Predicting the exhaustivity of embedded questions under factive predicates[*]

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1 Introduction

It has been observed in the semantic literature at least since Heim (1994) that predicates vary in the 'strength' of exhaustivity involved in the interpretation of their interrogative complements. Among question-embedding predicates, cognitive attitude predicates such as *know* and communication predicates such as *tell* license a so-called STRONGLY-EXHAUSTIVE (SE) reading (Groenendijk and Stokhof 1984) whereas EMOTIVE FACTIVES (EFs) like *be happy*, *be pleased*, *be surprised* and *be annoyed* select for a WEAKLY EXHAUSTIVE (WE) reading. This observation led authors to adopt 'flexible' approaches to question-embedding, i.e., to posit optionality as to whether the reading of an embedded interrogative is SE or WE (Heim 1994; Beck and Rullmann 1999; George 2011; Theiler 2014).

However, there have been relatively few proposals that attempt to *constrain* the theory of question-embedding so that the variation of exhaustivity in embedded questions can be *predicted* given lexical semantics of embedding predicates. Such attempts are made by Guerzoni (2007) and Nicolae (2013), but their accounts have their own problems as I discuss in the appendix. Also, both accounts do not take into account the possibility of so-called INTERMEDIATELY EXHAUSTIVE (IE) readings (Spector 2005, 2006; Cremers and Chemla to appear; the empirical characterization of IE readings will be given in the next section).

In this paper, focusing on the case of factive predicates, I will present a theory of exhaustivity of embedded questions that is properly constrained to capture the variation in possible exhaustive interpretations (including IE), based on the lexical semantics of embedding predicates. The crucial claims of the proposal will be the following. (The section numbers in the parentheses indicate where each point is discussed in the rest of the paper.)

(i) IE is derived by obligatory matrix exhaustification (Klinedinst and Rothschild 2011). (§3)

(ii) The effect of the exhaustification depends on the monotonicity property of the embedding predicate (§4). In particular,

- IE is derived if the embedding predicate is upward monotonic.
- Vacuous if the embedding predicate is non-monotonic.

[*] [Acknowledgement to be added]

(iii) Emotive predicates are non-monotonic. (§4)
(iv) There is no exhaustification in the embedded clause (pace Klinedinst and Rothschild) (§5).
(v) SE readings are derived from IE, via the mechanism of neg-raising. (§5)

The overall picture resulting from these claims is that there is only one semantic derivation for embedded questions, i.e., a derivation involving matrix exhaustification. The variation of exhaustivity falls out from this derivation once we take into account the lexical semantics of embedding predicates.

2 Exhaustivity of question-embedding sentences

Before going into the individual claims previewed above, I will introduce the relevant basic notions and empirical generalizations in this section. Specifically, I will characterize the three kinds of readings for question-embedding sentences, i.e., strongly, weakly and intermediately exhaustive readings, and lay out an empirical generalization about which question-embedding predicate is compatible with which kinds of exhaustivity.

2.1 Three kinds of exhaustivity

Let me first illustrate the three kinds of exhaustivity with examples. Suppose the sentence *John reported who came* was uttered in a situation where Ann and Bill came, but Chris didn't. Then, the weakly exhaustive (WE), intermediately exhaustive (IE) and strongly exhaustive (SE) readings of this sentence would correspond to the paraphrases given in the following (Note that I am using this example just to illustrate the range of theoretically possible readings, and not committed to any *empirical* claim about the readings of (1) at this point):

(1) John reported who came. [Situation: Ann and Bill came, but Chris didn't.]

WE 'John reported that Ann and Bill came.'

IE 'John reported that Ann and Bill came, but it is not the case that he reported that Chris came.'

SE 'John reported that Ann and Bill came but Chris didn't.

