski (2002), Fox and Hackl (2006), Chierchia (2006, 2013), Abrusán (2014) a.o., I assume that certain trivial meanings, which also include tautologies, lead to judgements of degradedness. As will be shown in section 6.2, the relevant notion of triviality is so-called l-triviality, of which the cases discussed will be seen to be examples. The assumption in (49) derives the pattern in (39), but also those in (24) and (25).

(49) **Triviality and degradedness (to be revised)**
If a sentence S has an l-trivial meaning, S is degraded.

The crucial reason why negation did not result in a contradiction was that it reverses the entailment patterns between the literal interpretation and the alternatives. As a consequence it follows that any entailment reversing environment, such as the downward monotonic contexts discussed in section 2.3.2 above, are predicted to not result in contradictions either. In particular, negative quantifiers, antecedents of conditionals, and restrictors of universal quantifiers are correctly predicted to license interrogatives under *be certain*. Moreover, the non-licensing under non-entailment reversing indefinites is also accounted for. This, however, leaves the consequents of conditionals and scopes of universal quantifiers unaccounted for. I discuss them in section 5.2.3.

3.2 Deriving the difference between *believe* and *know*

Let me now return to the difference between *know* and *believe*. Only the former embeds interrogatives. We now observe that negation does not affect this picture:

(50) a. John (doesn't) know(s) whether Mary smokes.
b. *John (doesn't) believe(s) whether Mary smokes.

Now, both *know* and *believe* have lexical properties differentiating them from each other, but setting them also apart from *be certain*. *Know*, on the one hand, is d-veridical, whereas the other two PTPs are not, as repeated in (51).

(51) a. John knows that Mary smokes. $\rightsquigarrow$ *Mary smokes*
b. John *believes* / *is certain* that Mary smokes. $\not\rightsquigarrow$ *Mary smokes*

Believe, on the other hand, is a neg-raising predicate (Horn 1978). When negated, it appears as if the negation took scope below *believe* giving rise to a stronger than expected inference, as shown in (52b).[19] Neither *know* nor *be certain* is neg-raising, as (52a) shows.

(52) a. John *doesn't know* / *isn't certain* that Mary smokes.
$\not\rightsquigarrow$ *John Ps that Mary doesn't smoke*
b. John doesn't believe that Mary smokes.
$\rightsquigarrow$ *John believes that Mary doesn't smoke*

In the following, I show how the lexical properties of d-veridicality and neg-raising interact with the system sketched in the preceding section thereby deriving the patterns in (50a).

3.2.1 Neg-raising predicates

The intuition that interrogative embedding under neg-raising PTPs yields trivial truth-con-ditions goes back to Zuber (1982). In particular, I argue that it is the existential semantics for interrogative embedding combined with the neg-raising property of the PTP that is responsible for this (see also Theiler et al. 2016[20]).

I adopt an analysis of neg-raising according to which the impression that the matrix negation scopes below *believe* is due to a presupposition of *believe*, namely the presupposition of the excluded middle (Bartsch 1973, Löbner 2003, Gajewski 2007). That is, *believe* has a denotation parallel to *be certain* with the additional presuppositional requirement that the subject either believe the propositional argument to be true or believe it to be false:[21] [22]

(53) $[\![\textbf{believe}]\!] = \lambda p_{st}.\lambda x_e.\lambda w_s : \underline{\forall w'[w' \in Dox_{x,w} \rightarrow p(w') = 1] \vee \forall w'[w' \in Dox_{x,w} \rightarrow p(w') = 0]} \,.\, \forall w'[w' \in Dox_{x,w} \rightarrow p(w') = 1]$

In the positive case of (51b) the presupposition in (53) is harmless as it is entailed by the assertive component. In the negative case in (52b), however, the presupposition and the assertion are logically independent. The consequence of this is that even though the assertion has weak wide-scope negation, the presupposition strengthens the intuited inference as in (54). This is equivalent to saying that John believes that Mary does not smoke.

[19] That is:

(i) Predicate P is neg-raising iff [not X P that S] licenses the inference *'that X P-s that not S'*.

[20] While Theiler et al.'s (2016) proposal for neg-raising PTPs is very similar to the present suggestions, it is not clear to me at this point whether it will ultimately be compatible with the overall architecture suggested here given their use of an alternative-based semantics. I must leave this for future research.

[21] Approaches to neg-raising relying on truth-value gaps (Križ 2015) are compatible with the proposal in the text; provided one assumes that for a context to successfully admit a sentences with a truth-value gap there must be both worlds in the context where the sentence is true and ones where it is false (Manuel Križ p.c.). Approaches making the neg-raising inference a scalar implicature (Romoli 2013) or the consequence of a transformation (Collins and Postal 2014) seem to be incompatible with the account.

[22] I adopt here and in the following Heim and Kratzer's (1998) convention where presuppositions are to be encoded as definedness conditions. I also adopt their notation for this, according to which $\lambda\chi : \underline{\phi} \,.\, \psi$ is a function that is only defined for objects χ such that ϕ holds. In addition presuppositions are underlined.

(54) $[\![\textbf{(52b)}]\!] = \lambda w : \underline{\forall w'[w' \in Dox_{J,w} \rightarrow \text{Mary smokes in } w'] \vee \forall w'[w' \in Dox_{J,w} \rightarrow \text{Mary doesn't smoke in } w']} \,.\, \neg\forall w'[w' \in Dox_{J,w} \rightarrow \text{ Mary smokes in } w']$

Consider now the degraded (55) repeated from above. Its literal truth-conditions are as in (56). Recall that Q' is defined as the set $\{\lambda w.$ Mary smokes in $w, \lambda w.$Mary doesn't smoke in $w\}$. What is the presupposition of (56)? Notice that the existential quantifier binds both into the assertive and the presuppositional components.[23] Assume the presupposition projects existentially as in (57). Then the presupposition is that John either believes that Mary smokes or that she does not smoke.[24] Given that the assertive component of the existentially quantified statement states that Mary smokes or that she does not smoke, it follows that the presupposition is equivalent to the assertion. This means that whenever (57) has a defined truth-value, it is true, i.e., it is a tautology. In yet other words, (55) with existential projection has trivial truth-conditions and is therefore degraded even without exhaustification.

(55) *John believes whether Mary smokes.

(56) $[\![\textbf{(55)}]\!]^g = \lambda w.\exists p \in Q' : \underline{\forall w'[w' \in Dox_{J,w} \rightarrow p(w') = 1] \vee \forall w'[w' \in Dox_{J,w} \rightarrow p(w') = 0]} \,.\, \forall w'[w' \in Dox_{J,w} \rightarrow p(w') = 1]$

(57) **Existential projection in $[\![\textbf{(55)}]\!]^g$**
$= \lambda w : \underline{\exists p \in Q'.\forall w'[w' \in Dox_{J,w} \rightarrow p(w') = 1] \vee \forall w'[w' \in Dox_{J,w} \rightarrow p(w') = 0]} \,.$
$\exists p \in Q'.\forall w'[w' \in Dox_{J,w} \rightarrow p(w') = 1]$

If the presupposition had not projected but had rather been locally accommodated, the result would have been the non-trivial (58). It just states that there is some answer that John believes.

(58) **Local accommodation in $[\![\textbf{(55)}]\!]^g$**
$= \lambda w.\exists p \in Q'[[\forall w'[w' \in Dox_{J,w} \rightarrow p(w') = 1] \vee \forall w'[w' \in Dox_{J,w} \rightarrow p(w') = 0]] \wedge$
$\forall w'[w' \in Dox_{J,w} \rightarrow p(w') = 1]]$
$= \lambda w.\exists p \in Q'.\forall w'[w' \in Dox_{J,w} \rightarrow p(w') = 1]$

Why is (58) not an option? I suggest that the grammar only chooses the local accommodation interpretation if it is not Strawson-entailed by the projection interpretation:[25]

(59) **Accommodation economy**
If ϕ is ambiguous between an existential projection reading R_1 and a local accommodation reading R_2, choose R_2 only if R_1 does not Strawson-entail R_2.

As defined in footnote 18 following von Fintel (1999), for a proposition p to Strawson-entail a proposition q the presuppositions of q must be assumed to be true. Now, clearly (57) and (58) are Strawson-equivalent to each other. They are true in exactly the same worlds. By (59) the latter

[23] (56) and similar examples below contain a bit of abuse of notation as they mix presuppositional and assertive content for reasons of perspicuity. In order to avoid that, one would have have to avoid λ-conversion as well.

[24] In fact, this presupposition is derived regardless of the question whether presuppositions embedded under quantifiers project existentially or universally (see Heim 1983, Beaver 2001, Chemla 2009, Fox 2013, Mayr and Sauerland 2016 a.o.).

[25] (59) is stated in terms of existential projection, as this is directly relevant for the present paper. Ultimately, (59) must be incorporated into a more general theory of projection also allowing for universal projection patterns. Singh (2008), Fox (2013) and Mayr and Sauerland (2016) argue that projection patterns from quantifiers more generally are subject to such considerations of strength, relating them to Dalrymple et al.'s (1998) Strongest Meaning Hypothesis. (59) also incorporates a preference for the projection reading all things being equal similar to DRT-based accounts of projection (van der Sandt 1992, Geurts 1999).

is therefore not a possible interpretation of (55) and only (57) remains. Recall once more that it is trivial because whenever defined at all, it yields truth. I call this Strawson-triviality. Note that for this to go through, I must require that (59) decides in favor of projection instead of local accommodation even if this results in triviality. That is, it is a process blind to the potential triviality of the whole sentence.

Given all this it is easy to see why (60) is also degraded.

(60) *John doesn't believe whether Mary smokes.

The literal meaning is as in (61a). Again, there is the option of existential projection and of local accommodation, as given in (61b) and (61c). This time the former strictly Strawson-entails the latter. So the projection reading is again chosen by (59). This is so because (61b) is a contradiction and therefore Strawson-entails anything. Its presupposition is as before, namely that John either believes that Mary smokes or that she does not smoke. This time, however, the assertive component states that John does not believe any of the propositions in Q'. Thus whenever (61) is defined, it is false. (60) is therefore degraded because it also has Strawson trivial truth-conditions.

(61) a. **Literal interpretation $[\![(60)]\!]^g$**
$= \lambda w.\neg\exists p \in Q' : \underline{\forall w'[w' \in Dox_{J,w} \rightarrow p(w') = 1] \vee}$
$\underline{\forall w'[w' \in Dox_{J,w} \rightarrow p(w') = 0]}\ .\ \forall w'[w' \in Dox_{J,w} \rightarrow p(w') = 1]$

b. **Existential projection in $[\![(60)]\!]^g$**
$= \lambda w : \underline{\exists p \in Q'.\forall w'[w' \in Dox_{J,w} \rightarrow p(w') = 1] \vee \forall w'[w' \in Dox_{J,w} \rightarrow p(w') = 0]}\ .$
$\neg\exists p \in Q'.\forall w'[w' \in Dox_{J,w} \rightarrow p(w') = 1]$

c. **Local accommodation in $[\![(60)]\!]^g$**
$= \lambda w.\neg\exists p \in Q'[[\forall w'[w' \in Dox_{J,w} \rightarrow p(w') = 1] \vee$
$\forall w'[w' \in Dox_{J,w} \rightarrow p(w') = 0]] \wedge \forall w'[w' \in Dox_{J,w} \rightarrow p(w') = 1]]$
$= \lambda w.\neg\exists p \in Q'.\forall w'[w' \in Dox_{J,w} \rightarrow p(w') = 1]$

This treatment of *believe* predicts, of course, that other neg-raising PTPs also do not embed interrogatives when unembedded or embedded under negation. This is indeed the case. For instance, all of the PTPs in (62) are neg-raising (Horn 1978), and none of them embeds interrogatives as (63) shows.

(62) John doesn't *assume* / *presume* / *reckon* / *think* that Mary drinks.
$\rightsquigarrow$ *John P-s that Mary doesn't drink*

(63) *John (doesn't) *assume(s)* / *presume(s)* / *reckon(s)* / *think(s)* whether Mary drinks.

The same observation holds with respect to the impersonal neg-raising PTPs in (64), as shown in (65).[26]

(64) It isn't *advisable* / *desirable* / *likely* / *probable* that Mary drinks.

[26]It has been argued that *doubt* is neg-raising whereas *question* is not, based on the inferences in (i). (Gajewski 2007, Abusch 2010). Here negation is built into the lexical meaning of the PTPs themselves. For instance, *doubt* could be analyzed as *believe not* and *question* as *not believe*. However, both PTPs embed interrogatives, as shown in (ii) (see White and Rawlins 2016). This might suggest the need for a modification of the present account. Alternatively, it might speak against a neg-raising analysis of *doubt*. In this respect, it should be pointed out that the German counterparts *bezweifeln* ('doubt') and *in Fragen stellen* ('question') behave as predicted by the neg-raising account.

(i) a. John *doubts* that Mary drinks. $\rightsquigarrow$ *John believes that Mary doesn't drink*
b. John *questions* that Mary drinks. $\not\rightsquigarrow$ *John believes that Mary doesn't drink*

$\rightsquigarrow$ *It is P that Mary doesn't drink*

(65) *It is(n't) *advisable* / *desirable* / *likely* / *probable* whether Mary drinks.

3.2.2 Further possible neg-raising predicates

The PTPs in (66), which do not embed interrogatives, have been argued to require a modification of the Hintikka-semantics that I have assumed so far. In particular, it has been suggested that these PTPs state that the subject believes that worlds where the complement is true are better—according to a ranking contributed by the PTP—than worlds where it is false (Heim 1992, Villalta 2008). The PTP *be desirable* in (64) might also be in need of modification.

(66) a. John doesn't *desire / expect / hope / want / wish* that Mary smoke(s).
$\rightsquigarrow$ *John P-ed that Mary doesn't smoke*

b. *John (doesn't) *desire / expect / hope / want / wish* whether Mary smokes.

While detailed discussion would lead too far, I want to point out that the PTPs are neg-raising, as shown by (66a). Combining the sketched preference semantics with neg-raising, this means that the PTPs should have an excluded middle presupposition of the form *the subject believes that the worlds where the complement is true are to be preferred to those where it is false or the other way round.* The cases in (66b) will presuppose that John believes that worlds where Mary smokes are better than those where she does not or he believes that worlds where Mary does not smoke are better than those where she does. Given the existential quantification over answers the assertive component of (66b) in the unnegated case will say the same thing. I.e., a trivial literal interpretation is the consequence, and the same for the negated case. That is, the unacceptability of (66b) can be explained by the present account.[27]

3.2.3 Factive predicates

Know is not just d-veridical but actually factive. A d-veridical PTP is also factive if the inference that the embedded sentence is true remains regardless of embedding in an entailment canceling environment.[28] Given this, the factivity inference of *know* is generally classified as a presupposition of the PTP (see e.g. Karttunen 1971, Kiparsky and Kiparsky 1971).

As discussed in section 2.4, *know* is moreover not only d-veridical but also i-veridical. That is, when *know* embeds an interrogative, the resulting meaning is about the true answer to the interrogative. For instance, (67) has as an inference that if Mary smokes John knows that she does, and if she does not smoke he knows that she does not.

(67) John knows whether Mary smokes.
$\rightsquigarrow$ *John knows the true answer to "Does Mary smoke?"*

When discussing the modified veridicality hypothesis (38) I suggested that the i-veridicality of *know* is a result of its d-veridicality. This means that it is a result of its factive presupposition.

(ii) a. John *doubts* whether Mary drinks.
b. John *questions* whether Mary drinks.

[27] *Wish* can also have a counterfactual interpretation presupposing that the complement is false. Such a presupposition independently has the consequence that interrogatives cannot be embedded. See section 5.1.2.

[28] More formally, a PTP P is factive if and only if utterance in world w of sentence S embedded in entailment canceling environment C with declarative sentence D embedded under P, i.e. $[_C\ [_S\ X\ P\ D\ ]]$, licenses the inference that $[\![\mathbf{D}]\!](w) = 1$.

It is not straightforward to derive this in the general case. But for the special case of polar interrogatives it is doable without amendments given the assumptions from above. Assume the standard lexical entry for *know* in (68). (68) applied to a proposition p and an individual x states that x believes p and presupposes that p is true.

(68) $[\![\textbf{know}]\!] = \lambda p_{st}.\lambda x_e.\lambda w_s : \underline{p(w) = 1}\ .\ \forall w'[w' \in Dox_{x,w} \rightarrow p(w') = 1]$

As a consequence the literal meaning of (67) is as in (69a). Again, we have the option of existential projection or of local accommodation. The former yields (69b). This trivially presupposes that there is a true proposition p in Q', i.e. that there is a true answer. It asserts that John believes some proposition p in Q', i.e., he believes some answer. The local accommodation reading in (69c) asserts that there is a true proposition p in Q' that John believes. Thus in a world in which Mary smokes (69c) says that John believes that Mary smokes, and in a world in which she does not smoke (69c) says that she does not do so. This time the local accommodation reading strictly Strawson-entails the projection reading. If John knows the true answer, then John believes some answer. Thus (69c) is chosen by accommodation economy.

(69) a. **Literal interpretation $[\![\textbf{(67)}]\!]^g$**
$= \lambda w.\exists p \in Q' : \underline{p(w) = 1}\ .\ \forall w'[w' \in Dox_{J,w} \rightarrow p(w') = 1]$

b. **Existential projection in $[\![\textbf{(67)}]\!]^g$**
$= \lambda w : \underline{\exists p \in Q'[p(w) = 1]}\ .\ \exists p \in Q'.\forall w'[w' \in Dox_{J,w} \rightarrow p(w') = 1]$
$= \lambda w.\underline{\exists p \in Q'.\forall w'[w' \in Dox_{J,w}}} \rightarrow p(w') = 1]$

c. **Local accommodation in $[\![\textbf{(67)}]\!]^g$**
$= \lambda w.\exists p \in Q'[p(w) = 1 \wedge \forall w'[w' \in Dox_{J,w} \rightarrow p(w') = 1]]$

This literal meaning in (69) is non-trivial. But what about its strengthened meaning? Given the discussion in section 3.1, the alternatives to (69) used by Exh are as in (71).

(70) $[\![\mathbf{S}]\!]^{alt} = \{\lambda w : \underline{\text{Mary smokes in } w}\ .\ \forall w'[w' \in Dox_{J,w} \rightarrow \text{Mary smokes in } w'],$
$\lambda w : \underline{\neg\text{Mary smokes in } w}\ .\ \forall w'[w' \in Dox_{J,w} \rightarrow \neg\text{Mary smokes in } w']\}$

Recall also that Exh negates only those alternatives that are not Strawson-weaker than its prejacent, i.e., those alternatives that are not Strawson-entailed by the prejacent. When we want to see whether (69a) Strawson-entails the first alternative in (70), we must assume that Mary smokes in some particular world w_o as in (71a), as this is the presupposition of the alternative. Now, (69c) is true in w_o if (71b) holds. Since the two propositions in Q' contradict each other, it follows that (71a) together with (71b) guarantees that Mary smokes is the true answer to Q' in w_o and that John believes that Mary smokes is true, as stated in (71c). Therefore, (69c) Strawson-entails the first alternative in (70). By the same logic (69c) also Strawson-entails the second alternative in (70).

(71) a. Mary smokes in w_o.
b. For some $p \in Q'$, $p(w_o) = 1$ and John belives in w_o that p.
c. (71a) & (71b) $\Rightarrow$ John believes in w_o that Mary smokes.

As a consequence, Exh does not negate any of the alternatives, and the strengthened meaning of (67) is equivalent to its literal meaning with local accommodation in (69c). Since this meaning is non-trivial, we have explained why (67) is acceptable. In addition, notice that the resulting interpretation accounts for the property of i-veridicality associated with *know*.

Consider now the negated (72).

(72) John doesn't know whether Mary smokes.

The literal interpretation is as in (73a). The existential projection interpretation in (73b) again has a trivial presupposition and asserts that John is not certain about the truth of any of the possible answers.[29] This is Strawson-equivalent to the the local accommodation reading in (73c) saying that John is not certain about the true answer. (73b) is thus chosen by (59).

(73) a. **Literal interpretation $[\![(72)]\!]^g$**
$= \lambda w.\neg\exists p \in Q' : \underline{p(w) = 1}\ .\ \forall w'[w' \in Dox_{J,w} \rightarrow p(w') = 1]$

b. **Existential projection in $[\![(73a)]\!]^g$**
$= \lambda w : \exists p \in Q'[p(w) = 1]\ .\ \neg\exists p \in Q'.\forall w'[w' \in Dox_{J,w} \rightarrow p(w') = 1]$
$= \lambda w.\neg\exists p \in Q'.\forall w'[w' \in Dox_{J,w} \rightarrow p(w') = 1]$

c. **Local accommodation in $[\![(73a)]\!]^g$**
$= \lambda w.\neg\exists p \in Q'[p(w) = 1 \wedge \forall w'[w' \in Dox_{J,w} \rightarrow p(w') = 1]]$

The alternatives are as in (74).[30]

(74) $[\![\mathbf{S}]\!]^{alt} = \{\lambda w : \underline{\text{Mary smokes in } w}\ .\ \neg\forall w'[w' \in Dox_{J,w} \rightarrow \text{Mary smokes in } w'],$
$\lambda w : \underline{\neg\text{Mary smokes in } w}\ .\ \neg\forall w'[w' \in Dox_{J,w} \rightarrow \neg\text{Mary smokes in } w']\}$

(73b) Strawson-entails both of the alternatives in (74). (75) shows this for the first alternative. So again, Exh does not negate any of the alternatives, and (72) comes out as acceptable.

(75) a. Mary smokes in w_o.
b. For all p in Q', John is not certain in w_o that p.
c. (75a) & (75b) $\Rightarrow$ John is not certain in w_o that Mary smokes.

The fact that the i-veridicality of *know* is derived from its factive presupposition has a number of consequences. First, factive PTPs in general should embed interrogatives. This is by and large borne out. All the d-veridical PTPs in (76) and (77), repeated from (10) and (11) respectively, are actually factive and thus automatically i-veridical, explaining why they embed interrogative clauses. For more detailed discussion see 4.3.1.

(76) John *deduced / discovered / discerned / disregarded / established / figured out / found out / forgot / foresaw / learned / noticed / overlooked / proved / recalled / remembered / sensed ...*
a. that Mary smokes. $\rightsquigarrow$ *Mary smokes*
b. whether Mary smokes. $\rightsquigarrow$ *John P-ed the true answer to "Does Mary smoke?"*

(77) a. It *matters / is relevant / important* that Mary smokes. $\rightsquigarrow$ *Mary smokes*
b. It *matters / is relevant / important* whether Mary smokes.
$\rightsquigarrow$ *The true answer to "Does Mary smoke?" Ps*

[29] In this case universal projection would lead to the contradictory presupposition that all possible answers are true. I assume that there is a ban on projecting contradictory presuppositions. This also applies in a number of other negative cases considered below.

[30] In case of the alternatives, (59) always chooses the projection reading over the local accommodation one. The reason is that the two readings are Strawson-equivalent. Consider, for instance, the two readings for the first alternative in (74):

(i) a. **Existential projection:** $\lambda w : \underline{\text{Mary smokes in } w}\ .\ \neg\forall w'[w' \in Dox_{J,w} \rightarrow \text{Mary smokes in } w']$
b. **Local accommodtion:** $\lambda w.\underline{\neg\text{Mary smokes in } w} \vee \neg\forall w'[w' \in Dox_{J,w} \rightarrow \text{Mary smokes in } w']$

Second regarding the modified veridicality hypothesis in (38), it must be stressed that the polarity system proposed here makes the fact that *be certain* embeds interrogatives only under negation the flip-side of the fact that *know* always does so. Thus the disjunctive statement of the generalization is not reflected by a disjunctive explanation at all.

Third, the present approach does not run into problems with PTPs like *be clear* unlike proposals built on the original veridicality hypothesis. As (78a) show this PTP is veridical, but at the same time this veridicality inference is not due to a factive presupposition as evidenced by (78b).

(78) a. It is clear that Mary smokes. $\rightsquigarrow$ *Mary smokes*
b. It isn't clear that Mary smokes. $\not\rightsquigarrow$ *Mary smokes*

Given the veridicality inference in (78a), both the original and the modified veridicality hypothesis would lead one to expect *be clear* to embed interrogatives without any further embedding. The present account, however, does not; the lack of factivity means that Strawson-entailment will be of no help when embedding the interrogative in (79a), unlike with *know*. We thus expect interrogative embedding with *be clear* to improve under negation, just as with *be certain*. As shown above and repeated in (79b), this is borne out.

(79) a. ??It is clear whether Mary smokes.
b. It isn't clear whether Mary smokes.

Finally, note that the use of Strawson-entailment rather than of regular entailment is crucial for the account. One might therefore ask why this particular type of entailment should be used. I do not have an answer to this. However, NPI-licensing in general is, arguably, subject to Strawson-entailment. As is well-known *only* and *exactly* in (80) are both non-monotonic. Therefore neither might be expected to license NPIs. Yet *only* does. *Only* is, however, Strawson-downward-monotonic in contrast to *exactly*, which is Strawson-non-monotonic. That is, it is not downward monotonicity that is crucial for NPI-licensing but rather Strawson-downward monotonicity (see von Fintel 1999, Chierchia 2013). And this fact is captured by the current definition of Exh.

(80) a. Only one boy has seen any girl.
b. *Exactly one boy has seen any girl.

3.2.4 No triviality despite excluded middle presupposition: agree

In section 3.2.1 I argued that the excluded middle presupposition of *believe* and other PTPs leads to unacceptability when embedding an interrogative. This is, however, not always the case. Recall the case of *agree* from (26) above:

(81) a. John and Bill agree (*on) that Mary smokes. $\not\rightsquigarrow$ *Mary smokes*
b. John and Bill agree ??(on) whether Mary smokes.
c. John and Bill don't agree (on) whether Mary smokes.

If *agree* simply required that the two subjects both believe the complement to be true, as one might assume given (81a), (82) would only state that not both John and Bill believe that Mary smokes. This is too weak. (82) requires that one of them believes that Mary smokes, and the other one believes that she does not do so.

(82) John and Bill don't agree that Mary smokes.

Spector and Egré (2015) therefore suggest that *agree* contributes an excluded middle presupposition, as in (83). Here $x \prec X$ says that the atomic individual x is a part of the non-atomic, plural individual X (Link 1983). (83) applied to (82) presupposes that both the atomic individuals John and Bill are opinionated with respect to whether Mary smokes and asserts that not both of them believe that Mary smokes. Taken together this means that one of them believes that Mary smokes, and the other one believes that Mary does not smoke.

(83) $[\![\textbf{agree}]\!] = \lambda p_{st}.\lambda X_e.\lambda w_s : \underline{\forall x \prec X[\forall w'[w' \in Dox_{x,w} \rightarrow p(w') = 1] \vee \forall w'[w' \in Dox_{x,w} \rightarrow p(w') = 0]]} \,.\, \forall x \prec X.\forall w'[w' \in Dox_{x,w} \rightarrow p(w') = 1]$

Applying (83) to (81b) without preposition *on* we get the literal interpretation in (84a). Here *JB* stands for the non-atomic individual made up of John and Bill. The existential projection interpretation in (84b) presupposes that there is an answer p in Q' such that both John and Bill are opinionated about p. Since the answers are mutually exclusive, both John and Bill are opinionated with respect to whether Mary smokes. Crucially, this allows for them to have different beliefs. Now, the assertive component states that John and Bill believe the same answer. The presupposition does not entail the assertion. Thus, the projection reading is non-trivial unlike the case of *believe*. The local accommodation reading in (84c) is Strawson-equivalent to the projection reading and therefore not selected.

(84) a. **Literal interpretation $[\![\textbf{(81b)}]\!]^g$**
$= \lambda w.\exists p \in Q' : \underline{\forall x \prec JB[\forall w'[w' \in Dox_{x,w} \rightarrow p(w') = 1] \vee \forall w'[w' \in Dox_{x,w} \rightarrow p(w') = 0]]} \,.\, \forall x \prec JB.\forall w'[w' \in Dox_{x,w} \rightarrow p(w') = 1]$

b. **Existential projection in $[\![\textbf{(81b)}]\!]^g$**
$= \lambda w : \exists p \in Q'.\forall x \prec JB[\forall w'[w' \in Dox_{x,w} \rightarrow p(w') = 1] \vee \forall w'[w' \in Dox_{x,w} \rightarrow p(w') = 0]] \,.\, \exists p \in Q'.\forall x \prec JB.\forall w'[w' \in Dox_{x,w} \rightarrow p(w') = 1]$

c. **Local accommodation in $[\![\textbf{(81b)}]\!]^g$**
$= \lambda w.\exists p \in Q'[\forall x \prec JB[\forall w'[w' \in Dox_{x,w} \rightarrow p(w') = 1] \vee \forall w'[w' \in Dox_{x,w} \rightarrow p(w') = 0]] \wedge \forall x \prec JB.\forall w'[w' \in Dox_{x,w} \rightarrow p(w') = 1]]$
$= \lambda w.\exists p \in Q'[\forall x \prec JB.\forall w'[w' \in Dox_{x,w} \rightarrow p(w') = 1]]$

This means that with *agree* embedding an interrogative the strengthened interpretation must also be considered. The alternatives relevant for Exh are as in (85). Each one presupposes that both John and Bill are opinionated about the particular answer. They only differ with respect to which of these answers John and Bill are both said to believe.

(85) $[\![\textbf{S}]\!]^{alt} = \{\lambda w : \underline{\forall x \prec JB[\forall w'[w' \in Dox_{x,w} \rightarrow \text{M smokes in } w'] \vee \forall w'[w' \in Dox_{x,w} \rightarrow \neg\text{M smokes in } w']]} \,.\, \forall x \prec JB.\forall w'[w' \in Dox_{x,w} \rightarrow \text{M smokes in } w'],$
$\lambda w : \underline{\forall x \prec JB[\forall w'[w' \in Dox_{x,w} \rightarrow \text{M smokes in } w'] \vee \forall w'[w' \in Dox_{x,w} \rightarrow \neg\text{M smokes in } w']]} \,.\, \forall x \prec JB.\forall w'[w' \in Dox_{x,w} \rightarrow \neg\text{M smokes in } w']\}$

Now, the projection reading in (84b) does not Strawson-entail any of the alternatives in (85). The presupposition of the first alternative in (86a) and the projection reading paraphrased in (86b) together are, for instance, true in case both John and Bill believe that Mary does not smoke. Clearly, the assertion of the alternative in (86c) is then false.

(86) a. John and Bill are opinionated in w_o with respect to whether Mary smokes.
b. For some $p \in Q'$ both John and Bill believe in w_o that p.
c. (86a) & (86b) $\not\Rightarrow$ John and Bill believe in w_o that Mary smokes.

The same holds for the other alternative. Therefore Exh negates both alternatives. The resulting strengthened interpretation is a contradiction. It requires that there is some answer both John and Bill believe, but neither are both certain that Mary smokes nor are both certain that she does not do so. (81b) without *on* is predicted to be unacceptable.

The same is not true for (81c) without *on*. Its literal meaning is given in (87). The existential projection reading in (88) presupposes that John and Bill both believe an answer to *Does Mary smoke?* and asserts that they do not agree on the answer, which is non-trivial. Again the accommodation reading is Strawson-equivalent to it and thus not selected:

(87) a. **Literal interpretation $[\![$(81c)$]\!]^g$**
$= \lambda w.\neg\exists p \in Q' : \forall x \prec JB[\forall w'[w' \in Dox_{x,w} \rightarrow p(w') = 1] \vee$
$\forall w'[w' \in Dox_{x,w} \rightarrow p(w') = 0]] \,.\, \forall x \prec JB.\forall w'[w' \in Dox_{x,w} \rightarrow p(w') = 1]$

b. **Existential projection in $[\![$(81c)$]\!]^g$**
$= \lambda w : \exists p \in Q'.\forall x \prec JB[\forall w'[w' \in Dox_{x,w} \rightarrow p(w') = 1] \vee$
$\forall w'[w' \in Dox_{x,w} \rightarrow p(w') = 0]] \,.\, \neg\exists p \in Q'.\forall x \prec JB.\forall w'[w' \in Dox_{x,w} \rightarrow p(w') = 1]$

c. **Local accommodation in $[\![$(81c)$]\!]^g$**
$= \lambda w.\neg\exists p \in Q'[\forall x \prec JB[\forall w'[w' \in Dox_{x,w} \rightarrow p(w') = 1] \vee \forall w'[w' \in Dox_{x,w} \rightarrow$
$p(w') = 0]] \wedge \forall x \prec JB.\forall w'[w' \in Dox_{x,w} \rightarrow p(w') = 1]]$
$= \lambda w.\neg\exists p \in Q'.\forall x \prec JB.\forall w'[w' \in Dox_{x,w} \rightarrow p(w') = 1]$

The alternatives in (89) are just the negations of those in (85).

(88) $[\![\mathbf{S}]\!]^{alt} = \{\lambda w : \forall x \prec JB[\forall w'[w' \in Dox_{x,w} \rightarrow$ M smokes in $w'] \vee \forall w'[w' \in Dox_{x,w} \rightarrow$
$\neg$M smokes in $w']] \,.\, \neg\forall x \prec JB.\forall w'[w' \in Dox_{x,w} \rightarrow$ M smokes in $w']$,
$\lambda w : \forall x \prec JB[\forall w'[w' \in Dox_{x,w} \rightarrow$ M smokes in $w'] \vee \forall w'[w' \in Dox_{x,w} \rightarrow$
$\neg$M smokes in $w']] \,.\, \neg\forall x \prec JB.\forall w'[w' \in Dox_{x,w} \rightarrow \neg$M smokes in $w']\}$

Consider the relation between the projection reading in (87b) and its first alternative in (88). Together with the presupposition of the latter in (89a), the literal interpretation of the former in (89b) states that John and Bill do not agree on which one of the answers to *Does Mary smoke?* is true. This does entail the assertion of the alternative, in (89c). The same holds for the other alternative. Thus Exh negates neither resulting again in the projection reading in (87b). Since this is non-trivial, (81c) is predicted to be acceptable without preposition.

(89) a. John and Bill are opinionated in w_o with respect to whether Mary smokes.
b. For no $p \in Q'$ both John and Bill believe in w_o that p.
c. (89a) & (89b) $\Rightarrow$ Not both John and Bill are certain in w_o that Mary smokes.

Thus, (81c) should embed interrogatives without preposition, but (81b) should not. This seems to be the case. Crucially, we saw that the excluded middle presupposition does not always make interrogative embedding impossible. In particular, it does not do so when the presupposition holds of a non-atomic individual.

This predicts that the non-symmetric version of *agree with* in (90) should never embed interrogatives without preposition. Without going into too much detail, the reason is as follows: (90a) presupposes both that Bill believes that Mary smokes and that John is opinionated about whether Mary smokes. It asserts that John believes that she does. Crucially, the excluded middle presupposition does not hold of a non-atomic individual here. As a consequence *agree with* is predicted to behave like *believe* and other neg-raising PTPs. When embedding an interrogative

as in (90b) and (90c), the literal meaning is trivial. While the judgements are delicate, this prediction might be borne out. A google search for *doesn't agree with him/her whether* does indeed not yield any results quite in contrast to *can't/don't agree whether*. I must leave further investigation for future research.

(90) a. John agrees with Bill (*on) that Mary smokes. $\not\rightsquigarrow$ *Mary smokes*
b. John agrees with Bill *(on) whether Mary smokes.
c. John doesn't agree with Bill *(on) whether Mary smokes.

3.3 Interim summary and open issues

I outlined the core of my proposal regarding interrogative embedding. I presented a polarity-based system in which PTPs are in principle free to embed interrogatives. If, however, either the resulting literal or strengthened meaning of the sentence comes out as trivial, the sentence results in unacceptability.

At this point a question arises. How should we deal with embedded *wh*-interrogatives such as in (91)? The *know-believe* distinction carries over to these, but the system as developed so far does not cover such cases.

(91) a. John knows who smokes.
b. *John believes who smokes.

Consider (91a). As before, the local accommodation reading in (92) is selected. Assume there are only three relevant individuals: Ann, Beth and Clara. Moreover, assume a Hamblin-/Karttunen denotation for *wh*-interrogatives. Then the question denotation Q'' is $\{\lambda w.$Ann smokes in w, $\lambda w.$Beth smokes in w, $\lambda w.$Clara smokes in $w\}$.

(92) **Local accommodation in $[\![$(91a)$]\!]^g$**
$= \lambda w.\exists p \in Q''[p(w) = 1 \wedge \forall w'[w' \in Dox_{J,w} \rightarrow p(w') = 1]]$

The alternatives would be as in (93).

(93) $[\![$**(91a)**$]\!]^{alt} = \{\lambda w :$ Ann smokes in w . $\forall w'[w' \in Dox_{J,w} \rightarrow$ Ann smokes in $w']$,
$\lambda w :$ Beth smokes in w . $\forall w'[w' \in Dox_{J,w} \rightarrow$ Beth smokes in $w']$,
$\lambda w :$ Clara smokes in w . $\forall w'[w' \in Dox_{J,w} \rightarrow$ Clara smokes in $w']\}$

Now, (92) does not Strawson-entail the alternatives in (93). Consider the first alternative. Even when its presupposition is assumed to be true in w_o as in (94a), it does not follow from John knowing some true proposition in Q'' as in (94b) that he knows that Ann smokes. For instance, if Beth also smokes in w_o and John knows this, (92) would be true. But from that nothing follows regarding John's beliefs about Ann's smoking:

(94) a. Ann smokes in w_o.
b. For some $p \in Q''$, $p(w_o) = 1$ and John is certain in w_o that p.
c. (94a) & (94b) $\not\Rightarrow$ John believes in w_o that Ann smokes.

The same holds mutatis mutandis for all other alternatives in (93). As a consequence Exh negates all of them. The result is a contradiction saying that John knows some true proposition in Q'' but for none of Ann, Beth and Clara does he know that they smoke. Thus (91a) should incorrectly come out as unacceptable. Note also that if Exh did not apply—for whatever

reason—we would get a literal meaning saying that John knows some proposition in Q''. Such truth-conditions are much too weak.

For (91b) the projection reading in (95) is selected, as before.

(95) **Existential projection in $[\![$(91b)$]\!]^g$**
$= \lambda w : \exists p \in Q''.\forall w'[w' \in Dox_{J,w} \rightarrow p(w') = 1] \vee$
$\underline{\forall w'[w' \in Dox_{J,w} \rightarrow p(w') = 0]}\ .\ \exists p \in Q''.\forall w'[w' \in Dox_{J,w} \rightarrow p(w') = 1]$

(95) presupposes that there is an answer in Q'' that John believes or that he believes is false and asserts that he believes some answer in Q''. If John believes that Ann does not smoke, the presupposition is thus defined. But from this it neither follows that the assertion is true nor that it is false. For instance, if John believes that Ann does not smoke and believes that Beth does smoke, (95) is true. If he, on the other hand, believes that Ann does not smoke but has no belief with respect to whether Beth or Clara smokes, (95) is false. Thus (95) is non-trivial and (91b) is predicted to be acceptable.

Another problem faced by the present analysis has to do with factive PTPs such as *forget*. Arguably, *forget* is similar to negated *know* in its assertive component. For instance, (96a) asserts that John does not currently believe that Mary smokes. For the result of interrogative embedding under negated *know* to carry over to (96b), however, the embedded interrogative would have to scope between the negation and the factive component of *forget*. This is difficult given my current assumptions as the two are both contributed by *forget*.

(96) a. John forgot that Mary smokes.
b. John forgot whether Mary smokes.

4 A new semantics for embedding

In this section I show how the insights from section 3 can be carried over to embedded *wh*-interrogatives with a more fine-grained semantic analysis of embedding.

4.1 Existential quantification over worlds

4.1.1 Existential quantification and strong exhaustive answers

Spector and Egré (2015) show a way to combine a rather standard semantics for interrogative embedding with existential quantification. They suggest that the declarative embedding denotation for any PTP is related the interrogative embedding denotation by a general meaning postulate. For instance, the standard entry for *know* in (97) is now to be thought of as a purely declarative embedding denotation.

(97) $[\![\mathbf{know}_d]\!] = \lambda p_{st}.\lambda x_e.\lambda w_s : \underline{p(w) = 1}\ .\ \forall w'[w' \in Dox_{x,w} \rightarrow p(w') = 1]$

The meaning postulate yields the following interrogative embedding entry:

(98) $[\![\mathbf{know}_i]\!] = \lambda Q_{\langle s,\langle st,t\rangle\rangle}.\lambda x_e.\lambda w_s.\exists w'.[\![\mathbf{know}_d]\!]([\![\mathbf{Ans}_2]\!](Q)(w'))(x)(w) = 1$

According to (98) when embedding an interrogative with denotation Q, the declarative *know* is applied to the strong exhaustive answer to Q. The strong exhaustive answer to Q says that the set of true propositions in Q is what it is in the world of evaluation. The operator Ans_2 used in (98) to achieve this is defined in (99) following Heim (1994).

(99) $[\![\textbf{Ans}_2]\!] = \lambda Q_{\langle s,\langle st,t\rangle\rangle}.\lambda w_s.\lambda w'_s.\{p : Q(w)(p) = 1 \wedge p(w) = 1\} =$
$\{p : Q(w')(p) = 1 \wedge p(w') = 1\}$

Now crucially, the interrogative embedding version of *know* in (98) involves existential quantification over worlds. Since the respective world variable is moreover the argument of the intension of a strong exhaustive answer to question Q, it follows that (100) involves existential quantification over possible strong exhaustive answers to Q. The LF for (100a) would accordingly be as in (100b).