Roughly, under the WE reading, (1) is true iff John reported all the true 'answers' (i.e., members of the question denotation) of the interrogative complement to be true. Under the IE reading, (1) is true iff John reported all the true answers to be true while, for each of the false answers, he didn't report it to be true. Under the SE reading, (1) is true iff John reported all true answers to be true and false answers to be false. Here, the difference between the IE and SE readings is that of the scope of the negation. In IE, the negation in the paraphrase is above the embedding predicate 'report' while in SE, the negation is below 'report'. Also, it is important to note at this point that I will restrict the discussion throughout this paper to the so-called *de re* readings of embedded questions (cf. Groenendijk and Stokhof 1984), assuming a fixed domain of relevant individuals over which *wh*-phrases range over.

WE and SE readings have been reported in the literature since the early studies (Karttunen 1977 for WE, and Groenendijk and Stokhof 1984 for SE). On the other hand, IE as an independent reading is a relatively recent observation (e.g., Spector 2005; Klinedinst and Rothschild 2011). Cremers and Chemla (to appear) experimentally tested the existence of IE readings using the predicates *know* and *predict*, controlling confounding factors such as domain restrictions.

To formally characterize the readings I just exemplified, we first assume proposition-set denotations for interrogative complements (Hamblin 1973; Karttunen 1977). A proposition-set denotation of an interrogative complement is the set of propositions corresponding to the possible 'positive' answers.[1] For example, the denotation of *who came* is the set of propositions of the form 'x came' as in the following:

(2) $\{p \mid \exists x[p = \lambda w.\mathbf{came}(w)(x)]\}$

WE and SE readings can then be characterized in terms of the kind of *derived answers* involved in the interpretation of question-embedding sentences (I will discuss IE later, which cannot be characterized this way). That is, the WE reading of *John Vs Q* is the reading which is paraphrased as 'John Vs the *WE answer* of *Q*' while the SE reading of *John Vs Q* is the reading which is paraphrased as 'John Vs the *SE answer* of *Q*'. The WE and SE answers of a question can be defined in the following way:

(3) **Weakly-exhaustive (WE) answer of** Q **in** w: $\lambda w' \forall p \in Q[p(w) \rightarrow p(w')]$
(i.e., the conjunction of all propositions in Q that are true in w.)

(4) **Strongly-exhaustive (SE) answer of** Q **in** w: $\lambda w' \forall p \in Q[p(w) \leftrightarrow p(w')]$
(i.e., the conjunction of (i) the WE answer of Q in w and (ii) the proposition that all propositions in Q that are false in w are false.)

Let us see how these definitions apply to *who came* and *who didn't come*. Below, we assume that Ann and Bill came but Chris didn't in the evaluation world w. The WE/SE answers of *who came* and *who didn't come* in w will then be the following. (Hereafter, I will abbreviate the propositions 'Ann came', 'Bill came' and 'Chris came' with A, B and C, respectively.)

(5) WE/SE-answers of *who came* in w [w: Ann and Bill came, but Chris didn't.]
  a. $[\![\text{who came}]\!]^w = \{A, B, C\}$
  b. WE answer in w: $A \wedge B$
  c. SE answer in w: $A \wedge B \wedge \neg C$

(6) WE/SE-answers of *who didn't come* in w [w: Ann and Bill came, but Chris didn't.]
  a. $[\![\text{who didn't come}]\!]^w = \{\neg A, \neg B, \neg C\}$
  b. WE answer in w: $\neg C$
  c. SE answer in w: $A \wedge B \wedge \neg C$

Thus, under the WE reading, *John reported who came* means that John reported (5b). Under the SE reading, it means that John reported (5c). An important thing to note here is that although the WE answers of *who came* and *who didn't come* are distinct, the SE answers are equivalent. By definition, SE answers will be equivalent for any pair of interrogative clauses with opposite polarities of the form 'who is *P*' and 'who is not *P*' given a fixed domain and *de re* readings.

IE readings of question-embedding sentences involve the requirement that the subject does not have the relevant attitude toward false answers (which I will refer to as the 'No-false-attitude'

[1] This is slightly different from Karttunen's (1977) question-denotation, which only contains true answers.

condition. In the case of (1), the condition states that John didn't report that Chris came). The reading can be stated as a conjunction of a WE reading and the no-false-attitude condition in the following way.