(100) a. John knows who smokes.
b. [$_{S'}$ John knows_i [$_S$ who smokes]]

The denotation of S′ in (100b) is as in (101). When applied to world w_o this is true if and only if there is a world w' such that the denotation of declarative *know* applied to the strong exhaustive answer to *Who smokes?* in w', to John, and to w_o is true. Notice that this is only the case if the factive presupposition of declarative *know* is true. That is, only if the set of true propositions in Q in w' is what it is in w_o. As a consequence, the truth-conditions of S′ state that there is a world w' such that the set of true propositions in *Who smokes?* in w' is what it is in w_o and in all of John's belief worlds w'' the same holds. In short, the sentence is true if and only if John believes the strong exhaustive answer to *Who smokes?* in w_o. If, for instance, Ann and Beth smoke in w_o but Clara does not, John must believe precisely this. This seems adequate (Groenendijk and Stokhof 1982).

(101) $[\![\textbf{S}']\!]^g = \lambda w.\exists w'.[\![\textbf{know}_d]\!]([\![\textbf{Ans}_2]\!]([\![\textbf{S}]\!]^g)(w'))(\text{John})(w) = 1$
$= \lambda w.\exists w'[\{p : [\![\textbf{S}]\!]^g(w')(p) \wedge p(w')\} = \{p : [\![\textbf{S}]\!]^g(w)(p) \wedge p(w)\} \wedge$
$\forall w'' \in Dox_{J,w}.\{p : [\![\textbf{S}]\!]^g(w')(p) \wedge p(w')\} = \{p : [\![\textbf{S}]\!]^g(w'')(p) \wedge p(w'')\}]$

4.1.2 The problem of intermediate exhaustivity

Klinedinst and Rothschild (2011) argue that a so-called intermediate exhaustive interpretation must be derived for sentences like (102) (see also Heim 1994, Spector 2005, Cremers and Chemla 2014). In particular, its truth-conditions seem to require John to have predicted of all girls who smoke that they do and to not have made any false predictions. This is weaker than the strong exhaustive interpretation, which would in addition require John to have predicted for all those who do not smoke to not smoke.

(102) John predicted who smokes.

Spector and Egré's meaning postulate based on Ans_2, however, would impose strong exhaustive truth-conditions on (102).

Now, one might think that for PTPs like *predict* the meaning postulate for interrogative embedding in (104) should involve the weak exhaustive answer operator Ans_1 in (103), again following Heim (1994). Then one might be able to use the process of exhaustification to derive intermediate exhaustivity as suggested by Klinedinst and Rothschild.

(103) $[\![\textbf{Ans}_1]\!] = \lambda Q_{\langle s,\langle st,t\rangle\rangle}.\lambda w_s.\cap\{p : Q(w)(p) = 1 \wedge p(w) = 1\}$

(104) $[\![\textbf{predict}_i]\!] = \lambda Q_{\langle s,\langle st,t\rangle\rangle}.\lambda x_e.\lambda w_s.\exists w'.[\![\textbf{predict}_d]\!]([\![\textbf{Ans}_1]\!](Q)(w'))(x)(w) = 1$

The problem with (104), as discussed by Spector and Egré, is that it gives much too weak literal truth-conditions for (102). In particular, with (104) the truth-conditions would say that there is

a weak exhaustive answer to *Who smokes?* that is true in w_o and that John predicted. This is essentially a mention-some reading as it does not even require John to have predicted all those individuals correctly who do smoke as long as he predicted one of them correctly. It is difficult to see how strengthening via exhaustification could remedy this defect. In fact, with (104) we get back one of the issues mentioned in section 3.3.[31]

In order to get around this issue for (102), Spector and Egré require that the weak exhaustive answer predicted by the subject be the weak exhaustive answer corresponding to the strong exhaustive answer actually holding in the world of evaluation. Thereby a mention-some interpretation is blocked. In the following section, I suggest something very much in this spirit without, however, using a strong exhaustive answer explicitly. Direct reference to such an answer is somewhat questionable once we acknowledge that it should be derived through a process of strengthening, as seems desirable given intermediate exhaustivity.

4.2 One semantics for declarative and interrogative embedding

I now put forward a new semantics for PTPs. This semantics allows us to derive a weak exhaustive interpretation—and not a mention-some one—as literal meaning that gets strengthened by exhaustification to an intermediate one. In addition, it keeps the factivity presupposition of a PTP even for interrogative embedding while still maintaining Spector and Egré's insights. It thereby retains the results from section 3, i.e., derives i-veridicality from factivity. In this semantics there is only one denotation for a given PTP, which is based on the standard Hintikka-semantics for PTPs used throughout section 3

4.2.1 Two ingredients for the semantics of embedding predicates

First, PTPs do not take propositions as arguments but rather intensions thereof, or propositional concepts. Groenendijk and Stokhof (1984) propose this for what they call intensional interrogative embedding predicates. Such a proposal is intuitive for interrogative embedding when we think of the argument of the PTP to correspond to an answer to the embedded interrogative. After all the extension of an answer varies with the worlds considered. I suggest to extend the intensional treatment to all PTPs regardless of whether a declarative or an interrogative clause is embedded. As a consequence the declarative argument of a PTP will also be a propositional concept. While this is less intuitive than for interrogatives, I argue that in this case the intensional abstraction is vacuous.

Second, a PTP contributes existential quantification over worlds as in Spector and Egré's (2015) account reviewed in section 4.1.1 above. Since there is no distinction between declarative and interrogative embedding on the present account, this quantification is there in both cases. But since the intensional abstraction is vacuous in the case of an embedded declarative—as just mentioned—the quantification, too, will be vacuous here.

[31] There is another more theory-internal cause for worry. As discussed in section 3, (i) should Strawson-entail its factive alternatives so that exhaustification becomes vacuous. But for Spector and Egré (i) is not factive as it uses the presuppositionless (97). To guarantee Strawson-entailment nervetheless, the alternatives would have to be defined syntactically so as to involve actual declarative embedding with the factive (98).

(i) John knows whether Mary smokes.

4.2.2 Declarative embedding

For a simple PTP like *be certain* the two ingredients just mentioned coupled with Hintikka's (1969) semantics amounts to the lexical entry in (105). Applied to a propositional concept p, i.e. an argument from $D_{\langle s,st\rangle}$, and an individual x, this returns the proposition saying that there is a world w' such that x believes the extension of p in w'.

(105) $[\![\textbf{be certain}]\!] = \lambda p_{\langle s,st\rangle}.\lambda x_e.\lambda w_s.\exists w'.\forall w''[w'' \in Dox_{x,w} \rightarrow p(w')(w'') = 1]$

Factive *know* has the entry in (106). (106) and (105) share their assertive components. But (106) also presupposes that the extension of the propositional concept in w' is true in w' and that moreover w' is the world of evaluation.

(106) $[\![\textbf{know}]\!] = \lambda p_{\langle s,st\rangle}.\lambda x_e.\lambda w_s.\exists w' : \underline{p(w')(w') = 1 \wedge w' = w}\,.$
$\forall w''[w'' \in Dox_{x,w} \rightarrow p(w')(w'') = 1]$

The argument of both (105) and (106) is a propositional concept. This is, however, not the kind of denotation one usually thinks that embedded declaratives as in (107) have. So how do the PTPs in (107) combine with the embedded declarative?

(107) a. John is certain that Mary smokes.
b. John knows that Mary smokes.

There is a number of ways this could be implemented. For concreteness I assume that the complementizer *that* denotes a function taking a proposition and abstracting vacuously over it as in (108).

(108) $[\![\textbf{that}]\!] = \lambda p_{st}.\lambda w_s.p$

The LFs for the examples in (107) look as in (109). Assuming furthermore that S in (109) has the denotation in (110a)—that is, assuming that the denotations of verbs and other predicates are already intensional—it follows that S′ has as its denotation (110b) given (108).

(109) a. $[_{S''_1}$ John is certain $[_{S'}$ that $[_{S}$ Mary smokes]]]
b. $[_{S''_2}$ John knows $[_{S'}$ that $[_{S}$ Mary smokes]]]

(110) a. $[\![\textbf{S}]\!] = \lambda w.$Mary smokes in w
b. $[\![\textbf{S}']\!] = \lambda w'.\lambda w.$Mary smokes in w

The denotations for the PTPs above can take the denotation of S′ as argument. For S''_1 we get the denotation in (111). It should be noticed that the effect of existential quantification is vacuous. This is because the world w' bound by the existential quantifier is the first argument of the propositional concept in (110b), but the first λ-operator abstracts vacuously. The denotation in (111) is thus adequate.

(111) $[\![\textbf{S}''_1]\!] = \lambda w.\exists w'.\forall w'' \in Dox_{J,w}.[\lambda w'''.\lambda w''''.$M smokes in $w''''](w')(w'') = 1$
$= \lambda w.\forall w' \in Dox_{J,w}.$M smokes in w'

The denotation of S''_2 is as in (112). The only thing that changes compared to (111) is that it is now presupposed that Mary smokes in w' and that w' is the world of evaluation. Thus (112) presupposes that Mary smokes and asserts that John believes this. This is as desired.

(112) $[\![\mathbf{S}''_2]\!] = \lambda w.\exists w' : \underline{\text{M smokes in } w' \wedge w' = w}\ .\ \forall w'' \in Dox_{J,w}.\text{M smokes in } w''$
$= \lambda w : \underline{\text{M smokes in } w}\ .\ \forall w' \in Dox_{J,w}.\text{M smokes in } w'$

To save space, I will in the following abbreviate $\exists w' \ldots \forall w''[w'' \in Dox_{x,w} \rightarrow p(w')(w'') = 1]$ as $\exists w' \ldots B^w_x(p(w'))$ where B^w_x is a mnemonic for *x believes in w*.

4.2.3 Interrogative embedding

I will assume that (113a) has an LF like (113b).

(113) a. John knows who smokes.
b. [$_{S''}$ John knows [$_{S'}$ Ans [$_S$ who 2[? t_2 smokes]]]]

I suggest the denotation in (114) for the answer operator used in (113b). This operator when applied to a question Q and a world w gives the weak exhaustive answer to Q in w, in case there are true propositions in the extension of Q in w. The weak exhaustive answer to Q is the intersection of the true propositions in Q. If there are no true propositions in it, the answer operator gives the proposition stating that this is the case. From now on I refer to $[\![\mathbf{Ans}]\!](Q)(w)$ as the answer to Q in w. This can be the weak exhaustive answer but need not be so. (114) is essentially a combination of Heim's (1994) semantics for her weak exhaustive answer operator Ans_1 and Karttunen's (1977) special case dealing with situations where there is no true proposition in the extension of the question.

(114) $[\![\mathbf{Ans}]\!] = f : D_{\langle s,\langle st,t\rangle\rangle} \rightarrow \{g : g \text{ is a function from } W \text{ to } D_{st}\}$
For every $Q \in D_{\langle s,\langle st,t\rangle\rangle}$ and $w \in W$, $f(Q)(w) =$
$\cap\{p : Q(w)(p) = 1 \wedge p(w) = 1\}$ if $\{p : Q(w)(p) = 1 \wedge p(w) = 1\} \neq \varnothing$,
$\lambda w.\{p : Q(w)(p) = 1 \wedge p(w) = 1\} = \varnothing$ otherwise.

For concreteness I adopt Karttunen's (1977) semantics for *wh*-interrogatives. The ?-operator in (115a) applied to a proposition p gives a proto-question from $D_{\langle s,\langle s,st\rangle\rangle}$, i.e., the intension of the characteristic function of the set containing just p. The denotation of *who* in (115b) is an existential quantifier taking abstracts over such denotations and giving back the intension of a question-denotation.

(115) a. $[\![\mathbf{?}]\!] = \lambda p_{st}.\lambda w_s.\lambda q_{st}.p = q$
b. $[\![\mathbf{who}]\!]^g = \lambda f_{\langle e,\langle s,\langle st,t\rangle\rangle\rangle}.\lambda w_s.\lambda p_{st}.\exists x[x \text{ is a person in } w \wedge f(x)(w)(p) = 1]$

The denotation of S in (113b) is then as in (116).

(116) $[\![\mathbf{S}]\!]^g = \lambda w.\lambda p.\exists x[x \text{ is a person in } w \wedge p = \lambda w'.x \text{ smokes in } w']$

Now, note that given (114) the denotation of S′—the intension of the answer to S—is a propositional concept. When applied to a world in which there are smokers, S′ denotes the proposition stating for all those who smoke that they smoke. When applied to a world in which there aren't any smokers, it denotes the proposition saying that there are no smokers.

The literal interpretation is as in (117a). Again, the presupposition can project existentially as in (117b) or be locally accommodated as in (117c). The former, on the one hand, has the trivial presupposition that there is a true answer and asserts that John believes some answer. The latter, on the other hand, asserts that there is a world w' corresponding to the world of evaluation w such that John believes the answer to Q in w', i.e., it asserts that John believes the true answer.

(117c) strictly Strawson-entails (117b), whereby it is selected by our accommodation economy principle (59). This is as in section 3.2.3.[32]

(117) a. **Literal interpretation $[\![S'']\!]^g$**
$= \lambda w.\exists w' : \underline{[\![\textbf{Ans}]\!]([\![S]\!]^g)(w')(w') = 1 \wedge w' = w}\ .\ B^w_J([\![\textbf{Ans}]\!]([\![S]\!]^g)(w'))$

b. **Existential projection in $[\![S'']\!]^g$**
$= \lambda w : \exists w'[[\![\textbf{Ans}]\!]([\![S]\!]^g)(w')(w') = 1 \wedge w' = w]\ .\ \exists w'.B^w_J([\![\textbf{Ans}]\!]([\![S]\!]^g)(w'))$
$= \lambda w.\underline{\exists w'.B^w_J([\![\textbf{Ans}]\!]([\![S]\!]^g)(w'))}$

c. **Local accommodation in $[\![S'']\!]^g$**
$= \lambda w.\exists w'[[\![\textbf{Ans}]\!]([\![S]\!]^g)(w')(w') = 1 \wedge w' = w \wedge B^w_J([\![\textbf{Ans}]\!]([\![S]\!]^g)(w'))]$
$= \lambda w.B^w_J([\![\textbf{Ans}]\!]([\![S]\!]^g)(w))$

(117c) has the following truth-conditions: in case there are smokers in the world of evaluation w_o John believes of all those who smoke in w_o that they do. This is the weakly exhaustive reading. In case there are no smokers in w_o, John believes that there are no smokers in w_o. For instance, assume that in w_o Ann smokes, but Beth and Clara do not. Then the answer to *Who smokes?* in w_o is as in (118a). S'' is thus true if and only if John believes this proposition.

(118) a. $[\![\textbf{Ans}]\!]([\![S'']\!]^g(w_o) = \lambda w.$Ann smokes in w
b. $[\![S'']\!]^g(w_o) = 1$ iff $\forall w' \in Dox_{J,w_o}$.Ann smokes in w'

Summarizing, the novel semantics for embedding employs existential quantification over possible answers as in Spector and Egré's (2015) account but with two twists: first, the factive presupposition of *know* is kept in the interrogative embedding case and leads to i-veridicality, as desired. Second, a weak exhaustive interpretation can obtain, which can in principle be strengthened to intermediate and also strong exhaustivity.

4.3 Predicting interrogative embedding with the new semantics

I now show four things: first, given the semantics for PTPs there is a natural way to define the alternatives necessary for exhaustification. Second, together with the factive presupposition of *know* and other such PTPs it becomes possible to explain why they embed interrogatives. Third, context dependence of interrogative embedding follows automatically. And finally, generalizing the excluded-middle presupposition predicts the impossibility of interrogative embedding under neg-raising PTPs.

4.3.1 Factive know and alternatives

Why is (113a) acceptable? Following the assumptions from section 3 its full LF should include the exhaustivity operator as in (119).

(119) [Exh_{Alt} [$_{S''}$ John knows [$_{S'}$ Ans [$_S$ who 2[? t_2 smokes]]]]]

The exhaustivity operator negates the Strawson non-weaker alternatives to $[\![S'']\!]^g$. Recall from before that the alternatives should be about particular answers rather than quantifying over possible ones. I suggest that the PTPs lexically come with alternatives. The alternatives are all those meanings of the same type as the PTP where the argument of the PTP—the propositional

[32] Given existential quantification over answers, accommodation economy (59) derives results parallel to those in section 3. To save space, I will therefore in the following only explicitly state the interpretation selected by (59) unless the example has not been discussed yet.

concept denoted by the embedded clause—is evaluated with respect to a particular world w^*. This is a way of implementing Klinedinst and Rothschild's (2011) ideas regarding focus alternatives of embedded wh-clauses in the present account. So the set of alternatives for *know* looks as follows:[33]

(120) $[\![\textbf{know}]\!]^{alt}$
$= \{\lambda p_{\langle s,st\rangle}.\lambda x_e.\lambda w_s.\exists w' : \underline{p(w^*)(w') = 1 \wedge w' = w}\ .\ B^w_x(p(w^*)) \mid w^* \in W\}$

The alternatives in (120) combine point-wise (Hamblin 1973, Rooth 1985) to give the alternatives to $[\![\mathbf{S}'']\!]^g$ in (121).

(121) $[\![\mathbf{S}'']\!]^{alt}$
$= \{\lambda w.\exists w' : \underline{[\![\textbf{Ans}]\!]([\![\mathbf{S}]\!]^g)(w^*)(w') = 1 \wedge w' = w}\ .\ B^w_J([\![\textbf{Ans}]\!]([\![\mathbf{S}]\!]^g)(w^*)) \mid w^* \in W\}$

Recall now the definition of the answer operator from (114). When applied to a world w and a question Q it gives one of two possible propositions: if there are true propositions in the extension of Q in w, it gives the weak exhaustive answer to Q in w. And if there are no true propositions in the extension, it gives the proposition stating that the extension is empty. Now, assume there are three individuals Ann, Beth, and Clara. Then the answer to *Who smokes?* must be one of (122) depending on the world it is evaluated in.

(122) $\{\lambda w.$Ann smokes in w, $\lambda w.$Beth smokes in w, …, $\lambda w.$Ann+Beth+Clara smoke in w, $\lambda w.$no one smokes in $w\}$

Crucially, the presupposition of each alternative in (121) depends on the w^* chosen. For instance, if the answer to *Who smokes?* in w^*, i.e., $[\![\textbf{Ans}]\!]([\![\mathbf{S}]\!]^g)(w^*)$, is $[\lambda w.$Ann smokes in $w]$, then the particular alternative to $[\![\mathbf{S}'']\!]^g$ is as in (123a). The projection reading is Strawson-equivalent to the local accommodation reading. So it is selected by (59).

(123) a. **Alternative in** w^*
$\lambda w.\exists w' :$ $\underline{\text{Ann smokes in } w' \wedge w' = w}$. $B^w_J(\lambda w''.$Ann smokes in $w'')$

b. **Existential projection in the alternative in** w^*
$= \lambda w :$ $\underline{\exists w'[\text{Ann smokes in } w' \wedge w' = w]}$. $\exists w'.B^w_J(\lambda w''.$Ann smokes in $w'')$
$= \lambda w :$ $\underline{\text{Ann smokes in } w}$. $B^w_J(\lambda w''.$Ann smokes in $w'')$

c. **Local accommodation in the alternative in** w^*
$= \lambda w.\exists w'[$Ann smokes in $w' \wedge w' = w \wedge B^w_J(\lambda w''.$Ann smokes in $w'')]$
$= \lambda w.$Ann smokes in $w \wedge B^w_J(\lambda w''.$Ann smokes in $w'')$

Parallel considerations apply to other choices of w^*. It follows that the alternatives to $[\![\mathbf{S}'']\!]^g$ in (121) can be restated as:

(124) $[\![\mathbf{S}'']\!]^{alt} = \{\lambda w :$ $\underline{\text{Ann smokes in } w}$. $B^w_J(\lambda w'.$Ann smokes in $w'),$
$\lambda w :$ $\underline{\text{Beth smokes in } w}$. $B^w_J(\lambda w'.$Beth smokes in $w'), \ldots,$
$\lambda w :$ $\underline{\text{A+B+C smoke in } w}$. $B^w_J(\lambda w'.$A+B+C smoke in $w'),$
$\lambda w :$ $\underline{\text{no one smokes in } w}$. $B^w_J($no one smokes in $w')\}$

Each alternative in (124) has a factive presupposition. Thus when checking whether $[\![\mathbf{S}'']\!]^g$

[33] Other ways of deriving the alternatives are conceivable, for instance by using Katzir's (2007) structural alternatives. It will become clear in section 6.1.2, however, that lexical alternatives afford one a direct way to implement intermediate exhaustivity with factive PTPs.

Strawson-entails an alternative its factive presupposition must be assumed to be true. Consider the first alternative in (124). Whenever its presupposition is true, as in (125a), the local accommodation reading of $[\![\mathbf{S}'']\!]^g$ in (117c) and paraphrased in (125b) entails the assertion of the alternative, as paraphrased in (125c). The same is true for any other alternative in (124). Therefore the exhaustivity operator does not negate any of the alternatives in (124), and the strengthened interpretation of (113a) comes out as non-contradictory.

(125) a. Ann smokes in w_o.
b. If there are people who smoke in w_o, John believes in w_o of all who do that they smoke, and if there are no people who smoke in w_o, John believes in w_o that no one smokes.
c. (125a) & (125b) $\Rightarrow$ John believes in w_o that Ann smokes.

Consider next the negated (126a) and its LF in (126b). Its literal interpretation is as in (127). As in section 3.2.3, the projection reading strictly Strawson-entails the local accommodation interpretation and is selected by (59). It states that none of the possible answers to *Who smokes?* is true in all of John's belief worlds, i.e., the negation of each is consistent with his doxastic alternatives.[34]

(126) a. John doesn't know who smokes.
b. [Exh_{Alt} [$_{S''}$ not [John knows [$_{S'}$ Ans [$_{S}$ who 2[? t_2 smokes]]]]]]

(127) **Existential projection in $[\![\mathbf{S}'']\!]^g$**
$= \lambda w : \underline{\exists w'[[\![\mathbf{Ans}]\!]([\![\mathbf{S}]\!]^g)(w')(w') = 1 \wedge w' = w]} \,.\, \neg\exists w'.B^w_J([\![\mathbf{Ans}]\!]([\![\mathbf{S}]\!]^g)(w'))$
$= \lambda w.\neg\exists w'.B^w_J([\![\mathbf{Ans}]\!]([\![\mathbf{S}]\!]^g)(w'))$

What are the alternatives to $[\![\mathbf{S}'']\!]^g$? Consider again a world w^* where Ann smokes. The answer in that world to *Who smokes?* is $[\lambda w.$Ann smokes in $w]$. The corresponding alternative is then as in (128a). As in section 3.2.3, the projection and local accommodation readings are Strawson-equivalent. So the former is chosen. It states that John is not certain whether Ann smokes and presupposes that Ann does smoke. So again each alternative to $[\![\mathbf{S}'']\!]^g$ has a factive presupposition.[35]

(128) **Existential projection in the negative alternative in w^***
$= \lambda w : \underline{\exists w'[\text{Ann smokes in } w' \wedge w' = w]} \,.\, \neg\exists w'.B^w_J(\lambda w''.\text{Ann smokes in } w'')$
$= \lambda w : \underline{\text{Ann smokes in } w} \,.\, \neg B^w_J(\lambda w''.\text{Ann smokes in } w'')$

Assume now that the presupposition of (128) is true in w_o as in (129a). Assume also that the literal interpretation $[\![\mathbf{S}'']\!]^g$ is true in w_o as paraphrased in (129b). The latter in particular requires that in one of John's doxastic alternatives Ann does not smoke. Thus John is not certain that Ann smokes, i.e., (129a) and (129b) together entail the assertive component of (128), as paraphrased in (129c). Parallel considerations apply to the rest of the alternatives. So again the exhaustivity operator does not negate any of the alternatives.

(129) a. Ann smokes in w_o.
b. For no possible answer to *Who smokes?* John is certain in w_o that it is true.

[34] Note that (126a) would indeed be odd in a context where Ann and Beth smoke and John knows part of the answer to *Who smokes?*. For instance, if he believes that Ann smokes but is not sure about Beth and Clara.

[35] Generally, downward monotonic environments let the factivity presupposition of a PTP project no matter what, whereas upward monotonic ones only do so in the case of the alternatives.

c. (129a) & (129b) ⇒ John is not certain in w_o that Ann smokes.

So the new semantics coupled with the system from section 3 predicts that *wh*-interrogatives can be embedded under factive *know*. Given that the accommodation economy principle (59) delivers results completely parallel to those from that section, this new system will not affect embedding of polar interrogatives.

4.3.2 Other factive predicates: the case of forget

This result generalizes to other factive PTPs. Such PTPs typically have further presuppositions. Consider for instance *forget*, which is downward monotonic. Recall from section 3.3 that for this reason the simpler system from before could not deal with it. *Forget* contributes the presupposition that the subject used to believe the complement and asserts that she does not do so anymore. For concreteness assume the entry in (130), where UB_x^w stands for *x used to believe in w* and NB_x^w stands for *x now believes in w*.

(130) $[\![\textbf{forget}]\!]$
$= \lambda p_{\langle s,st\rangle}.\lambda x_e.\lambda w_s.\neg\exists w' : \underline{p(w')(w') = 1 \wedge w' = w \wedge UB_x^w(p(w'))}\ .\ NB_x^w(p(w'))$

Assuming the representation in (131b) for (131a), we get the literal meaning in (132a). As with negated *know* the inherent negation causes the existential projection reading in (132b) to be selected. It strictly Strawson-entails the accommodation reading in (132c). The assertive component of (132b) is parallel to the one of (126a) saying that John is not certain about the truth of any answer to *Who smokes?* now. Its presuppositional component says that John used to believe the actual answer.

(131) a. John forgot who smokes.
b. [Exh_{Alt} [$_{S''}$ John forgot [$_{S'}$ Ans [$_{S}$ who 2[? t_2 smokes]]]]]

(132) a. **Literal interpretation $[\![S'']\!]^g$**
$= \lambda w.\neg\exists w' : \underline{[\![\textbf{Ans}]\!]([\![S]\!]^g)(w')(w') = 1 \wedge w' = w \wedge UB_x^w([\![\textbf{Ans}]\!]([\![S]\!]^g)(w'))}\ .$
$NB_J^w([\![\textbf{Ans}]\!]([\![S]\!]^g)(w'))$
b. **Existential projection in $[\![S'']\!]^g$**
$= \lambda w : \exists w'[[\![\textbf{Ans}]\!]([\![S]\!]^g)(w')(w') = 1 \wedge w' = w \wedge \underline{UB_x^w([\![\textbf{Ans}]\!]([\![S]\!]^g)(w'))}]\ .$
$\neg\exists w'[NB_J^w([\![\textbf{Ans}]\!]([\![S]\!]^g)(w'))]$
$= \lambda w : \underline{UB_x^w([\![\textbf{Ans}]\!]([\![S]\!]^g)(w))}\ .\ \neg\exists w'.NB_J^w([\![\textbf{Ans}]\!]([\![S]\!]^g)(w'))$
c. **Local accommodation in $[\![S'']\!]^g$**
$= \lambda w.\neg\exists w'[[\![\textbf{Ans}]\!]([\![S]\!]^g)(w')(w') = 1 \wedge w' = w \wedge UB_x^w([\![\textbf{Ans}]\!]([\![S]\!]^g)(w')) \wedge$
$NB_J^w([\![\textbf{Ans}]\!]([\![S]\!]^g)(w'))]$
$= \lambda w.\neg UB_x^w([\![\textbf{Ans}]\!]([\![S]\!]^g)(w)) \vee \neg NB_J^w([\![\textbf{Ans}]\!]([\![S]\!]^g)(w))$

Assume the alternatives contributed by *forget* follow the format established for *know* in (120), as in (133). Then the alternative to the literal interpretation in a world where Ann smokes is as in (134a). The projection reading in (134b) is Strawson-equivalent to the accommodation reading in (134c). So the former is selected. It presupposes that Ann smokes and that John used to believe this and asserts that John is not certain of this anymore.

(133) $[\![\textbf{forget}]\!]^{alt} = \{\lambda p_{\langle s,st\rangle}.\lambda x_e.\lambda w_s.\exists w' : \underline{p(w^*)(w') = 1 \wedge w' = w \wedge UB_x^w(p(w^*))}\ .$
$NB_x^w(p(w^*))\ |\ w^* \in W\}$

(134) a. **Alternative with *forget***

$= \lambda w.\neg\exists w' :$ Ann smokes in $w' \wedge w' = w \wedge UB_J^w(\lambda w''.$Ann smokes in $w'')$.
$NB_J^w(\lambda w''.$Ann smokes in $w'')$

b. **Existential projection in alternative with *forget***
$= \lambda w : \exists w'[$Ann smokes in $w' \wedge w' = w \wedge UB_J^w(\lambda w''.$Ann smokes in $w'')]$.
$\neg\exists w'.NB_J^w(\lambda w''.$Ann smokes in $w'')$
$= \lambda w :$ Ann smokes in $w \wedge UB_J^w(\lambda w''.$Ann smokes in $w'')$.
$\neg NB_J^w(\lambda w''.$Ann smokes in $w'')$

c. **Local accommodation in alternative with *forget***
$= \lambda w.\neg\exists w'[$Ann smokes in $w' \wedge w' = w \wedge UB_J^w(\lambda w''.$Ann smokes in $w'') \wedge$
$NB_J^w(\lambda w''.$Ann smokes in $w'')]$
$= \lambda w.\neg$Ann smokes in $w \vee \neg UB_J^w(\lambda w''.$Ann smokes in $w'') \vee$
$\neg NB_J^w(\lambda w''.$Ann smokes in $w'')$

Similar considerations hold for the remaining alternatives. Assume that the presupposition of (134b) is true as in (135a). Moreover assume that (132b) as paraphrased in (135b) is true. These two together entail that the assertive component of the alternative, as paraphrased in (135c), is also true. In other words, there is Strawson-entailment. The same holds for the other alternatives, i.e., none of them is negated by Exh and the strengthened interpretation of (131a) is non-contradictory and therefore acceptable.

(135) a. Ann smokes in w_o and John used to believe it.
b. John used to believe in w_o the answer to *Who smokes?* but for no possible answer to *Who smokes?* John is now certain in w_o that it is true.
c. (135a) & (135b) $\Rightarrow$ John is not certain in w_o now that Ann smokes.

From the preceding discussion it should be clear that the negation of (131a) in (136) will work very much in parallel to the case with unnegated *know* in (113a). For reasons of space, I refrain from detailed discussion.

(136) John didn't forget who smokes.

4.3.3 Context dependence again

Consider once more the familiar *be certain* examples in (137). In the new system their LFs must be as in (138).

(137) a. John isn't certain whether Mary smokes.
b. *John is certain whether Mary smokes.

(138) a. [Exh_{Alt} [$_{S''}$ not John certain [$_{S'}$ Ans [$_{S}$ whether Mary smokes]]]]
b. [Exh_{Alt} [$_{S'''}$ John certain [$_{S'}$ Ans [$_{S}$ whether Mary smokes]]]]

Assume for concreteness the denotation of *whether* is as in (139a) following Karttunen (1977). This gives as denotation for the polar interrogative S (139b). The denotation of S′ in (139c) gives the proposition that Mary smokes for a world in which she does and the one that she doesn't smoke for a world where she does not.

(139) a. $[\![\textbf{whether}]\!] = \lambda p_{st}.\lambda w'_s.\lambda q_{st}.q = p \vee q = \lambda w.\neg p(w)$
b. $[\![\textbf{S}]\!]^g = \lambda w'.\lambda p.p = \lambda w.$M smokes in $w \vee p = \lambda w.$M doesn't smoke in w
c. $[\![\textbf{S}']\!]^g = [\![\textbf{Ans}]\!]([\![\textbf{S}]\!]^g)$

Thus the denotation of S″ in (138a) is as in (140a), asserting that there is no possible answer to *Does Mary smoke?* that John believes. The denotation for S‴ in (138b) is as in (140b) saying that John believes some answer to the question.

(140) a. $[\![\mathbf{S}'']\!]^g = \lambda w.\neg\exists w'.B^w_J([\![\mathbf{Ans}]\!]([\![\mathbf{S}]\!]^g)(w'))$
b. $[\![\mathbf{S}''']\!]^g = \lambda w.\exists w'.B^w_J([\![\mathbf{Ans}]\!]([\![\mathbf{S}]\!]^g)(w'))$

The denotations in (139) and (140) correspond to the results the simpler system in section 3.1 had derived, given there as (44a) and (44b).

The exhaustivity operator now negates the Strawson non-weaker alternatives to (140a) and (140b). Assume *be certain* contributes alternatives as in (141). From the discussion in the preceding section, it is then easy to see that in both cases these will end up equivalent to those used in section 3.1, (45a) and (45b) respectively, namely (142a) and (142b).

(141) $[\![\mathbf{be\ certain}]\!]^{alt} = \{\lambda p_{\langle s,st\rangle}.\lambda x_e.\lambda w_s.\exists w'.B^w_x(p(w^*)) \mid w^* \in W\}$

(142) a. $[\![\mathbf{S}'']\!]^{alt} = \{\lambda w.\neg B^w_J(\lambda w'.\text{Mary smokes in } w'),$
$\lambda w.\neg B^w_J(\lambda w'.\text{Mary doesn't smoke in } w')\}$
b. $[\![\mathbf{S}''']\!]^{alt} = \{\lambda w.B^w_J(\lambda w'.\text{Mary smokes in } w'),$
$\lambda w.B^w_J(\lambda w'.\text{Mary doesn't smoke in } w')\}$

As a consequence, the pattern in (137) is still predicted.[36]

4.3.4 Neg-raising predicates again

Consider now the unacceptable examples in (143) again. The excluded middle presupposition gives the entry in (144) for *believe*.

(143) a. *John believes whether Mary smokes.
b. *John doesn't believe whether Mary smokes.

(144) $[\![\mathbf{believe}]\!] = \lambda p_{\langle s,st\rangle}.\lambda x_e.\lambda w_s.\exists w' : \underline{B^w_x(p(w')) \vee B^w_x(\neg p(w'))}\ .\ B^w_x(p(w'))$

Consider first (143a). As in section 3.2.1, accommodation economy selects the the projection reading in (145). It presupposes that John believes some answer to *Does Mary smoke?*. The assertion says exactly the same. So as before, whenever (143a) has a defined truth-value, it is true. This means (143a) is Strawson-trivial.

(145) **Existential projection in $[\![$(143a)$]\!]^g$**
$= \lambda w : \underline{\exists w'[B^w_J([\![\mathbf{Ans}]\!](Q)(w')) \vee B^w_J(\neg[\![\mathbf{Ans}]\!](Q)(w'))]}\ .\ \exists w'.B^w_J([\![\mathbf{Ans}]\!](Q)(w'))$

Negating (145) for (143b) also gives a Strawson-trivial meaning. Its presupposition is the one of (143a). The assertion, however, says that John does not believe any possible answer to *Does Mary smoke?*. So whenever (143b) has a defined truth-value it is false.

The results from the simplified account in section 3.2.1 are thus inherited by the novel semantics for clause embedding. However, this does not generalize to *wh*-interrogatives embedded under *believe* as in (146). With the entry in (144), the problem noted in section 3.3 still stands. With the truth-conditions in (145), (146a) would presuppose that either there is an individual x among Ann, Beth, and Clara such that John believes x smokes or he believes that x does not

[36] This result extends to *wh*-interrogatives under *be certain*. Since here the empirical picture is a bit more nuanced, however, I defer discussion to section 5.4.2.

smoke or he believes that no one smokes. This does not entail the assertive component, which says that John believes one of the individuals to smoke or that he believes that no one smokes. For instance, if John believes that Ann does not smoke the presupposition would be satisfied but nothing follows about the truth of the assertion. That is, for (146a) the truth-conditions in (145) would be non-trivial and therefore the sentence should be acceptable. Parallel considerations apply to (146b).

(146) a. *John believes who smokes.
b. *John doesn't believe who smokes.

The essence of the problem is that the semantics in (144) delivers an excluded middle presupposition when there are exactly two propositions which are negations of each other, but not when there are multiple propositions which are not negations of each other. The latter situation obtains with the potential answers to a *wh*-interrogative. To remedy this and preserve the insight from polar interrogatives I adjust the lexical entry for *believe* to (147). The excluded middle presupposition is strengthened so that it holds both for the subject's relation to the extension in w' of the embedded clause p as well as her relations to the extensions in w' of the alternatives to p, Alt. I assume that p is always a member of Alt. In other words, (147) requires that the subject be opinionated not only about the truth of the embedded clause itself but also about the truth of its alternatives. This seems reasonable. Russell (2006) suggests exactly this in order to deal with scalar implicatures embedded under *believe*.

(147) $[\![\textbf{believe}]\!] = \lambda p_{\langle s,st\rangle}.\lambda x_e.\lambda w_s.\exists w' : \underline{\forall q \in Alt[B^w_x(q(w')) \vee B^w_x(\neg q(w'))]}\ .\ B^w_x(p(w'))$

Assuming that the alternatives relevant for the excluded middle presupposition in the case of (143a) and (143b) are the possible answers to the interrogative, (147) does not affect the result from above.[37]

For (146a) and (146b), (147) does however make a difference. The new entry for *believe* gives the literal meaning in (148) for (146a). Assume again that the alternatives relevant are the possible answers to the question *Who smokes?*. Then the projection reading presupposes that John is opinionated about all answers to *Who smokes?* and asserts that John believes some answer. The local accommodation reading asserts all of this. That is, the two readings are Strawson-equivalent and (148b) is selected.

(148) a. **Literal interpretation $[\![$(146a)$]\!]$**
$= \lambda w.\exists w' : \underline{\forall q \in Alt[B^w_J(q(w')) \vee B^w_J(\neg q(w'))]}\ .\ B^w_J([\![\textbf{Ans}]\!](Q)(w'))$
b. **Existential projection in $[\![$(146a)$]\!]$**
$= \lambda w : \underline{\exists w'.\forall q \in Alt[B^w_J(q(w')) \vee B^w_J(\neg q(w'))]}\ .\ \exists w'.B^w_J([\![\textbf{Ans}]\!](Q)(w'))$
c. **Local accommodation in $[\![$(146a)$]\!]$**
$= \lambda w.\exists w'[\forall q \in Alt[B^w_J(q(w')) \vee B^w_J(\neg q(w'))] \wedge B^w_J([\![\textbf{Ans}]\!](Q)(w'))]$

The presupposition of (148b) can be rendered as in (149).

(149) $[B^w_J(a) \vee B^w_J(\neg a)] \wedge [B^w_J(b) \vee B^w_J(\neg b)] \wedge [B^w_J(c) \vee B^w_J(\neg c)] \wedge \ldots \wedge [B^w_J(\varnothing) \vee B^w_J(\neg \varnothing)]$

Clearly, as soon as John believes one of the possible answers to be true—i.e., as soon as one of the left disjuncts is true in (149)—the assertion in (148b) cannot fail to be true as well. Now notice that not all of the right disjuncts in (149) can be true at the same time if John's beliefs

[37] For declarative clauses embedded under *believe* the set of alternatives will have to include just the denotation of that clause. This derives the familiar neg-raising effect.

are coherent, as this would say that John believes that no one smokes but believes that someone does. Thus one of the left disjuncts must be true. But this will entail the assertion. Thus the literal meaning in (148b) is trivial.[38] Negating the literal meaning in (148a) as in the case of (146b) does not alter the presupposition, as we know from section 3.2.1. That is, the projection reading is again selected. Its assertive component would now say, however, that John does not believe any possible answer. This contradicts the presupposition in (149). So both of (146) are predicted to be the degraded.[39]

4.3.5 Excluded middle presupposition plus factivity: regret **and** resent

Recall now the data from (15) showing that neither *regret* nor *resent* embed interrogatives, even though they are d-veridical (Lahiri 2002, Egré 2008). In fact they are factive, as (151a) shows. Moreover, they presuppose that the subject believes the complement.[40] Given the factivity, we would expect the PTPs to embed interrogatives.

(150) a. John *regrets* / *resents* that Mary smokes. $\rightsquigarrow$ *Mary smokes*
$\rightsquigarrow$ *John believes that Mary smokes*

b. *John *regrets* / *resents* whether Mary smokes.

c. *John *regrets* / *resents* which students smoke.

(151) a. John doesn't *regret* / *resent* that Mary smokes. $\rightsquigarrow$ *Mary smokes*
$\rightsquigarrow$ *John believes that Mary smokes*
$\rightsquigarrow$ *John is happy that Mary smokes*

b. *John doesn't *regret* / *resent* whether Mary smokes.

c. *John doesn't *regret* / *resent* which students smoke.

Notice, however, that the two PTPs might also contribute an excluded middle presupposition, as (151a) can be read to suggest that John does not just not mind that Mary smokes but is in fact happy about it.

The suggestions just made can be cashed out in the present system with an entry as in (152). Here $D^w_x(p(w'))$ is short for $\exists w' \ldots \forall w''[w''$ is compatible with what x desires in $w \rightarrow p(w')(w'') = 1]$. The excluded middle presupposition regards the subject's desires with respect to the truth of the complement. For simplicity, I revert here to the non-strengthened format of the excluded middle presupposition.

[38] *Which*-interrogatives might come with an existential presupposition. Thereby the embedded interrogative in (i) presupposes that one of the girls smokes. This presupposition projects to the root requiring that John believe that some girl smokes (Karttunen 1974, Heim 1992, Schlenker 2009). There might then be no alternative to the literal meaning of (i) available stating *John believes that no girl smokes*. That is, the strengthened excluded middle presupposition of (i) would amount to (ii) and not (149). Here the right disjuncts could be true together entailing John believes that no girl smokes. This contradicts the presupposition projected from the *which*-interrogative. To avoid this, one of the left disjuncts in (ii) must be true guaranteeing triviality.

(i) *John believes which girl smokes.