(7) **Intermediately-exhaustive (IE) reading** of x Vs Q is true in w iff[2]
$[\![\text{V}]\!]^{w}(\lambda w' \forall p \in Q[p(w) \rightarrow p(w')])(x) \wedge \forall p \in Q[p(w) = 0 \rightarrow \neg [\![\text{V}]\!]^{w}(p)(x)]$ (to be revised)

In the case of (1) above, the first conjunct of (7) corresponds to 'John reported that Ann and Bill came' and the second conjunct corresponds to 'It is not the case that John reported that Chris came'.

2.2 Which predicate allows which readings

Having defined WE, SE and IE readings of question-embedding sentences, let us move on to empirical generalizations. As discussed in the introduction, question-embedding predicates vary in the kind of readings they are compatible with. Specifically, we will see that cognitive attitude predicates, such as *know*, as well as communication predicates, such as *report*, are compatible with SE and IE readings whereas EMOTIVE FACTIVES, such as *be surprised*, *be happy*, only allow WE readings.

Before going into the actual data, let me make a brief overview of the empirical claims and observations made in the previous literature. The fact that *know* licenses SE but not WE readings (contra Karttunen 1977) was observed by Groenendijk and Stokhof (1984). Heim (1994) and Beck and Rullmann (1999) considered broader set of embedding predicates and observed that emotive factives such as *surprise* do not license SE readings, but rather license WE readings. IE readings are relatively recent observations, discussed by Spector (2005) for *know* and by Klinedinst and Rothschild (2011) for *predict*. Cremers and Chemla (to appear) validated the existence of SE and IE readings for *know* and *predict*, controlling confounding factors such as domain restrictions. Finally, the possibility of SE readings under emotive factives (contra the traditional judgment) is discussed by Klinedinst and Rothschild (2011) and Theiler (2014).

2.2.1 Cognitive attitude predicates and communication predicates

Groenendijk and Stokhof (1984) provide evidence indicating that SE readings are at least available for *know*. One piece of such evidence comes from the validity of the following kind of inference, at least under one reading of (i):

(8) (i) John knows which students came.
⇒ (ii) John knows which students didn't come.

Note that this inference is valid only under the SE readings of (i). In fact, as we saw in the previous section, the SE reading of the interrogative complement of (i) (i.e., *which students came*) and that of (ii) (i.e., *which students didn't come*) are equivalent (given the *de re* readings). On the other hand, both WE and IE readings of (i) are compatible with John not knowing anything about

[2] The variables x and Q in this formula are to stand both for object language expressions and for their semantic values, to aid readability.

those who didn't come, which makes the inference invalid. The same judgment obtains for other cognitive predicates and communication predicates, such as *predict* and *report*.[3]

Furthermore, there is evidence that cognitive predicates and communication predicates are compatible with IE readings as well (Spector 2005, 2006; Klinedinst and Rothschild 2011; Cremers and Chemla to appear). This can be seen by the fact that (9) is intuitively true given the situation in (9a) but false given (9b).[4]

(9) John knows/reported which students came.

(**Judgment**: True under (9a); False under (9b))

a. **Situation A**: Ann and Bill came, but Chris didn't. John {believes/reported} that Ann and Bill came, but he is {unopinionated about/didn't report anything about} whether Chris came.

b. **Situation B**: Ann and Bill came, but Chris didn't. John believes/reported that Ann, Bill and Chris came.

The situation in (9a) validates example (9) under both IE and WE readings while (9b) validates (9) only under its WE reading. The fact that (9) sounds true only under (9a) suggests that (9) has an IE reading. On the other hand, the fact that (9) sounds false under (9b) suggests that the sentence lacks a WE reading. To wrap up, we have seen that cognitive predicates and communication predicates allow SE and IE, but not WE. This is in line with the result of Cremers and Chemla's (to appear) experiment using truth-value judgment tasks, which shows that *know* and *predict* clearly allow SE and IE readings while WE readings are not robust.