(ii) $[B^w_J(a) \vee B^w_J(\neg a)] \wedge [B^w_J(b) \vee B^w_J(\neg b)] \wedge [B^w_J(c) \vee B^w_J(\neg c)] \wedge \ldots \wedge [B^w_J(a+b+c) \vee B^w_J(\neg a+b+c)]$

[39] The strengthening of the excluded middle presupposition was necessary because of the assumption that embedded *wh*-interrogatives have a weak exhaustive literal interpretation in order to be able to derive intermediate exhaustivity. Should the latter turn out to be unnecessary, one could work with strong exhaustivity. In this case the standard excluded middle presupposition would deliver the desired results of triviality.

[40] Klein (1975), Gazdar (1979) and Egré (2008) suggest that *regret* is not factive but only presupposes that the subject believes the complement. This weak presupposition would then have to be strengthened.

(152) $[\![\textbf{regret}]\!] = \lambda p_{\langle s,st\rangle}.\lambda x_e.\lambda w_s.\neg\exists w' : \underline{p(w')(w') = 1 \wedge w' = w \wedge B^w_x(p(w')) \wedge [D^w_x(p(w')) \vee D^w_x.(\neg p(w'))]} \,.\, D^w_x(p(w'))$

The literal interpretation of (150b) with *regret* is as in (153a). The projection reading in (153b) presupposes that John believes the true answer and either desires it or desires its negation, but it asserts that John has no desires regarding any answer. That is, whenever there is a defined truth-value, the sentence is false. Such a Strawson-contradiction therefore automatically entails the local accommodation reading and is thus selected by accommodation economy (59). The deviance of (150b) is accounted for.

(153) a. **Literal interpretation $[\![$(150b)$]\!]^g$**
$= \lambda w.\neg\exists w' : [\![\textbf{Ans}]\!](Q)(w')(w') = 1 \wedge w' = w \wedge B^w_J([\![\textbf{Ans}]\!](Q)(w')) \wedge \underline{[D^w_J([\![\textbf{Ans}]\!](Q)(w')) \vee D^w_J.(\neg[\![\textbf{Ans}]\!](Q)(w'))]} \,.\, D^w_J([\![\textbf{Ans}]\!](Q)(w'))$

b. **Existential projection in $[\![$(150b)$]\!]^g$**
$= \lambda w : \exists w'[[\![\textbf{Ans}]\!](Q)(w')(w') = 1 \wedge w' = w \wedge B^w_J([\![\textbf{Ans}]\!](Q)(w')) \wedge \underline{[D^w_J([\![\textbf{Ans}]\!](Q)(w')) \vee D^w_J.(\neg[\![\textbf{Ans}]\!](Q)(w'))]} \,.\, \neg\exists w'.D^w_J([\![\textbf{Ans}]\!](Q)(w'))$
$= \lambda w : \underline{B^w_J([\![\textbf{Ans}]\!](Q)(w)) \wedge [D^w_J([\![\textbf{Ans}]\!](Q)(w)) \vee D^w_J.(\neg[\![\textbf{Ans}]\!](Q)(w))]} \,.\, \neg\exists w'.D^w_J([\![\textbf{Ans}]\!](Q)(w'))$

The literal interpretation of the negated case in (151b) is as in (154a). The projection reading in (154b) presupposes that John believes the true answer and either desires it or its negation. It asserts that John desires some answer. Whenever this is defined, the sentence would be true, i.e., the projection reading is trivial. The accommodation reading in (154c) states that John believes the true answer and desires it, which is not trivial. This time, however, (154c) Strawson-entails (154b) and by accommodation economy should be selected.

(154) a. **Literal interpretation $[\![$(151b)$]\!]^g$**
$= \lambda w.\exists w' : [\![\textbf{Ans}]\!](Q)(w')(w') = 1 \wedge w' = w \wedge B^w_J([\![\textbf{Ans}]\!](Q)(w')) \wedge \underline{[D^w_J([\![\textbf{Ans}]\!](Q)(w')) \vee D^w_J.(\neg[\![\textbf{Ans}]\!](Q)(w'))]} \,.\, D^w_J([\![\textbf{Ans}]\!](Q)(w'))$

b. **Existential projection in $[\![$(151b)$]\!]^g$**
$= \lambda w : \exists w'[[\![\textbf{Ans}]\!](Q)(w')(w') = 1 \wedge w' = w \wedge B^w_J([\![\textbf{Ans}]\!](Q)(w')) \wedge \underline{[D^w_J([\![\textbf{Ans}]\!](Q)(w')) \vee D^w_J.(\neg[\![\textbf{Ans}]\!](Q)(w'))]} \,.\, \exists w'.D^w_J([\![\textbf{Ans}]\!](Q)(w'))$
$= \lambda w : \underline{B^w_J([\![\textbf{Ans}]\!](Q)(w)) \wedge [D^w_J([\![\textbf{Ans}]\!](Q)(w)) \vee D^w_J.(\neg[\![\textbf{Ans}]\!](Q)(w))]} \,.\, \exists w'.D^w_J([\![\textbf{Ans}]\!](Q)(w'))$

c. **Local accommodation in $[\![$(151b)$]\!]^g$**
$= \lambda w.\exists w'[[\![\textbf{Ans}]\!](Q)(w')(w') = 1 \wedge w' = w \wedge B^w_J([\![\textbf{Ans}]\!](Q)(w')) \wedge [D^w_J([\![\textbf{Ans}]\!](Q)(w')) \vee D^w_J.(\neg[\![\textbf{Ans}]\!](Q)(w'))] \wedge D^w_J([\![\textbf{Ans}]\!](Q)(w'))]$
$= \lambda w.B^w_J([\![\textbf{Ans}]\!](Q)(w)) \wedge D^w_J([\![\textbf{Ans}]\!](Q)(w))$

Would exhaustification of (154c) lead to triviality? The answer is negative. As with unnegated *know*, the factive presuppositions of the alternatives prevent them from being negated by Exh as they are Strawson-entailed by (154c). But then (151b) should be acceptable.

The nature of the problem is as follows. (150b) comes out as trivial because of the negation that is built into the meaning of *regret*. As we have seen with negation it is always the projection reading that is selected, regardless of whether the PTP involved has the factivity or the excluded middle presupposition or both as in the present case. Because of the neg-raising property of *regret* triviality follows. This is as desired. Now, in the negated (151b) and therefore upward monotonic context, the factivity of *regret* has the effect that the accommodation interpretation

is chosen. Factivity also lets the triviality disappear, just as we are used to from other factive PTPs. But in the present case this is not desired.

I take this situation to suggest that we should follow Gajewski (2002) more closely than done so far, by assuming that any l-trivial constituent leads to degradedness:

(155) **Triviality and degradedness (revised)**
If a sentence S contains an l-trivial constituent, S is degraded.

Now, consider the LF of (151b) in (156) and assume that accommodation economy applies at each level where a scope bearing expression is encountered. That is, at each such level there is the possibility of projecting the presupposition or not. Then at the level of S in (156) accommodation economy would select the projection reading as in (154) above for the unnegated (150b). But then the S-constituent is trivial, and that would suffice to make (151b) unacceptable. With the strengthened excluded middle presupposition, (150c) and (151c) would also come out as unacceptable on this reasoning.[41]

(156) $[_{S'}$ not $[_{S}$ John regrets [Ans [whether Mary smokes]]]]

4.4 Interim summary

According to the present section, the denotations of PTPs embedding declaratives do not differ from those of their interrogative embedding varieties. Both take a propositional concept as argument, and both are existential. I showed that this allows for wider empirical coverage than the simple system from section 3 by encompassing *wh*-interrogatives and additional PTPs. Crucially, the unified semantics for embedding proposed here allows to keep the insight from section 3 according to which i-veridicality is just the result of a factive presupposition when an interrogative is embedded.

5 Avoidance of triviality

In this section I attend to some extensions and predictions of the system regarding avoidance of triviality with interrogative embedding.

5.1 Truth and falsity of complement clauses

5.1.1 Ambiguity between factive and non-factive interpretations

Recall the PTPs in (157) from (14). They constitute a problem for the original veridicality hypothesis because they embed interrogatives even though they are non-veridical.

(157) John *announced / confirmed / concluded / considered / contemplated / decided / declared / established / explained / guessed / heard / indicated / inferred / predicted / reported / told us* ...
a. that Mary smokes. $\not\rightarrow$ *Mary smokes*

[41] For the familiar case in (i) this means that there are now two trivial constituents: the sentence as a whole and the constituent below negation.

(i) *John doesn't believe whether Mary smokes.

b. whether Mary smokes.$\rightsquigarrow$ *John P-ed the true answer to "Does Mary smoke?"*

I suggested in section 2.4 that the PTPs in (157) are optionally d-veridical and that d-veridicality entails i-veridicality. I showed that d- and thus i-veridicality follow from the factivity of a PTP and that factivity is sufficient for embedding interrogative clauses.

To account for the pattern observed in (157), I thus follow Spector and Egré (2015) in assuming that the PTPs in (157) come in both a factive and a non-factive version (see also Berman 1991). Consider *tell* for concreteness. In (157a), on the one hand, its non-factive version in (158) is, or at least can be chosen. Thereby no veridicality inference is felt.

(158) $[\![\textbf{tell}_1]\!] = \lambda p_{\langle s,st\rangle}.\lambda y_e.\lambda x_e.\lambda w_s.\exists w'.$
$\forall w''[w''$ is compatible with what x tells y in $w \rightarrow p(w')(w'') = 1]$

The reason why, on the other hand, in (157b) the factive version in (159) must be chosen is now straightforwardly explained: using the non-factive version of *tell* in (158) would result in a trivial strengthened meaning and thereby degradedness. That is, it would lead to a contradiction after exhaustification completely parallel to what we have seen with *be certain* in sections 3.1 and 4.3.3 above. On its factive interpretation, however, *tell* works just like *know*. Factivity blocks the triviality otherwise derived by exhaustification.

(159) $[\![\textbf{tell}_2]\!] = \lambda p_{\langle s,st\rangle}.\lambda y_e.\lambda x_e.\lambda w_s.\exists w' : \underline{p(w')(w') = 1 \wedge w' = w}\,.$
$\forall w''[w''$ is compatible with $\overline{\text{what } x \text{ tells } y \text{ in } w \rightarrow p}(w')(w'') = 1]$

So the present account is in a position to explain why seemingly non-veridical PTPs must be about the true answer when embedding an interrogative clause as in (157b). The only other account of this pattern that I am aware of is also based on ambiguity (Uegaki 2015b:chapt. 4). I briefly compare the two proposals in section 5.3.

I suspect that whether a given PTP is ambiguous between a factive and a non-factive interpretation will ultimately be to a large extent an idiosyncratic property of that PTP, at least in English. It should be mentioned that languages can lexicalize the different interpretations hypothesized for English. For instance, German has two translations for English *guess*, namely *raten* and *erraten*. The former is non-factive whereas the latter is factive as shown by the contrast between (160a) and (161a). As predicted by the account suggested here only the latter embeds interrogative clauses and crucially requires the subject to stand in the guess-relation to the true answer, as (161b) shows.

(160) a. Hans hat geraten, dass Maria raucht.
Hans has guessed that Maria smokes
'Hans guessed that Maria smokes.' $\not\rightsquigarrow$ *Maria smokes*

b. *Hans hat geraten, ob Maria raucht.
Hans has guessed whether Maria smokes.

(161) a. Hans hat erraten, dass Maria raucht.
Hans has guessed that Maria smokes
'Hans guessed that Maria smokes.' $\rightsquigarrow$ *Maria smokes*

b. Hans hat erraten, ob Maria raucht.
Hans has guessed whether Maria smokes
'Hans guessed whether Maria smokes.'
$\rightsquigarrow$ *Hans guessed the true answer to "Does Maria smoke?"*

Polish suggests that the pattern in (160) and (161) is related to aspect. In particular, imperfective *zgadywać* ('guess') is non-factive and does not seem to embed interrogatives, similarly to (160). Perfective *zgadnąć*, on the other hand, is factive and embeds interrogatives, similarly to (161).[42] Comments in Spector and Egré 2015 credited to Marta Abrusán suggest that a similar situation might be observed in Hungarian.

(162) a. Jan zgadywał, że Marek boi się duchów.
Jan guessed.IPFV that Marek fears.IPFV REFL ghost
'Jan guessed that Marek fears ghosts.' $\not\rightsquigarrow$ *Marek fears ghosts*

b. ??Jan zgadywał, czy Ania boi się duchów.
Jan guess.IPFV whether Ania fear REFL ghosts.

(163) a. Jan zgadł, że Marek boi się duchów.
Jan guessed.PFV that Marek fears.IPFV REFL ghost
'Jan guessed that Marek fears ghosts.' $\rightsquigarrow$ *Marek fears ghosts*

b. Jan zgadł, czy Ania boi się duchów.
Jan guess.PFV whether Ania fear REFL ghosts.
'Jan guessed whether Ania fears ghosts.'
$\rightsquigarrow$ *Jan guessed the true answer to "Does Marek fear ghosts?"*

5.1.2 Potential falsity

Recall now the non-veridical PTPs from (12) in (164). Unlike the ambiguous PTPs just seen, here interrogative embedding is impossible as (164b) shows. And crucially, the situation does not improve under negation.

(164) John (didn't) *allege(d) / assert(ed) / claim(ed) / conjecture(d) / propose(d) / suggest(ed) ...*

a. that Mary smokes. $\not\rightsquigarrow$ *Mary smokes*

b. *whether Mary smokes.

Why would that be? It is not unreasonable to assume that the PTPs in (164) presuppose their complement to be possibly false. At least in every day use this is what the PTPs suggest. To see this, compare (164a) to a minimally differing sentence with *say* or *tell*, for instance. *Allege* would then have an entry as in (165). With this entry, (164a) presupposes that it is possible that Mary does not smoke.[43]

(165) $[\![\textbf{allege}]\!] = \lambda p_{\langle s,st\rangle}.\lambda x_e.\lambda w_s.\exists w' : \underline{p(w')(w') = 0}\,.$
$\forall w''[w''$ is compatible with what x alleges in $w \rightarrow p(w')(w'') = 1]$

(165), however, immediately explains why *allege* does not embed interrogative clauses. Assuming that Q is the denotation of *Does Mary smoke?*, we get the literal meaning for unnegated (164b) with *allege* in (166a). Here the accommodation reading in (166b) is selected. It asserts that there is a world w' such that the answer to Q in w' is false in w'. This obviously cannot be

[42] I thank a reviewer for suggesting the connection to aspect and Karolina Zuchwicz (p.c.) for her help with (160b) and (161b). See Zuchewicz 2018 on the interaction between aspect and factivity in Polish, from which (160a) and (161a) are cited.

[43] This leaves open the possibility that some of the PTPs in (164) might presuppose something stronger, namely that the complement is false in the world evaluation. This seems, for instance, possible with *allege*. As noted in footnote 27 something similar holds for *wish* on at least one of its readings.

the case. (166b) is thus trivial.[44] This immediately extends to the negated version.[45]

(166) a. **Literal interpretation ⟦(164b)⟧**
$= \lambda w.\exists w' : \underline{[\![\textbf{Ans}]\!](Q)(w')(w') = 0}\ .$
$\forall w''[w''$ is compatible with what x alleges in $w \rightarrow [\![\textbf{Ans}]\!](Q)(w')(w'') = 1]$

b. **Accommodation reading in ⟦(164b)⟧**
$= \lambda w.\exists w'[[\![\textbf{Ans}]\!](Q)(w')(w') = 0 \wedge$
$\forall w''[w''$ is compatible with what x alleges in $w \rightarrow [\![\textbf{Ans}]\!](Q)(w')(w'') = 1]]$

5.2 Being about some vs. the true answer

The discussion in section 5.1.1 makes a testable prediction. Whenever one of the PTPs from (157)—i.e., one of those that are ambiguous between factive and non-factive interpretations—embeds an interrogative clause and moreover occurs in an environment where triviality by exhaustification is avoided independently, the non-factive interpretation should be usable. That is, an i-veridicality inference should not be obligatory then. Rather an interpretation should surface according to which the subject stands in a relation to some possible answer.[46]

5.2.1 Interrogative embedding and being about some answer

Consider (167). The sentence in (167a) is odd in the context given. Now notice that on the factive interpretation of *tell* in (159) the sentence should be acceptable. With (159) the sentence would assert that John did not tell us the true answer to *Does Mary smoke?*. Since the context satisfies this, we conclude that the sentence does not have such truth-conditions.

(167) **Context:** *John told us that Mary smokes, which is in fact false.*

a. #John didn't tell us whether Mary smokes.
b. ?John didn't tell us whether Mary smokes. That is, he didn't tell us the truth.

On the other hand, if the non-factive interpretation in (158) is chosen the oddness of (167a) in the context given is explained. Without a factive presupposition, the sentence just states that John did not tell us any possible answer to the question *Does Mary smoke?*. These truth-conditions are not fulfilled by the context. (168a) shows the same for *predict*.

(168) **Context:** *John predicted that Mary smokes, which is in fact false.*

a. #John didn't predict whether Mary smokes.
b. ?John didn't predict whether Mary smokes. That is, he didn't predict it correctly.

Notice that this type of explanation for the oddness observed in (167a) and (168a) presupposes that the non-factive interpretation of the PTP is chosen when possible. Otherwise, with the factive interpretation readily available, we would not expect oddness. Notice also that when

[44] The projection reading would presuppose that there is a world in which the answer is false. I assume that contradictory presuppositions are not projected. See also footnote 29.

[45] A reviewer notes that the entry in (165) only works because I stipulate the first argument of p to be w', which does not play a role in the declarative embedding case. I do not have a good explanation for this but point out that the entry is parallel to those hypothesized to be necessary for PTPs throughout the paper. That is, I must assume that (165) is to follow from a general lexical pattern.

[46] Given the discussion in section 5.1.2 this must be qualified: it is conceivable that for some of the PTPs in (157) a purely non-factive interpretation does not even exist. Rather for some of these the non-factive interpretation might in fact presuppose potential falsity of the complement clause.

followed up with a statement making it clear that the factive interpretation is intended for the PTP the sentences improve in the contexts given. This is what is shown by (167b) and (168b). If only the factive interpretation is available, as with *know*, we do not observe oddness:

(169) **Context:** *John believes that Mary smokes, which is in fact false.*
John doesn't know whether Mary smokes.

I must leave open for future research how the system decides which interpretation of the PTP is used and whether it does so at all. It might just be that there is full ambiguity between factive and non-factive interpretations and that the oddness of (167a) and (168a) is due to this essentially. One might also contemplate, however, that part of the semantic interpretation system is blind to contextual information as hypothesized by e.g. Fox and Hackl (2006): whenever there is no threat of triviality, the basic non-factive interpretation would then be used. The factive interpretation is therefore not used simply when context would suggest so but rather as a last resort mechanism to avoid triviality.[47]

5.2.2 Obviation by modals and embedded Exh

Spector and Egré (2015) suggest that ambiguous PTPs can always have the non-factive interpretation when embedding interrogative clauses. They cite the cases in (170a) as evidence for this, minimally modified to show a *whether*-interrogative here. (170a) seemingly does not require the subject to stay in a relation to the true answer. This contrasts with (170b) using an obligatory factive PTP such as *know*, where a contraction obtains.

(170) a. Every day, the meteorologists *tell* the population / *predict* / *announce* whether it will rain the following day, but they are often wrong.
b. #Every day, the meteorologists *know* whether it will rain the following day, but they are often wrong.

I suggest that the surfacing of the non-factive interpretations of the PTPs involved is due to the fact that they are embedded under the universal temporal quantifier *every day*. Note that the deontic universal modal *be required* in (171) has a parallel effect.[48]

(171) The meteorologists were required to *tell* the population / *predict* / *announce* whether it would rain the following day, but they were wrong.

It is well-known that universal quantifiers obviate contradictions which would otherwise arise through exhaustification when occurring unembeddedly (e.g. Fox and Hackl 2006, Fox 2007, Chierchia 2013, Abrusán 2014). Consider briefly how this works for (171) with the non-factive version of *tell*. The LF would be something like (172).

(172) $[_{S''}$ Exh_{Alt} $[_{S'}$ required [the meteorologists to $tell_1$ the population $[_S$ Ans whether it will rain]]]]

The literal meaning of S′ states that in every deontically accessible world the meteorologists tell the population a possible answer to the question *Will it rain?*. This neither entails that in every such world the meteorologists tell the population that it will rain nor that in every world they tell

[47] The reader is also referred to Berman's (1991) discussion of the pragmatic variability of factivity.

[48] (171) is episodic in contrast to (170a) in order to forestall the complicating factor of genericity discussed below. I thank an anonymous reviewer for this suggestion.

them that it will not rain. That is, the literal meaning does not entail its alternatives. Therefore the exhaustivity operator negates them giving the strengthened meaning in (173). Crucially, (173) is not trivial. It states that the meteorologists are required to tell the population some answer but neither are they required to tell them that it will rain nor are they required to tell them that it will not rain. This explains why (170a) and (171) are non-degraded even when no relation between the subject and the actual true answer is involved.