Digression: IE with factive predicates The reader may have noticed that the IE reading assumed for *know* in (9) slightly differs from the definition of the reading in the previous section. If we apply the definition of IE readings to *know*, we would get the reading paraphrased in (10a). Instead, the reading that I referred to as the IE reading is the one in (10b).

(10) a. 'John knows $A \wedge B$, but does not *know* C.'

b. 'John knows $A \wedge B$, but does not *believe* C.'

The exact reading we get from (10a) depends on the presupposition-projection property of the negation, but regardless of it, we can see that the reading in (10a) is not something we observe for (9). First, if the negation projects the presupposition of its scope, (10a) would face a presupposition failure. This is so because the factivity presupposition of *know* is not satisfied since C is a false proposition given the situation. If the negation is defined to return true as long as its scope is not true, then the second clause would be tautological, making (10a) as a whole equivalent to a WE reading. Neither reading is observed in (9). Rather, the attested IE reading for *know* involves 'believe' in the second clause of the paraphrase, as in (10b) (Spector 2005, 2006; Cremers and Chemla to appear).

Spector and Egré (2015) speculate that, generally, IE readings of factive predicates involve a negation of the *non-factive counterpart* of the relevant attitude expressed by the predicate. That is, the descriptive characterization of IE readings has to be revised as follows:

[3]In section 5.2.2, we will discuss the fact that some communication predicates, especially under their 'literal' reading, seem to resist SE readings, as discussed by Heim (1994); Beck and Rullmann (1999) and Theiler (2014).

[4]I am assuming here that true belief constitutes knowledge, excluding any Gettier-like case.

(11) **Intermediately-exhaustive (IE) reading** of x Vs Q is true in w iff
$[\![V]\!](\mathsf{A}_{\mathsf{WE}}(Q)(w))(x)(w) \wedge \forall p \in Q[p(w) = 0 \rightarrow \neg [\![V]\!]_{-\text{fac}}(p)(x)(w)]$

where $[\![V]\!]_{-\text{fac}}$ is equivalent to $[\![V]\!]$ except that it lacks the factivity presupposition of V, if any.

Here, the notation $[\![...]\!]_{-\text{fac}}$ is used for expository purposes, and the exact analysis of factivity that derives this effect in IE will be given later. Hereafter, I will use (11) as the descriptive characterization of IE readings.

2.2.2 Emotive factives

The traditional judgment: emotives only allow WE readings Heim (1994); Beck and Rullmann (1999); George (2011) among many others observe that emotive factives like *surprise* only allow WE readings. This can be seen from the following example:

(12) [**Situation**: Among Ann, Bill and Chris, John expected that everyone would come. In fact, Ann and Bill came but Chris didn't.]

a. It surprised John which students came. (**Judgment**: False)

b. It surprised John which students didn't come. (**Judgment**: True)

If *surprise* allowed an SE reading, (12a) would be true, contrary to the fact, since the SE answer of *which students came* is in fact surprising to John given the situation. On the other hand, under the WE reading, both judgments in (12a) and (12b) are accounted for: the WE answer to *which students came*, i.e., 'Ann and Bill came', was *not* surprising to John while the WE answer to *which students didn't come*, i.e., 'Chris didn't come' was surprising to John.

Similar data can be replicated with *be happy*, as in the following example:

(13) [**Situation**: John is holding a party and invited all five students, i.e., Ann, Bill, Chris, Dana and Emma. John will be happy if at least one of Ann, Bill and Chris comes, but it doesn't matter to him whether the other two students come. At the party, only Ann and Bill showed up, which made John happy.]

a. John was happy about which students didn't come to the party. (False)

b. John was happy about which students came to the party. (True)

Similarly to the case of *surprise* above, (13a) under its SE reading would be true contrary to the fact since John was in fact happy about the SE answer of *which students didn't come to the party*, i.e., that only Ann and Bill came. On the other hand, the WE readings of (13a) and (13b) are both compatible with the judgments: 'John is happy that Chris, Dana and Emma didn't come' is false while 'John is happy that Ann and Bill came' is true.