(173) $[\![\mathbf{S}'']\!]^g = \lambda w.\forall w' \in DEON_w.\exists w''.$m tells p in w' $[\![\mathbf{Ans}]\!]([\![\mathbf{S}]\!]^g)(w'') \wedge$
$\neg\forall w' \in DEON_w.$m tells p in w' it will rain $\wedge$
$\neg\forall w' \in DEON_w.$m tells p in w' it will not rain

This raises at least two issues. First, why is (174) without an overt universal modal acceptable? Without such a modal, the factive interpretation of the PTP would be necessary thereby yielding a contradiction given the continuation. Given the meaning of (174), however, it seems likely that there is a covert generic operator present (Krifka et al. 1995). Such an operator with a semantics roughly similar to *always* would equally avoid triviality (see Magri 2009 for related use of a generic operator).

(174) The meteorologists *tell* the population / *predict* / *announce* whether it will rain the following day, but they are often wrong.

Second, existential modals like *be allowed* are not known to obviate contradictions in the same way as universal modals. Why then is (175) as acceptable as (171) above? If we analyzed (175) on a par with (171), its strengthened meaning would say that the meteorologists are allowed to tell the population some answer but are neither allowed to tell them that it will rain nor allowed to tell them that it will not rain, which would be contradictory.

(175) Even though they are always wrong, the meteorologists are allowed to *tell* the population / *predict* / *announce* whether it will rain the following day.

I suggest that in cases like (175) it is actually the factive version of the PTP that is used, as in the LF in (176), with Exh embedded under the modal.

(176) $[_{S''}$ allowed $[_{S'}$ Exh_{Alt} [the meteorologists to tell_2 the population $[_S$ Ans whether it will rain]]]]

First, notice that the alternatives to the prejacent of Exh are Strawson-entailed by the prejacent. That is, Exh does not negate any of them, as in the case of *know* discussed above. Second, this delivers the literal interpretation of S'' in (177a). The projection reading in (177b) says that in some deontically accessible world the meteorologists tell an answer. The accommodation reading says that in some deontically accessible world w' the meteorologists tell the population the true answer to the interrogative in w'. The latter Strawson-entails the former and is selected by accommodation economy. Crucially (177c) does not clash with the first part of (175). In other words, with embedded exhaustification and the factive use of *tell*, (175) does not come out as degraded.[49] [50]

[49] A parallel analysis might be available for the universal case in (171) in addition to the one discussed in the text. With a non-realistic modal base, no triviality would arise.

[50] A reviewer notes that (i) with episodic past is acceptable with a seemingly non-veridical *tell*. An analysis similar to the one sketched for (175) with factive *tell* might, however, be possible. What is crucial is to (a) relativize Ans not only to worlds but also to times and (b) realize that the question is about the future. The embedded clause is then

(177) a. **Literal interpretation $[\![S'']\!]^g$**
$= \lambda w.\exists w' \in DEON_w.\exists w'' : [\![\textbf{Ans}]\!]([\![S]\!]^g)(w'')(w'') = 1 \wedge w'' = w'$.
$\underline{\text{m tells p in } w' [\![\textbf{Ans}]\!]([\![S]\!]^g)(w'')}$

b. **Projection reading in $[\![S'']\!]^g$**
$= \lambda w.\exists w' \in DEON_w.\exists w''[[\![\textbf{Ans}]\!]([\![S]\!]^g)(w'')(w'') = 1 \wedge w'' = w']$.
$\underline{\exists w' \in DEON_w.\exists w''[\text{m tells p in } w' [\![\textbf{Ans}]\!]([\![S]\!]^g)(w'')]}$
$= \lambda w.\exists w' \in DEON_w.\exists w''[\text{m tells p in } w' [\![\textbf{Ans}]\!]([\![S]\!]^g)(w'')]$

c. **Accommodation reading in $[\![S'']\!]^g$**
$= \lambda w.\exists w' \in DEON_w.\exists w''[[\![\textbf{Ans}]\!]([\![S]\!]^g)(w'')(w'') = 1 \wedge w'' = w' \wedge$
m tells p in $w' [\![\textbf{Ans}]\!]([\![S]\!]^g)(w'')]$
$= \lambda w.\exists w' \in DEON_w[\text{m tells p in } w' [\![\textbf{Ans}]\!]([\![S]\!]^g)(w')]$

This treatment of ambiguous PTPs like *tell* under modals makes the following prediction. Unambiguous non-veridical PTPs like *be certain* should be acceptable under universal modals but not under existential ones. Universal modals, on the one hand, obviate contradiction licensing the non-veridical use of *tell*. Thus they should have the same effect for *be certain*. Existential modals, on the other hand, do not obviate contradiction blocking *be certain* below them. Moreover, Exh embedded under the existential modal similar to (176) would lead to triviality. These predictions are borne out as the contrast between (178a) and (178b) shows. Negation as in (178c) improves the situation, as expected.[51] [52]

(178) a. The meteorologists are required to be certain whether it will rain.
b. *The meteorologists are allowed to be certain whether it will rain.
c. The meteorologists aren't allowed to be certain whether it will rain.

5.2.3 Obviation by universal quantifiers

Remember now from (28) that there is no difference in interrogative embedding under *be certain* with regards to whether the latter occurs in the antecedent (179a) or the consequent of a conditional (179b). The former is accounted for by taking antecedents to be downward monotonic, albeit in a restricted sense (e.g. Heim 1984, von Fintel 1999), which avoids contradiction, as we know. The latter, however, has so far been left unaccounted for. The discussion in the preceding section opens a way to explain that observation, too. Following Kratzer (1979, 1981) et seq. in taking conditionals without overt modal to express modal necessity statements, the acceptability of (179b) becomes parallel to the the cases discussed above with an overt necessity modal. In

paraphrasable as *'the answer in w at t' to "Does it rain in w at some t'' after t'?"'*. PAST in the matrix binds t' but not w and the resulting interpretation is *'There is a time t' before t such that the meteorologists told the population in w at t' the answer in w at t' to "Does it rain in w at some t'' after t'?"'*. This could involve factive *tell*. The true answer in w at t' to a question about the future need not correspond to the true answer in w at t. I must leave this for the future to be worked out in detail.

(i) The meteorologists told the population whether it would rain the following day, but they were wrong.

[51] A reviewer notes that they and their informants find (178a) and (178b) equally bad. I must leave more careful investigation of this for another occasion. Recall, however, that van Gessel et al. (2017) indirectly support the claim in the text given their findings about conditionals. See section 5.2.3.

[52] I also want to point out that the future auxiliary *will* also licenses embedded *be certain*. This is expected if future *will* is a universal modal as in much work following Kratzer (1981):

(i) The meteorologists will be certain whether it will rain.

both *be certain* occurs in the scope of a universal modal operator whereby triviality is avoided.

(179) a. If John is certain whether Mary smokes, he met her.
b. If John met Mary, he is certain whether she smokes.

For entirely parallel reasons we can then explain why there is no contrast in acceptability between the restrictor (180a) and the scope (180b) of *every* with respect to interrogative embedding under *be certain* either. Again the former is a downward monotonic environment explaining (180a). Crucially, a universal quantifier over individuals obviates contradiction in its scope just as much as a universal necessity modal does (e.g. Mayr 2013, Schwarz 2016). This is why (180b) is acceptable.

(180) a. Every student who is certain whether Mary smokes met her.
b. Every student who met Mary is certain whether she smokes.

This raises the following issue: the view adopted in this paper where application of Exh either leads to triviality or does not do so predicts (181) to be acceptable (Chierchia 2013). Why is NPI *any* not acceptable in the scope of *every* unlike interrogatives under *be certain*?

(181) *Every student met any girl.

I do not wish to take a final stance on this issue. But I point out the following analytical option. Crnič (2014) discusses the possibility that with *any* it is not Exh but rather a covert version of *even* that either leads to acceptability or unacceptability. *Even* would indeed predict the judgement in (181). To then predict the divergence of interrogatives under *be certain* and NPI *any* in the scope of universal quantifiers one could assume that in the former case *even* is not an option. Exh is obligatorily involved here.[53] Section 6.1 suggests that there are independent reasons for the latter.

5.3 Interrogative embedding in non-monotonic environments

Consider now the non-monotonic case in (182a). There are two types of LFs relevant for our purposes, given in (182b) and (182c). It is clear that with (182b) results parallel to those derived for the non-quantificational *John knows whether Mary smokes* follow. Since no alternatives can be be negated by Exh in (182b), the interpretation would simply say that exactly one student knows the answer, whatever it is.

(182) a. Exactly one student knows whether Mary smokes.
b. $[_{S'}$ exactly one student 2 $[_S$ Exh_{Alt} t_2 knows [Ans whether Mary smokes]]]
c. $[_{S''}$ Exh_{Alt} $[_{S'}$ exactly one student knows $[_S$ Ans [whether Mary smokes]]]]

(182c) with Exh applying globally is also an option. Given the literal interpretation in (183a), it is the accommodation reading that is selected by the accommodation economy principle (59), because the projection reading and the accommodation reading are logically independent. (183c) says that exactly one student believes the true answer.

(183) a. **Literal interpretation $[\![S']\!]^g$ of (182c)**
$= \lambda w.\exists!x.\exists w' : \underline{[\![\textbf{Ans}]\!]([\![\textbf{S}]\!]^g)(w')(w') = 1 \wedge w' = w}\ .\ B^w_x([\![\textbf{Ans}]\!]([\![\textbf{S}]\!]^g)(w'))$

[53] Chierchia (2013) discusses the possibility that syntactic minimality considerations in addition to Exh play a role in the unacceptability of (181).

b. **Existential projection in $[\![S']\!]^g$**
$= \lambda w : \underline{\exists w'[[\![\textbf{Ans}]\!]([\![S]\!]^g)(w')(w') = 1 \wedge w' = w]} \,.\, \exists!x.\exists w'.B^w_x([\![\textbf{Ans}]\!]([\![S]\!]^g)(w'))$
$= \lambda w.\underline{\exists!x.\exists w'.B^w_x([\![\textbf{Ans}]\!]([\![S]\!]^g)(w'))}$

c. **Local accommodation in $[\![S']\!]^g$**
$= \lambda w.\exists!x.\exists w'[[\![\textbf{Ans}]\!]([\![S]\!]^g)(w')(w') = 1 \wedge w' = w \wedge B^w_x([\![\textbf{Ans}]\!]([\![S]\!]^g)(w'))]$
$= \lambda w.\exists!x.B^w_x([\![\textbf{Ans}]\!]([\![S]\!]^g)(w))$

In the case of the alternatives, the projection and accommodation readings are, however, Strawson-equivalent, as shown in (184) for one of the alternatives. Thus the projection reading is chosen.

(184) a. **Non-monotonic alternative**
$\lambda w.\exists!x.\exists w' :$ $\underline{\text{Mary smokes in } w' \wedge w' = w}$. $B^w_x(\lambda w''.\text{Mary smokes in } w'')$

b. **Existential projection in the non-monotonic alternative**
$= \lambda w :$ $\underline{\exists w'[\text{M smokes in } w' \wedge w' = w]}$. $\exists!x.\exists w'.B^w_x(\lambda w''.\text{M smokes in } w'')$
$= \lambda w :$ $\underline{\text{M smokes in } w}$. $\exists!x.B^w_x(\lambda w''.\text{M smokes in } w'')$

c. **Local accommodation in the non-monotonic alternative**
$= \lambda w.\exists!x.\exists w'[\text{M smokes in } w' \wedge w' = w \wedge B^w_x(\lambda w''.\text{M smokes in } w'')]$
$= \lambda w.\text{M smokes in } w \wedge \exists!x.B^w_x(\lambda w''.\text{M smokes in } w'')$

(183c) Strawson-entails each of its alternatives. This is shown in (185) for (184b).

(185) a. Mary smokes in w_o.
b. If Mary smokes in w_o, exactly one student believes in w_o that she does, and if she does not smoke in w_o exactly one student believes in w_o that she does not smoke.
c. (185a) & (185b) $\Rightarrow$ exactly one student believes in w_o that Mary smokes.

Consequently, Exh does not negate any of the alternatives and no triviality results. In other words, both (182c) and (182b) are possible LFs for (182a) and they have moreover equivalent but adequate truth-conditions.[54]

At the end of section 5.1.1, I noted that Uegaki (2015b) offers a competing explanation for why *tell* and similar PTPs are about the true answer when occurring unembeddedly as in (186a). On his account the reason is that the i-veridical interpretation saying that John told us the true answer strictly Strawson-entails the competing non-veridical, existential intepretation saying that John told us some answer. Assuming Dalrymple et al.'s (1998) strongest meaning hypothesis, the stronger interpretation must be chosen. In downward monotonic environments such as in (186b), the Strawson-entailment relation reverses whereby the non-veridical interpretation is chosen.

(186) a. John told us whether Mary smokes.
$\rightsquigarrow$ *John told us the true answer to "Does Mary smoke?"*
b. John didn't tell us whether Mary smokes.
$\rightsquigarrow$ *John didn't tell us any answer to "Does Mary smoke?"*

[54] For a wh-interrogative embedded in a non-monotonic environment such as in (ia), however, only the LF in (ic) with Exh embedded under the subject delivers a non-trivial meaning. The reason is that given non-monotonicity and the weak exhaustive interpretation of the embedded clause by Ans the alternatives are not Strawson-entailed by the prejacent S′ in (ib) anymore. Exh therefore yields a trivial interpretation for (ib).

(i) a. Exactly one student knows who smokes.
b. $[_{S''}\ \text{Exh}_{Alt}\ [_{S'}$ exactly one student knows $[_S$ Ans [who smokes]]]]
c. $[_{S''}$ exactly one student $\lambda_2\ [_{S'}\ \text{Exh}_{Alt}\ t_2$ knows $[_S$ Ans [who smokes]]]]

This raises the question what would happen in non-monotonic environments such as (187). Here the two competing interpretations are logically independent. In particular, the i-veridical one says that exactly one student told us the true answer, whereas the non-veridical, existential one says that exactly one student told us some potential answer. It appears then that the strongest meaning hypothesis would not be able to choose between the two interpretations and (187) should be ambiguous. (187) is, however, felt to be about the true answer. That is, (187) requires that exactly one student told the true answer.

(187) Exactly one student told us whether Mary smokes.
$\rightsquigarrow$ *One student told us the true answer to "Does Mary smoke?"*

The present account, in comparison, does predict the i-veridical interpretation. Consider first the option where non-veridical $tell_1$ is chosen. There are again two relevant LFs. (188a) is not an option as its S-constituent is trivial.

(188) a. [exactly one student λ_2 [$_S$ Exh_{Alt} t_2 $told_1$ us [Ans whether Mary smokes]]]
b. [Exh_{Alt} [exactly one student $told_1$ us [Ans whether Mary smokes]]]

(188b) is also not an option. Its literal interpretation states that exactly one student told us some answer to the question whether Mary smokes. This Strawson-entails neither of its alternatives in (189a). So Exh negates both. But the result in (189b) is contradictory.

(189) a. {exactly one student $told_1$ us that Mary smokes, exactly one student $told_1$ us that Mary does not smoke}
b. $[\![\textbf{(188b)}]\!]^g(w) = 1$ iff exactly one student $told_1$ us in w some answer to whether Mary smokes but not exactly one $told_1$ us in w that Mary smokes and not exactly one $told_1$ us in w that Mary does not smoke

If factive $tell_2$ is chosen as in (190), however, no triviality is generated. The reason for this is the same as for the case in (182) with *know* above. The present account therefore predicts that factive $tell_2$ must be used even in non-monotonic environments such as (187).[55]

(190) a. [Exh_{Alt} [exactly one student $told_2$ us [Ans whether Mary smokes]]]
b. [exactly one student λ_2[Exh_{Alt} t_2 $told_2$ us [Ans whether Mary smokes]]]

5.4 Some other mechanisms for avoidance of triviality

5.4.1 Leaving out Exh

The degradedness of interrogative embedding under unnegated *be certain* is somewhat less severe than interrogative embedding under *believe*, as given in (191). Why would that be?

(191) a. ??John is certain whether Mary smokes.
b. *John believes whether Mary smokes.

Recall the structure of the present account of the facts in (191). (191b), on the one hand, is degraded because its literal interpretation is trivial. (191a), on the other hand, is degraded because its strengthened interpretation is trivial but not its literal one. This suggests that the perceived

[55] It is possible to derive even stronger truth-conditions for (187) than the literal meaning, namely ones requiring that no student told us the false answer. Assuming LF (190a) and an additional indefinite alternative of the form *One student told us that Mary smokes*, the modification of Exh in 6.1.2 delivers this result.

difference in degradedness is to be sought here. That is, I suggest that the exhaustivity operator can be left out, but only marginally so. The reason for this would be that unlike with real NPIs like *any*, there is no lexical expression in the structure that must undergo a feature relation with Exh (Chierchia 2013). In (192) such agreement is necessary. Thereby Exh cannot be left out accounting for its more severe degradedness.

(192) *John saw any girl.

The pressure to use Exh in (191a) then is due to entirely semantic reasons. While I must leave the reason for the preference for Exh over its absence ultimately open, I will suggest in section 6.1.2 that it is essentially the same as the one that requires intermediate and strong exhaustive interpretations of embedded interrogatives more generally.

5.4.2 Last resort universal quantification[56]

Recall now (193) repeated from (31). Compared to (191a), a *wh*-interrogative embedded under unnegated *be certain* as in (193a) is even less degraded. Note, however, that most speakers still detect a difference between the negated (193b) and the unnegated (193a).

(193) a. ?John is certain who smokes.
b. John isn't certain who smokes.

I suggest that (193a), unlike (191a), can as a last resort have an LF that avoids triviality such as in (194). Here the *wh*-expression is restricted by the variable 5 which is abstracted over. Notice that I decompose *who* into a *wh*-part and a restrictor necessitating an obvious modification for the entry of *who*. At the top of the clause sits a covert universal quantifier.

(194) [$_{S'}$ Univ λ_5 [John is certain [Ans [$_S$ [wh [person 5]] λ_2 [? t_2 smokes]]]]]

The universal quantifier has the entry in (195). It quantifies over singleton subsets of the set of individuals D_e.

(195) $[\![\textbf{Univ}]\!] = \lambda f_{\langle et,st\rangle}.\lambda w_s.\forall X[X \subseteq D_e \wedge |X| = 1 \rightarrow f(X)(w) = 1]$

If the variable 5 in (195) is of type $\langle e,t\rangle$, by abstraction we get a function of type $\langle et,st\rangle$ to which the covert universal quantifier can apply. This yields the literal truth-conditions in (196), where for simplicity sets and their characteristic functions are equated. Since X is a singleton set effectively restricting *who* to a single individual x, the *wh*-question reduces to a polar question about that x, which is then universally quantified over.

(196) $[\![\textbf{(194)}]\!]^g = \lambda w.\forall X[X \subseteq D_e \wedge |X| = 1 \rightarrow \exists w'[B^w_J([\![\textbf{Ans}]\!](\lambda w''.\lambda p.\exists x[x \text{ is a person in } w'' \wedge x \in X \wedge p = \lambda w'''.x \text{ smokes in } w''']))(w')]]$
$= \lambda w.\forall x[x \in D_e \rightarrow \exists w'[B^w_J([\![\textbf{Ans}]\!](\lambda w''.\lambda p.p = \lambda w'''.x \text{ smokes in } w''')(w')]]$

So (196) says that for every individual x John believes some answer to *Does x smoke?*. That is, for each individual John believes that they smoke or believes that they do not smoke, a strong exhaustive interpretation of sorts. Now notice that the alternatives to (196) will be of two forms: *For every individual x John believes that x smokes* or *For every individual x John believes that x does not smoke*. We know that universal alternatives can be negated by Exh

[56] I thank the reviewers for pressing me to think more about the issue discussed in this section which led me to abandon a previous suggestion.

without contradiction. This gives rise to a strengthened interpretation for (193a) saying that for each individual John believes that they smoke or believes that they do not smoke and that there is at least one that he believes to smoke and at least one that he believes to not smoke. This interpretation is arguably adequate.

As said above, such covert universal quantification is a last resort mechanism to avoid triviality for (193a). Notice moreover that it will not be of much help with a polar interrogative embedded under *be certain* as in (191a). This accounts for the stronger degradedness of the latter when compared to the former.

5.4.3 Non-veridical predicates with prepositions

I noted in (13), repeated as (197), that embedding of interrogative clauses under unnegated non-veridical PTPs sometimes improves with the use of a preposition. Crucially, this preposition cannot be used in the declarative embedding case, (197a), suggesting that the reason for the acceptability of (197b) is the preposition.

(197) a. John is *certain* / *conjectures* (*about) that Mary smokes. $\not\rightsquigarrow$ *Mary smokes*
b. John is *certain* / *conjectures* *(about) whether Mary smokes.

Note that *about* can also occur with PTPs that allow for interrogative embedding straightforwardly such as *know* in (198). Unlike the case without *about*, (198) does not require John to know of all individuals who smoke that they do and of all who do not that they do not. That is, (198) does not necessitate strong exhaustivity, but rather has a mention-some interpretation. So *about* has a semantic effect.

(198) John knows about who smokes.