Do IE readings account for the judgment pattern above? It turns out that the answer is negative. IE readings of (12b) and (13b) would be false in the given situations contrary to the judgment that the sentences are true. If these sentences had IE readings, the readings would be paraphrased as in (14-15): (Here I am using the subjunctive conditional 'John would be surprised/happy if p' to paraphrase the non-factive counterpart of *John is surprised/happy that p*.)

(14) **IE reading of (12b)**:

- John was surprised that $\neg C$,
- it is not the case that he would be surprised if $\neg A$ were the case, and
- it is not the case that he would be surprised if $\neg B$ were the case.

(15) **IE reading of (13b)**:

- John is happy that $A \wedge B$,
- it is not the case that he would be happy if C were the case,
- it is not the case that he would be happy if D were the case, and
- it is not the case that he would be happy if E were the case.

The statement in (14) is false in the situation in (12) since John would be surprised if $\neg A$ or $\neg B$ were the case (as he was expecting A and B to hold). Also, (15) is false in the situation in (13) since John would be happy if C were the case. Thus, we can conclude that the judgment patterns in (12) and (13) are accounted for only with the WE readings.

One might wonder if emotive factives in fact allow IE readings in addition to WE readings and if the IE readings are simply dispreferred in (12b) and (13b) since they lead to false readings. A general pragmatic principle like Principle of Charity (Quine 1960) can account for such a preference. However, the judgment on the negation of (12b) and (13b) suggests that IE readings are in fact unavailable. As illustrated below, the negation of (12b) and (13b) would be false under their WE readings and true under their IE readings.

(16) It didn't surprise John which students didn't come. (**Judgment**: False)
  a. **WE**: 'John was not surprised that $\neg C$'. (False in (12))
  b. **IE**: The negation of (14) (True in (12))

(17) John isn't happy about what was on the menu. (**Judgment**: False)
  a. **WE**: 'John is not happy that $A \wedge B$'. (False in (13))
  b. **IE**: The negation of (15) (True in (13))

If IE readings were available, the Principle of Charity would this time prefer the IE readings, and the sentences would be judged as true. This is not what we empirically observe. The negated sentences in (16) and (17) are intuitively false in the original situations in (12) and (13). Hence, I conclude that emotive factives do not allow IE readings.

SE judgment with emotives The empirical claim that *surprise* and other emotive factives only allow WE readings is debated in the recent literature. Klinedinst and Rothschild (2011: fn. 18) argue that *surprise* in fact allows an SE reading, citing the following example:

(18) Four students run a race: Bob, Ted, Alice and Sue. Emily expects Bob, Ted and Alice to run it in under six minutes. Only Bob runs it in under six minutes. Emily is surprised who ran the race in under six minutes (since she expected more people to).

The last sentence above would be false under its WE reading because the WE answer of the embedded question 'Bob runs the race in under six minutes' is unsurprising to Emily. Theiler

(2014) provides a more detailed discussion about when emotive predicates allow an SE reading. According to her, there are two readings of emotive predicates: LITERAL and DEDUCTIVE, and it is only when the emotive predicates are interpreted with a deductive reading that they allow an SE reading. Roughly, the difference between the literal reading and the deductive reading corresponds to the difference between an immediate emotive reaction against a perception and an emotive state that one reaches after an inference. For example, the literal reading of *be surprised by p* can be paraphrased as 'be immediately surprised by the direct perception of *p*' and the deductive reading as 'reaches the conclusion that *p* is surprising'.

Theiler suggests that adding sentential adverbs like *in effect* forces a deductive reading. In fact, adding *in effect* to the false examples above, i.e., (12a) and (13a), make them sound true in the same situations at least for some speakers:

(19) In effect, it surprised John which students came.

(20) In effect, John was happy about which students didn't come.

Also, it can be argued that the *since*-clause in Klinedinst and Rothschild's example (18) forces the deductive reading since it suggests that an inference is involved in Emily's surprise. On the other hand, there is no definite way to force a literal reading, but Theiler suggests that an example that ensures that the relevant emotion is a result of a direct perception tends to be interpreted as 'literal'. For example, the following rendition of the last sentence of Klinedinst and Rothschild example in (18) sounds less natural as a consistent continuation of the earlier context.

(21) Watching all the runners finish, Emily was immediately surprised who ran the race in under six minutes.

I will assume that Theiler's (2014) description of the SE judgment of emotive factives is correct: emotive factives are ambiguous between the literal reading and the deductive reading, and the SE judgment obtains only with deductive readings. In the following, when I simply use the term 'emotive factives', it refers to emotive factives with the literal readings, i.e., the ones that conform to the 'traditional' judgment discussed above. I will discuss how the SE judgment in the deductive reading comes about in section 5.2.4.

2.2.3 Summary of the empirical generalization

The following table summarizes the empirical generalization about which class of predicates allows which readings:

	WE	**IE**	**SE**
Cognitive/communication	*	✓	✓
Emotive factives ('literal')	✓	*	*

Table 1: Summary of attested readings

We have seen evidence that cognitive attitude predicates, such as *know*, and communication predicates, such as *report*, are compatible with IE and SE, but incompatible with WE. On the other hand, emotive factives, such as *be surprised* and *be happy*, are only compatible with WE readings under their 'literal' readings. We have also seen empirical claims in the literature that emotive factives allow SE readings under their 'deductive' readings. In the following sections, I will propose a theory of question-embedding that can systematically capture this generalization.

3 Deriving WE and IE readings

In this section, I lay out my basic analysis of WE and IE readings, based on Klinedinst and Rothschild's (2011) analysis. SE readings will be discussed in section 5. Note that the discussion in this section only concerns how WE and IE *can* be derived, and says nothing about the SE reading and how the overall theory can be *constrained* to account for the empirical generalization laid out in the previous section. These tasks will be taken up in the subsequent sections.

3.1 WE as a baseline interpretation

My strategy for analyzing the three readings of embedded questions is to assume that WE readings are the basic interpretation of interrogative complements, and derive the stronger readings, i.e., IE and SE readings, by applying further operations to the baseline interpretation. Following Heim (1994); Dayal (1996); Beck and Rullmann (1999), I assume that WE readings of interrogative complements are derived by applying the answerhood operator Ans to the question denotation. Here, Ans returns the conjunction of all the true members of the input question denotation.[5]

(22) $[\![\text{Ans}]\!]^w = \lambda Q_{\langle st,t\rangle}\lambda w'.\forall p \in Q[p(w) \rightarrow p(w')]$ (Version 1/3)

(23) $[\![\text{Ans [which students will come]}]\!]^w = A \wedge B$

Under the standard assumption that responsive predicates have proposition-taking denotations, the WE answers derived as in (23) can be directly combined with the proposition-taking denotation of responsive predicates, such as *know* and *predict* in (24). Such derivations derive WE readings, as shown in (25).

(24) a. $[\![\text{know}]\!]^w = \lambda p_{\langle s,t\rangle} : [p(w)]\lambda x_e.\text{DOX}_x^w \subseteq p$

b. $[\![\text{predict}]\!]^w = \lambda p_{\langle s,t\rangle}\lambda x_e.\textbf{predict}(x, p, w)$

(25) $[\![\text{John predicted [Ans [which students would come]]}]\!]^w = 1$ iff $\textbf{predicted}(x, A \wedge B, w)$

3.2 IE via matrix exhaustification

We need ways to derive IE and SE readings in addition to WE readings. I will follow Klinedinst and Rothschild (2011) (K&R) in analyzing IE readings by positing an exhaustification operator, which I call X,[6] at the matrix level, as in the following example.