There are a number of strategies one could adopt here. On the one hand, following suggestions by Egré (2008) one could simply assume that *about* turns the question into an existential quantifier over the propositions in the question denotation, parallel to the simple system discussed in section 3.1. This would have the consequence that the PTPs in (197b) and (198) cannot apply to the quantifier created by the preposition. In order to resolve the type mismatch, the quantifier would undergo QR. QR above Exh and the PTP, as well as QR below Exh but above the PTP would avoid triviality. The mention-some interpretation of (198) would be the consequence of the existential quantification contributed by *about* and QR. As discussed in section 3.2.1, even with QR of the embedded interrogative the excluded middle presupposition of *believe* would render (199) degraded, as desired.

(199) *John believes about who smokes.

On the other hand, it is possible that the ungrammaticality of (199) should not be due to neg-raising at all. The reason is that neg-raising *think* is compatible with embedded interrogatives when occurring under *about*, as a reviewer reminds me:

(200) John thinks about who smokes.

(200) might suggest another option to deal with *about*. Simplifying considerably and building on the two competing ideas by Boër (1978) and Rawlins (2013), we might analyze *about* as a type shifter turning a non-propositional argument into a propositional concept. In particular, it would take an (abstract) entity—which is independently necessary given the existence of

data like (201)—and return the propositional concept that when applied to any world gives back the content associated to that entity. In a sense then *about* would allow for interrogatives but also individuals to provide propositional concepts parallel to those provided by declarative complementizer *that*. And as we know, in that case the existential quantification contributed by the PTP is vacuous and triviality is avoided.[57]

(201) John *is certain* / *knows* / *thinks* about Mary.

6 Exhaustivity and triviality

This section deals with the exhaustive interpretation of embedded interrogatives, the notion of triviality and returns to the question of the existence of s-selection.

6.1 Intermediate and strong exhaustivity

Imagine a situation where Ann and Beth smoke, but Clara does not. Then according to the truth-conditions from section 4.2.3 for (202), John is only required to know that Ann and Beth smoke but he need not know whether Clara does. Such truth-conditions seem too weak, as they do not entail that John knows that Clara does not smoke and are thus not strongly exhaustive in the sense of Groenendijk and Stokhof 1982, 1984.

(202) John knows who smokes.

I will now suggest, following Klinedinst and Rothschild (2011) a.o., that strong exhaustivity is too strong in the general case. Moreover, I show following Klinedinst and Rothschild (2011) and Uegaki (2014) that Exh as currently employed can be used to derive the correct amount of exhaustivity associated with interrogative embedding including strong exhaustivity for (202).[58]

6.1.1 Arguments for intermediate exhaustivity

With strong exhaustivity (203) requires John to stand in the predict-relation to the strong exhaustive answer to the question in the world of evaluation. The strong exhaustive answer to a *wh*-interrogative is the proposition entailing for each individual making the question nucleus true that it does so and for each individual making it false that it does so. That is, in the context in (203) the strong exhaustive answer is the proposition *that Ann and Beth smoke and that Clara does not smoke*. Assuming that (203) requires John to stand in the predict-relation to this proposition would explain its degradedness in the context.

(203) **Context:** *Ann and Beth smoke but not Clara. John predicted all of them to smoke.*
#John predicted who smokes.

[57] A reviewer notes that on the first view (i) should have a wide scope reading paraphrasable as *'There is an answer to "Does Mary smoke?" that John is not certain about'*, which is compatible with him believing one of the answers. The intuitive absence of this reading might be seen as evidence for the second view. A defender of the former might, however, argue that (i) is ambiguous but unusable if only one of the possibilities is a live option, as is familiar from disjunctions.

(i) John isn't certain about whether Mary smokes.

[58] The system as developed here could work with strong exhaustivity too. Instead of Ans in (114), I could adopt Heim's (1994) Ans_2 in (99). Ans_2 would, however, not allow me to capture intermediate exhaustivity.

Now, Klinedinst and Rothschild (2011) point out that the strong exhaustive answer to the question does not seem to be involved in (204) (see also Heim 1994, Spector 2005, Cremers and Chemla 2014). Once more John does not stand in the predict-relation to the strong exhaustive answer in the context. Yet the sentence is acceptable. Why?

(204) **Context:** *Ann and Beth smoke. Clara does not. John predicted that Ann and Beth smoke but did not predict anything about Clara.*
John predicted who smokes.

One reaction to (204) could be that the truth-conditions of the example simply require John to stand in a relation to the weak exhaustive answer to the question (Sharvit 2002), entailing for each individual making the question nucleus true that it does so. For (204) this amounts to the proposition *that Ann and Beth smoke*. John does stand in the predict-relation to this proposition, accounting for the acceptability of the sentence in the context in (204). But this move would also make the sentence acceptable in the context in (203), contrary to fact.

Klinedinst and Rothschild (2011) therefore argue that the truth-conditions require John to stand in the predict-relation to the actual weak exhaustive answer and in addition require that he do not stand in the predict-relation to any possible weak exhaustive answer not entailed by the former. In the case at hand, this amounts to John having predicted that Ann and Beth smoke and not having predicted Clara does. This is true in (204) but not in (203).

Crucially, the intermediate exhaustive interpretation amounts to a strengthening of the weak exhaustive interpretation by negating non-weaker alternatives. The present system already assume such strengthening anyway. So it is reasonable to think that Exh not only is responsible for the licensing of embedded interrogatives, but also for the degree of exhaustivity (Klinedinst and Rothschild 2011, Uegaki 2014).[59]

6.1.2 Deriving intermediate exhaustivity

I now implement Klinedinst and Rothschild's (2011) suggestions for deriving intermediate exhaustivity in the present system. Exh when applied to a sentence with a factive PTP does not only take into account the alternatives we have assumed so far to be contributed by that PTP, i.e., only factive alternatives. Rather it also considers non-factive alternatives. To see why, consider (205) again.

(205) John knows who smokes.

Its intermediate exhaustive interpretation can be paraphrased as in (206).

(206) 'John *knows* in *w* the weak exhaustive answer to *Who smokes?* in *w* and John is not *certain* in *w* that any non-weaker proposition in the set of possible weak exhaustive answers to *Who smokes?* is true.'

[59] Notice that in case there are no individuals making the question nucleus true, as in the context in (i), a weak exhaustive answer does not exist. Given the definition of Ans in (114) the present account derives a strong exhaustive interpretation as the literal meaning of the sentence in the special case where no individuals make the question nucleus true. That is, I predict the sentence to be acceptable in the context.

(i) **Context:** *Neither Ann, Beth nor Clara smoke. John predicted that none of them smoke.*
John predicted who smokes.

Note that in (206) *know* is used in the first conjunct but *be certain* is used in the second conjunct. The first conjunct corresponds to the literal meaning of (205), and the second one is contributed by Exh. Crucially, using *know* in the second conjunct as well would not make sense: any possible weak exhaustive answer that is non-weaker than the actual one is false. Thus John can neither know nor not know them.

I therefore require that in addition to the familiar factive alternatives, *know* also has alternatives without the factive component as in (207). One can think of this as adding the alternatives contributed by *be certain* to those of *know*.[60] On the other hand, I do not require that *be certain* has factive alternatives as well. Nothing crucial hinges on this simplification.

(207) $[\![\textbf{know}]\!]^{alt} = \{\lambda p_{\langle s,st\rangle}.\lambda x_e.\lambda w_s.\exists w' \in W : \underline{p(w^*)(w') = 1 \wedge w' = w}\,.$
$B^w_x(p(w^*)) \mid w^* \in W\} \cup$
$\{\lambda p_{\langle s,st\rangle}.\lambda x_e.\lambda w_s.\exists w' \in W.B^w_x(p(w^*)) \mid w^* \in W\}$

I suggest that this pattern is generally true for PTPs with factive uses. For doxastic PTPs like *find out* and *recall* I assume that they also have the *be certain* alternatives available. The factive uses of the ambiguous PTPs from section 5.1.1 also have enlarged sets of alternatives, namely in the sense that the alternatives of their non-factive uses contribute to them.[61]

Now, recall once more the LF of (205) in (208). The denotation of S′ is that if someone smokes John knows of all who do that they do, and if no one smokes he knows that no one does.

(208) $[_{S''}$ Exh $[_{S'}$ John knows [Ans $[_{S}$ who 2[? t_2 smokes]]]]]

The alternatives to S′ given (207) are as in (209).

(209) $[\![S']\!]^{g,alt} = \{$J knows that A smokes, J knows that B smokes, …,
J knows that no one smoke, J is certain that A smokes,
J is certain that B smokes, …, J is certain that no one smokes$\}$

The factive alternatives in (209) are all Strawson-entailed by the denotation of S′. Thus Exh does not negate them. The newly added non-factive ones, however, do not stand in an entailment relation to S′. For instance, the denotation of S′ does not entail that John is certain that Ann smokes, nor is the reverse the case. As a consequence Exh as currently defined would negate all of the non-factive alternatives giving rise to a trivial meaning.

I therefore suggest to update Exh from (46) to (210). The operator in (210) when applied to a prejacent p in w still negates those alternatives q of p that are Strawson-non-weaker than p. But it moreover requires that these q are not classically entailed by an alternative r that is Strawson-entailed by p and is moreover true in w.

(210) $[\![\textbf{Exh}]\!] = \lambda w.p(w) = 1 \wedge \forall q \in Alt[[\neg\exists r \in Alt[p \Rightarrow_S r \wedge r(w) = 1 \wedge r \Rightarrow q]] \rightarrow$
$[p \not\Rightarrow_S q \rightarrow q(w) = 0]]$

[60] See Chemla 2008, Cremers 2017 for related views. Here the relevant alternatives to *know* would, however, be contributed by neg-raising *believe*. Cremers argues that this is desirable for independent reasons.

[61] In Klinedinst and Rothschild's (2011) proposal the alternatives for Exh were not contributed by the PTPs themselves but rather by the embedded interrogative. Therefore the factivity of *know* prohibited strengthening in the desired way. That is, they could not derive (206). *Predict*, on the other hand, was assumed to be non-factive when embedding interrogatives thereby creating no problem. On the present view, *predict* must be factive when embedding an interrogative. So Klinedinst and Rothschhild's problem with *know* generalizes. Since in the present paper the alternatives are, however, contributed by the PTP itself and not by the embedded clause, the problem vanishes as it becomes a matter of lexical stipulation.

The intuition behind (210) is as follows. Our original Exh from (46) does not negate alternatives which are Strawson-entailed by the prejacent. From this one is now allowed to infer that alternatives which are themselves not Strawson-entailed by the prejacent but are classically entailed by one of the true ones among the former Strawson-entailed alternatives are not negated either.

To see how this works, assume that in w Ann and Beth smoke and that Clara does not. Then the alternatives to S$'$ that can, in principle, be excluded by Exh in w are as in (211)—i.e., the propositions in the set *Alt* restricted along the lines of (210). These are the factive and non-factive alternatives from (209) entailing John's belief that Clara smokes. The reason is that they are not entailed by the true alternative *John knows that Ann and Beth smoke* from (209)—the alternative essentially expressed by the denotation of S$'$ in w. Crucially, the non-factive alternatives that are about either Ann or Beth without entailing anything about Clara are absent from (211). For instance, the alternative *John is certain that Ann smokes* is not in (211). The reason is that it is classically entailed by *John knows that Ann and Beth smoke*, that is, the factive alternative in (209) Strawson-entailed by the denotation of S$'$ that is true in w.

(211) {J knows that C smokes, J knows that A+C smokes, ..., J knows that no one smokes, J is certain that C smokes, J is certain that A+C smokes, ..., J is certain that no one smokes}

The meaning of S$''$ in w is thus as in (212). Exh does not negate any of the factive alternatives in *Alt* restricted to (211), but it does negate all non-factive ones. (212) only shows the negation of the crucial alternative. (212) says that John knows that Ann and Beth smoke and he is not certain that Clara smokes. This is the desired intermediate exhaustive interpretation.

(212) $[\![\mathbf{S}'']\!]^g(w) = 1$ iff $B^w_J([\![\mathbf{Ans}]\!]([\![\mathbf{S}]\!]^g)(w)) \wedge \neg B^w_J(\lambda w'.\text{Clara smokes in } w')$

The intermediate exhaustive interpretation for the sentences in (203) and (204) is derived in a completely parallel fashion by using the factive version of *predict*.[62]

6.1.3 A note on strong exhaustivity

It should be noted that on this picture intermediate exhaustivity follows from the same system responsible for the licensing of embedded interrogative clauses argued for in this paper. Arguably, this is a desirable outcome given that exhaustivity is a property that is uncontroversially associated with interrogative embedding.

Now, recall once more that (213) must have a strong exhaustive interpretation in case no one smokes. As noted above this follows from the literal meaning of (213). Now, it must be noted that (213) can also be taken to suggest that John believes for all those who do not smoke that they do not do so, even in cases where there are people who smoke. This does not follow from the intermediate exhaustive interpretation derived in (212).

[62] Klinedinst and Rothschild (2011) note that strengthening at the sentential level in a case like (i) predicts truth-conditions paraphrasable as *"At least one student predicted who came and no student made an incorrect prediction regarding who came"*. Since this reading is unavailable, they suggest that Exh is constrained to apply at the VP-level below the subject quantifier giving rise to truth-conditions like *"For at least one student x it is the case that x predicted who came and x did not make an incorrect prediction regarding who came"*.

(i) At least one student predicted who came.

On the present account, Exh cannot be restricted to the VP-level. For instance, in the case of interrogative embedding under negated *be certain* Exh must scope over negation. Thus I am forced to assume that (i) is ambiguous, which might be given that the wide scope reading is strictly stronger than the narrow scope one.

(213) John knows who smokes.

Uegaki (2014) shows how the strong exhaustive interpretation can be derived from (213) by appealing to general pragmatic considerations. He argues that the speaker of (213) is normally taken to be knowledgable about the truth-values of the alternatives to a sentence. Crucially, he will either believe that John is certain that Clara smokes or will believe that John is certain that Clara does not smoke. Now, the former would contradict the basic truth-conditions in (212). Thereby it follows that the speaker must believe that John is certain that Clara does not smoke. This inference is part of the strong exhaustive interpretation. So the strong exhaustive interpretation is the result of pragmatic strengthening of the intermediate exhaustive one. This is directly compatible with the present account.

6.2 Triviality and s-selection

One obvious issue that the present view faces is that sentences with trivial meanings are not always unacceptable. For instance, the literal interpretation of (214a) is arguably a contradiction and the one of (214b) a tautology. There is, however, a clear intuitive difference between these cases and those discussed in the present paper such as, for instance, (215). While the latter is degraded, the former are not. In fact, we may even imagine situations in which they are informative despite their trivial literal meanings.

(214) a. It is raining and it isn't.
b. Every woman is a woman.

(215) *John believes whether Mary smokes.

This issue is not unique to the present account and has been discussed before (see e.g. Gajewski 2002, Fox and Hackl 2006, Chierchia 2013, Abrusán 2014). I will therefore briefly indicate how existing options might be extended to the present system.

6.2.1 Triviality and the logical skeleton

As mentioned in section 3.1, Gajewski (2002) distinguishes between regular triviality, as expressed by sentences like (214), and l-triviality. Trivial sentences are in addition l-trivial if their triviality is dependent on their formal properties alone. Crucially, only l-triviality manifests itself in unacceptability. In fact, for l-trivial sentences speakers are assumed to not be in a position to intuit the triviality to begin with. This sets the merely trivial sentences in (214) apart from arguably l-trivial ones like (215).[63]

The idea is that for l-triviality not the complete LF of a sentence but only the logical skeleton thereof matters. The logical skeleton is a kind of impoverished LF where only the logical vocabulary of the original LF is visible. For the sentences in (214), the logical skeletons would look something like in (216), where I assume for simplicity that the copula and post-copular *a* are semantically vacuous (e.g. Heim and Kratzer 1998). As can be seen, the connective *and*, the negation and the universal quantifier are represented as such. The predicates *rain* and *woman* are, however, replaced by variables of the same type. The reason is that they are not seen as part of the logical vocabulary. The relevant intuition here is that the logical vocabulary consists of only those lexical expressions whose interpretation is invariant. The intended sense

[63] One might further assume that l-triviality is negotiated in an encapsulated linguistic component, termed the deductive system (see also Chierchia 1984, Fox 2000).

of invariance is that even if the domain of interpretation is altered, the interpretation of such lexical expressions remains unaffected. Negation, conjunction and quantifiers fall into this category, whereas predicates like *rain* and *woman* clearly do not do so.[64] Now crucially, the two instances of *rain* and the two of *woman*—the instances of the two non-logical expressions—are replaced by distinct variables. As a consequence, (216a) is not necessarily a contradiction, and (216b) is not necessarily a tautology; namely if P and Q are receive different assignments. That is, (216a) and (216b) are not necessarily trivial.

(216) a. [P] and [not Q]
b. [[every P] [Q]]

Sentences that are trivial on their original LFs but not necessarily so on the logical skeletons based on these LFs are not ruled as l-trivial and are thus acceptable. This is the desired result for (214).

On this view, it is thus necessary to derive (215) as an l-triviality rather than just a simple triviality. I will not argue for this here in detail, but will just indicate what would be necessary for this to go through. The answer and the question-operators are arguably part of the logical vocabulary. For (215) to come out as an l-triviality, however, the embedding PTP *believe* must also be. As discussed by Abrusán (2014) this is not obvious. PTPs, unlike other quantifiers, are not elements of a closed lexical class. It is, however, conceivable that PTPs are to be decomposed into a quantificational, logical component and a lexical component. If the presupposition is moreover attached to the former, we would get a logical skeleton along the lines of (217), where $\Box_{excl-mid}$ stands for the universal quantifier with the excluded middle presupposition attached. P is the variable standing for the lexical restriction of the quantifier that is not part of the logical vocabulary. It is clear that given the account in section 4.3.4, (217) necessarily comes out as a triviality. Thus it is an l-triviality and ruled as unacceptable by the deductive system.

(217) [X [[$\Box_{excl-mid}$ P] [Ans whether Y Qs]]]

Consider now briefly what would have to be assumed for (218) to come out as l-trivial. Such sentences come out as trivial only if strengthened. Thus the exhaustivity operator must be part of the logical vocabulary, as in Chierchia's (2013) approach, which is arguably the case given its status as a universal quantifier. Now crucially given the way the alternatives are derived in the present system, the meanings of X, Y, P, and Q will figure in them. Therefore (219) will come out as l-trivial deriving the unacceptability of (218).

(218) ??John is certain whether Mary smokes.

(219) [Exh_{Alt} [X [[$\Box$ P] [Ans whether Y Qs]]]]

A reviewer suggests an interesting alternative: maybe the relative acceptability of (218) when compared to (215) is not due the possibility of leaving out Exh in the former case so to avoid l-triviality, as suggested in section 5.4.1 above. Rather, Exh might be part of the LF but, for whatever reason, not part of the logical skeleton. Then (218) would come out as merely trivial in contrast to the l-triviality of (215). The reason why (218) would be worse than (214) could be due to the relative ease of reinterpreting the latter so as to avoid triviality, which might not be

[64] In the general case it is, however, often not so straightforward to draw the distinction between invariant and variant expressions at the line that seems empirically adequate. See Gajewski (2002) and Abrusán (2014) and immediately below for discussion.

straightforward for (218).[65]

There are many open issues here that I must leave for future research due to space limitations. For instance, the present formulation of Exh is not contradiction-free. That is, unlike the exhaustivity operator argued to be necessary for scalar implicature computation (Fox 2007), Exh negates alternatives even if the outcome is a contradiction (Chierchia 2013). The relevant intuition here would be that the operator used in the present work is less pragmatic in nature than the one relevant for scalar implicatures.

6.2.2 S-selection based on triviality?

In section 2.3 I argued that an account of interrogative embedding based on s-selection is problematic. In the remainder of the paper I suggested a novel account where apparent unacceptability of interrogative embedding is not due to s-selectional properties of PTPs but rather due to l-triviality assigned to a constituent of the sentence.

Given this, one might now ask whether s-selection is not a viable option after all. In particular, one might assume that PTPs are lexically marked for s-selectional properties and that the algorithm for l-triviality is the basis for this marking. *Believe*, on the one hand, would be marked as not s-selecting for interrogative clauses because the interpretative system would derive l-triviality whenever an interrogative would be embedded by it. *Be certain*, on the other hand, would then be marked as s-selecting for an interrogative clause only when itself occurring in a downward monotonic environment. While we would now explain why a downward monotonic environment is necessary for interrogative embedding in this case, it seems that s-selection would have to be seen as a kind of global filter on sentences. The reason is the fact that whether a PTP is in a downward monotonic environment is not visible at the point where it is combined with its complement. I must also leave detailed investigation of this possibility for the future.

7 Conclusion

The present paper argued for an account of interrogative clause embedding under PTPs constrained by semantic considerations. More specifically, I suggested based on the observation that interrogative embedding is sometimes context dependent that lexical specification accounts—e.g. s-selectional ones—must at the least be supplemented by a semantic algorithm determining whether embedding is possible or not. In particular, I argued that interrogative clauses can be embedded under a given PTP if and only if the interpretation of the whole sentence is not trivial, i.e., neither tautological nor contradictory. Crucially this considers both the literal and the strengthened interpretations of the sentence. I argued that for such a view to be conceivable an existential semantics for PTPs is necessary.

The proposed system makes some welcome predictions. Moreover, along the way a number of innovations were proposed. Both the predictions and the innovations would benefit from future investigation. First, I showed that a fully unified semantics for declarative and interrogative clause embedding under responsive PTPs is possible with an existential semantics when the argument of the PTP is taken to be a propositional concept. Among other things, the system

[65] In this light Abrusán 2014 should be mentioned (see also Del Pinal 2017). According to her triviality results in degradedness only if no reinterpretation is possible making l-triviality superfluous. This view would be compatible with the suggestion that the relative acceptability of (218) is due to leaving out Exh. It would be less straightforwardly compatible with the reviewer's suggestion as then the three-way acceptability contrast discussed would not be explained, unless reinterpretation is easier with (218) than with (215).

explains why interrogative embedding under an otherwise non-veridical PTP appears to make the PTP veridical.

Second, I suggested that polarity sensitive items need not be lexical expressions. In the present empirical domain it is the combination of PTP and interrogative clause that constitutes the polarity sensitive item, as it were. This might make polarity sensitivity a much more widely encountered phenomena than previously thought.

Third, I proposed a novel definition of alternatives excludable by Exh. Normally, Exh would negate all alternatives that are neither classically nor Strawson-entailed by the prejacent. I showed, however, that those among these alternatives that are classically entailed by an alternative that is itself Strawson-entailed by the prejacent—and thus not negated by Exh—are also not negated by Exh. While this is desirable for the domain of question embedding, it needs to be seen whether this extends to other empirical domains.

While the system discussed captures many facts, there are still numerous open issues that I must leave for future research. But I want to briefly point to a few such areas. First, there is the obvious issue that not only verbs and adjectives occurring in verbal constructions can take propositions as arguments. Crucially, the central pattern of polarity sensitivity discussed in this paper emerges here as well:

(220) a. John's certainty that Mary smokes
b. ??John's certainty whether Mary smokes
c. John's uncertainty whether Mary smokes

(221) a. John's belief that Mary smokes
b. *John's belief whether Mary smokes

A number of options come to mind how the present account could be extended to (221a). On the one hand, *belief* might simply have an excluded middle presupposition similar to *believe*. On the other hand, the discussion in section 6.2.2 opens the possibility that *belief* does not have such a presupposition but rather is lexically derived from *believe* and inherits its s-selectional specification based on the algorithm determining triviality. Given (221), we might then moreover entertain the thought that it is the embedding predicate itself that contributes Exh and that *certainty* inherits this property from *be certain*.

Second, recall from footnote 9 that emotive factive PTPs allow embedding of *wh-* but not polar interrogatives. While I mentioned that there are a number of accounts seeking to explain the contrast between (221b) and (221c) from factors largely independent from the particular issues discussed in this paper, it remains to be seen which of these accounts if any is compatible with the present proposal. In particular, it becomes important to see how, say, *be surprised* differs from *regret*, which the present system correctly predicts to not embed interrogatives at all.

(222) a. John *is amazed / happy / surprised / complains* that Mary smokes.
$\rightsquigarrow$ *Mary smokes*
b. *John *is amazed / happy / surprised / complains* whether Mary smokes.
c. John *is amazed / happy / surprised / complains* who smokes.

Third, there is the question of cross-linguistic stability. While I cast some doubt on the prediction of lexical specification accounts that embedding properties show completely random variation, careful empirical work is called for in this domain to substantiate this intuition.

References

Abrusán, Márta. 2014. *Weak Island Semantics*. Oxford University Press.

Abusch, Dorit. 2010. Presupposition triggering from alternatives. *Journal of Semantics* 27:37–80.

Adger, David, and Josep Quer. 2001. The syntax and semantics of unselected embedded questions. *Language* 77:107–133.

Asher, Nicholas. 1987. A typology for attitude verbs and their anaphoric properties. *Linguistics and Philosophy* 10:125–197.

Baker, C. Lee. 1968. Indirect questions in English. Doctoral dissertation, University of Illinois at Urbana-Champaign.

Bartsch, Renate. 1973. 'Negative Transportation' gibt es nicht. *Linguistische Berichte* 27:1–7.

Beaver, David I. 2001. *Presupposition and Assertion in Dynamic Semantics*. Stanford University: CSLI Publications.

Beck, Sigrid, and Hotze Rullmann. 1999. A flexible approach to exhaustivity in questions. *Natural Language Semantics* 7:249–298.

Beck, Sigrid, and Yael Sharvit. 2002. Pluralities of questions. *Journal of Semantics* 19:105–157.

Berman, Stephen. 1991. On the Semantics and Logical Form of Wh-Clauses. Doctoral dissertation, University of Massachusetts, Amherst.

Boër, Steven E. 1978. 'Who' and 'whether': Towards a theory of indirect question clauses. *Linguistics and Philosophy* 2:307–345.

Chemla, Emmanuel. 2008. An epistemic step for anti-presuppositions. *Journal of Semantics* 25:141–173.

Chemla, Emmanuel. 2009. Presuppositions of quantified sentences: experimental data. *Natural Language Semantics* 17:299–340.

Chierchia, Gennaro. 1984. Topics in the Syntax and Semantics of Infinitives and Gerunds. Doctoral dissertation, University of Massachusetts, Amherst.

Chierchia, Gennaro. 1992. Functional wh and weak crossover. In *The Proceedings of the Tenth West Coast Conference on Formal Linguistics*, ed. Dawn Bates, 75–90. Stanford, California: Center for the Study of Language and Information.

Chierchia, Gennaro. 2004. Scalar implicatures, polarity phenomena, and the syntax/pragmatics interface. In *Structures and Beyond: The Cartography of Syntactic Structures*, ed. Adriana Belletti, 39–103. Oxford: Oxford University Press.

Chierchia, Gennaro. 2006. Broaden your views: Implicatures of domain widening and the "logicality" of language. *Linguistic Inquiry* 37:535–590.

Chierchia, Gennaro. 2013. *Logic in Grammar: Polarity, Free Choice, and Intervention*. Oxford: Oxford University Press.

Chierchia, Gennaro, Danny Fox, and Benjamin Spector. 2012. The grammatical view of scalar implicatures and the relationship between semantics and pragmatics. In *Semantics: An International Handbook of Natural Language Meaning*, ed. Paul Portner, Claudia Maienborn, and Klaus von Heusinger, volume 3. Berlin: Mouton de Gruyter.

Chomsky, Noam. 1965. *Aspects of the theory of syntax*. Cambridge, Massachusetts: MIT Press.

Collins, Chris, and Paul M. Postal. 2014. *Classical NEG Raising: An essay on the syntax of negation*. Cambridge, MA: MIT Press.

Cremers, Alexandre. 2017. Plurality effects and exhaustive readings of embedded questions. Ms. ILLC.

Cremers, Alexandre, and Emmanuel Chemla. 2014. A psycholinguistic study of the exhaustive readings of embedded questions. *Journal of Semantics* 1–37.

Crnič, Luka. 2014. Non-monotonicity in NPI licensing. *Natural Language Semantics* 22:169–217.

Dalrymple, Mary, Makoto Kanazawa, Yookyung Kim, Sam Mchombo, and Stanley Peters. 1998. Reciprocal expressions and the concept of reciprocity. *Linguistics and Philosophy* 21:159–210.

Davidson, Kathryn, and Ivano Caponigro. 2016. Embedding polar interrogative clauses in american sign language. In *Complex Sentences and Beyond: Sign Languages and Deaf Communities*, ed. Annika Herrman, Markus Steinbach, and Roland Pfau. Mouton de Gruyter.

Del Pinal, Guillermo. 2017. The logicality of language: A new take on triviality, "ungrammaticality", and logical form. *Noûs* 1–34.

Eckardt, Regine. 2007. The syntax and pragmatics of embedded *yes/no* questions. In *On Information Structure, Meaning and Form*, ed. Kerstin Schwabe and Susanne Winkler, 447–466. Amsterdam: John Benjamins.

Egré, Paul. 2008. Question-embedding and factivity. *Grazer Philosophische Studien* 77:85–125.

Elliott, Patrick D., Nathan Klinedinst, Yasutada Sudo, and Wataru Uegaki. 2017. Predicates of relevance and theories of question embedding. *Journal of Semantics* 43:547–554.

Fauconnier, Gilles. 1979. Implication reversal in a natural language. In *Formal semantics and pragmatics for natural languages*, ed. Franz Guenther and Schmidt S. J., 289–301. Dordrecht: Reidel.

von Fintel, Kai. 1999. NPI licensing, Strawson entailment, and context dependency. *Journal of Semantics* 16:97–148.

Fox, Danny. 2000. *Economy and semantic interpretation*. Cambridge, Massachusetts: MIT Press.

Fox, Danny. 2007. Free choice and the theory of scalar implicatures. In *Presupposition and Implicature in Compositional Semantics*, ed. Uli Sauerland and Penka Stateva, 71–120. Basingstoke, New York: Palgrave.

Fox, Danny. 2013. Presupposition projection from quantificational sentences: trivalence, local accommodation, and presupposition strengthening. In *From Grammar to Meaning: The Spontaneous Logicality of Language*, ed. Ivano Caponigro and Carlo Cecchetto, 201–232. Cambridge: Cambridge University Press.

Fox, Danny, and Martin Hackl. 2006. The universal density of measurement. *Linguistics and Philosophy* 29:537–586.

Gajewski, Jon R. 2002. L-analyticity in natural language. Ms. MIT.

Gajewski, Jon R. 2007. Neg-raising and polarity. *Linguistics and Philosophy* 30:289–328.

Gazdar, Gerald. 1979. *Pragmatics: Implicature, Presupposition, and Logical Form*. New York: Academic Press.

van Gessel, Thom, Alexandre Cremers, and Floris Roelofsen. 2017. Acceptability of interrogatives under 'be certain'. Ms. ILLC.

Geurts, Bart. 1999. *Presuppositions and Pronouns*. Elsevier North-Holland, Inc.

Giannakidou, Anastasia. 1999. Affective dependencies. *Linguistics and Philosophy* 22:367–421.

Ginzburg, Jonathan. 1995a. Resolving questions, I. *Linguistics and Philosophy* 18:459–527.

Ginzburg, Jonathan. 1995b. Resolving questions, II. *Linguistics and Philosophy* 18:567–609.

Grimshaw, Jane. 1979. Complement selection and the lexicon. *Linguistic Inquiry* 10:279–326.

Groenendijk, J., and M. Stokhof. 1982. Semantic analysis of wh-complements. *Linguistics and Philosophy* 5:173–233.

Groenendijk, Jeroen, and Martin Stokhof. 1984. Studies on the Semantics of Questions and the Pragmatics of Answers. Doctoral dissertation, University of Amsterdam, Amsterdam.

Guerzoni, Elena. 2007. Weak exhaustivity and *Whether*: A pragmatic approach. In *Proceedings of SALT XVII*, ed. T. Friedman and M. Gibson, 112–129. Ithaca, NY: Cornell University.

Hamblin, Charles. 1973. Questions in Montague grammar. *Foundations of Language* 10:41–53.

Heim, Irene. 1983. On the projection problem for presuppositions. In *Proceedings of WCCFL 2*, ed. Daniel P. Flickinger, 114–125. Stanford University, Stanford, California: CSLI Publications.

Heim, Irene. 1984. A note on negative polarity and downward entailingness. In *Proceedings of the 14th North Eastern Linguistic Society meeting*, ed. Charles Jones and Peter Sells, 98–107. Amherst: GLSA.

Heim, Irene. 1992. Presupposition projection and the semantics of attitude verbs. *Journal of Semantics* 9:183–221.

Heim, Irene. 1994. Interrogative semantics and Karttunen's semantics for *know*. In *the Israeli Association of Theoretical Linguistics 1*, ed. Rhoanna Buchalle and Anita Mittwoch, 128–144.

Heim, Irene, and Angelika Kratzer. 1998. *Semantics in generative grammar*. Malden, MA: Blackwell.

Hintikka, Jaako. 1969. Semantics for propositional attitudes. In *Philosophical Logic*, ed. J. W. Davis, Hockney, and Wilson, 21–45. Reidel.

Hintikka, Jaako. 1975. Different constructions in terms of the basic epistemological verbs. In *The intentions of intensionality*, 1–25. Dordrecht: Kluwer.

Horn, Laurence R. 1978. Remarks on neg-raising. *Semantics and Pragmatics* 9:129–220.

Kadmon, Nirit, and Fred Landman. 1993. Any. *Linguistics and Philosophy* 16:353–422.

Karttunen, Lauri. 1971. Some observations on factivity. *Papers in Linguistics* 4:55–69.

Karttunen, Lauri. 1974. Presupposition and linguistic context. *Theoretical Linguistics* 1:181–194.

Karttunen, Lauri. 1977. Syntax and semantics of questions. *Linguistics and Philosophy* 1:3–44.

Katzir, Roni. 2007. Structurally-defined alternatives. *Linguistics and Philosophy* 30:669–690.

Kiparsky, Paul, and Carol Kiparsky. 1971. Fact. In *Semantics*, ed. D. Steinberg and L. Jacobovits, 345–369. Cambridge: Cambridge University Press.

Klein, Ewan. 1975. Two sorts of factive predicate. *Pragmatic Microfiche* I:B5–C14.

Klinedinst, Nathan, and Daniel Rothschild. 2011. Exhaustivity in questions with non-factives. *Semantics and Pragmatics* 4:1–23.

Kratzer, Angelika. 1979. Conditional necessity and possibility. In *Semantics from Different Points of View*, ed. Rainer Bäuerle, Urs Egli, and Arnim von Stechow. Springer.

Kratzer, Angelika. 1981. The notional category of modality. In *Words, Worlds, and Contexts*, ed. Hans-Jürgen Eikmeyer and Hannes Rieser, 38–74. Berlin, New York: De Gruyter.

Krifka, Manfred. 1995. The semantics and pragmatics of polarity items. *Linguistic Analysis* 25:209–257.

Krifka, Manfred, Francis Jeffrey Pelletier, Greg N. Carlson, Alice ter Meulen, Gennaro Chierchia, and Godehard Link. 1995. *The Generic Book*. Chicago: Chicago University Press.

Križ, Manuel. 2015. Aspects of Homogeneity in the Semantics of Natural Language. Doctoral dissertation, University of Vienna.

Ladusaw, William A. 1979. Polarity Sensitivity as Inherent Scope Relations. Doctoral dissertation, University of Massachusetts, Amherst, Amherst, MA.

Lahiri, Utpal. 2002. *Questions and Answers in Embedded Contexts*. Oxford: Oxford University Press.

Linebarger, Marcia. 1987. Negative polarity and grammatical representation. *Linguistics and Philosophy* 10:325–387.

Link, Godehard. 1983. The logical analysis of plurals and mass terms: A lattice-theoretical approach. In *Meaning, Use and Interpretation of Language*, ed. Rainer Bäuerle, Christoph Schwarze, and Arnim von Stechow. Berlin, New York: de Gruyter.

Löbner, Sebastian. 2003. Polarity in natural language: Predication, quantification and negation in particular and characterizing sentences. *Linguistics and Philosophy* 23:213–308.

Magri, Giorgio. 2009. A theory of individual-level predicates based on blind mandatory scalar implicatures. *Natural Language Semantics* 17:245–297.

Mayr, Clemens. 2013. Implicatures of modified numerals. In *From Grammar to Meaning: The Spontaneous Logicality of Language*, ed. Ivano Caponigro and Carlo Cecchetto, 139–171. Cambridge: Cambridge University Press.

Mayr, Clemens. 2017. Predicting *whether*-question embedding. In *Proceedings of Sinn und Bedeutung 21*.

Mayr, Clemens, and Uli Sauerland. 2016. Accommodation and the Strongest Meaning Hypothesis. In *Proceedings of the 20th Amsterdam Colloquium*, ed. Thomas Brochhagen, Floris Roelofsen, and Nadine Theiler, 276–285. Amsterdam: ILLC.

Nathan, Lance. 2005. On the interpretation of concealed questions. Doctoral dissertation, Massachusetts Institute of Technology, Cambridge, MA.

Nicolae, Andreea Cristina. 2013. Any Questions? Polarity as a Window into the Structure of Questions. Doctoral dissertation, Harvard University, Cambridge, Massachusetts.

Öhl, Peter. 2007. Unselected embedded interrogatives in German and English: S-selection as dependency formation. *Linguistische Berichte* 212:403–437.

Rawlins, Kyle. 2013. About 'about'. In *Proceedings of SALT 23*, ed. Todd Snider, 336–357. LSA.

Roelofsen, Floris, Michele Herbstritt, and Maria Aloni. to appear. The **whether* puzzle. In *Questions in discourse*, ed. Klaus von Heusinger, Edgar Onea, and Malte Zimmerman.

Romero, Maribel. 2015. *Surprise*-predicates, strong exhaustivity and alternative questions. In *Semantics and Linguistic Theory (SALT) 25*, ed. Sarah D'Antonio and Mia Wiegand, 225–245. Ithaca, NY: CLC Publications.

Romoli, Jacopo. 2013. A scalar implicature-based approach to neg-raising. *Linguistics and Philosophy* 36:291–353.

van Rooij, Robert, and Katrin Schulz. 2004. Exhaustive interpretation of complex sentences. *Journal of Logic, Language and Information* 13:491–519.

Rooth, Mats. 1985. Association with Focus. Doctoral dissertation, University of Massachusetts, Amherst, Amherst, Massachusetts.

Russell, Benjamin. 2006. Against grammatical computation of scalar implicatures. *Journal of Semantics* 23:361–382.

Sæbø, Kjell Johan. 2007. A whether forecast. In *TbiLLC 2005*, ed. B. T. ten Cate and Henk Zeevat, 189–199. Berlin, Heidelberg: Springer.

van der Sandt, Rob. 1992. Presupposition projection as anaphora resolution. *Journal of Semantics* 9:333–377.

Schlenker, Philippe. 2009. Local contexts. *Semantics and Pragmatics* 2:1–78.

Schwabe, Kerstin, and Robert Fittler. 2009. Semantic characterizations of German question-embedding predicates. In *Logic, language, and computation: 7th international Tbilisi symposium on logic, language, and computation, TbiLLC 2007*, ed. Peter Bosch, David Gabelaia, and Jérôme Lang, 229–241. Berlin: Springer.

Schwarz, Bernhard. 2016. Consistency preservation in quantity implicature: The case of *at least*. *Semantics and Pragmatics* 9:1–47.

Sharvit, Yael. 2002. Embedded questions and 'de dicto' readings. *Natural Language Semantics* 10:97–123.

Singh, Raj. 2008. Economy and intermediate accommodation. Ms. MIT.

Spector, Benjamin. 2005. Exhaustive interpretations: what to say and what not to say. Ms. Université Paris 7 & ENS.

Spector, Benjamin. 2007. Scalar implicatures: Exhaustivity and Gricean reasoning. In *Questions in Dynamic Semantics*, ed. Maria Aloni, Alastair Butler, and Paul Dekker, 225–249. Oxford, Amsterdam: Elsevier.

Spector, Benjamin, and Paul Egré. 2015. A uniform semantics for embedded interrogatives: *An* answer, not necessarily *the* answer. *Synthese* 192:1729–1784.

Theiler, Nadine, Floris Roelofsen, and Maria Aloni. 2016. A truthful resolution semantics for declarative and interrogative complements. Ms. ILLC.

Uegaki, Wataru. 2014. Predicting the variation in exhaustivity of embedded questions. Ms. MIT.

Uegaki, Wataru. 2015a. Content nouns and the semantics of question-embedding. *Journal of Semantics* 1–38.

Uegaki, Watarua. 2015b. Interpreting Questions under Attitudes. Doctoral dissertation, Massachusetts Institute of Technology, Cambridge, MA.

Villalta, Elisabeth. 2008. Mood and gradability: An investigation of the subjunctive mood in spanish. *Linguistics and Philosophy* 31:467–522.

White, Aaron S., Valentine Hacquard, and Jeffrey Lidz. 2017. Semantic information and the syntax of propositional attitude verbs. *Cognitive Science* 1–41.

White, Aaron S., and Kyle Rawlins. 2016. A computational model of s-selection. In *Proceedings of SALT 26*, ed. Mary Moroney, Carol Rose Little, Jacob Collard, and Dan Burgdorf, 641–653. LSA.

Zuber, R. 1982. Semantic restrictions on certain complementizers. In *Proceedings of the 13th International Congress of Linguists*, ed. S. Hattori and Kazuo Inoue. Tokyo.

Zuchewicz, Karolina. 2018. How factive is the perfective? On the interaction between perfectivity and factivity in Polish. In *Advances in formal Slavic linguistics 2016*, ed. Denisa Lenertová, Roland Meyer, Radek Šimík, and Luka Szucsich. Language Science Press.