[5] The definition of Ans here leads to an implausible consequence that the WE reading of *which students will come* is the tautology if no one came in the actual world. This problem will be addressed in section 3.3 by adding an existential presupposition to Ans following Dayal (1996).

[6] Klinedinst and Rothschild themselves call the operator EXH, following the literature on grammatical theory of scalar implicature (e.g., Chierchia et al. 2012; Fox 2007). However, the operator I will posit in the analysis crucially differs from EXH in this literature in that the former negates *strictly stronger* alternatives while the latter negates

(26) [X [John predicts Ans [which students will come]]].

The effect of the operator X is similar to *only* and the exhaustivity operator O/EXH in the grammatical theory of scalar implicature (e.g., Chierchia et al. 2012; Fox 2007). When X is applied to a clause φ, the resulting interpretation is that of the conjunction of φ and the negation of *alternatives* to φ that are strictly stronger than φ. Klinedinst and Rothschild (2011) define the operator as in (27), employing the system of focus semantics (Rooth 1985), where constituents come with the ORDINARY-SEMANTIC VALUE $[\![\cdot]\!]^w$ as well as the ALTERNATIVE-SEMANTIC VALUE $[\![\cdot]\!]^{\text{Alt}}$:

(27) $[\![\text{X}\ \varphi]\!]^w \Leftrightarrow [\![\varphi]\!]^w \wedge \forall p \in [\![\varphi]\!]^{\text{Alt}}[p \subset [\![\varphi]\!] \rightarrow \neg p(w)]$

In this section, I illustrate how the IE reading is derived from the LF in (26), given a particular assumption about the alternatives of an interrogative complement. I further propose an implementation of X as a quantifier that binds into the world-argument of Ans, and argue that this analysis does away with a technical problem associated with the first analysis. A more general comparison between X and the exhaustivity operator employed in the literature on the grammaticalized theory of exhaustive inferences is given in 4.2.2.

3.2.1 X as an alternative-sensitive operator

In the formulation in (27), the clause that X adjoins to (i.e., the 'prejacent' of X), i.e., φ, has its ordinary-semantic value (in w), $[\![\varphi]\!]^w$, and its alternative-semantic value, $[\![\varphi]\!]^{\text{Alt}}$. Klinedinst and Rothschild (2011) assume that the ordinary-semantic value of a complement of responsive predicates is its WE reading. For example, assuming the (ordinary-semantic) denotation of *which students will come* as in (28) and that A, B, and $A \wedge B$ are its true members, the ordinary-semantic value of Ans +*which students will come* looks like (29):

(28) $[\![\text{which students will come}]\!]^w = \{A, B, C, A \wedge B, B \wedge C, C \wedge A, A \wedge B \wedge C\}$

(29) $[\![\text{Ans [which students will came]}]\!]^w = A \wedge B$

Klinedinst and Rothschild (2011) further stipulate that the alternative-semantic value of an interrogative complement is the set of its *possible* WE answers.[7] For instance, the alternative-semantic value of Ans +*which students will come* looks like the following:

(30) $[\![\text{Ans [which students will come]}]\!]^{\text{Alt}} = \{A, B, C, A \wedge B, B \wedge C, C \wedge A, A \wedge B \wedge C\}$

Effectively, the alternative-semantic value of Ans+complement ends up being equivalent to the alternative-semantic value of the complement itself. Before discussing how this value is

non-weaker alternatives. Also, it will be discussed in section 4.2 that the syntactic properties of the two operators differ.

[7] I call this a stipulation because this assumption does not follow from the general theory of alternatives or focus. For example, there is no focused item in an interrogative complement whose focus-semantic value compositionally derives the set of WE answers. Klinedinst and Rothschild (2011) state the following regarding this issue:

> [I]t is not clear to us how well this will integrate with the general theory of focus. In this respect we follow the scalar implicature literature (Sauerland 2004; Spector 2006), where focus-like structures (i.e., sets of alternatives) are used but not necessarily identified with standard focus values. (Klinedinst and Rothschild 2011: 11).

compositionally derived, let us see how we can derive IE readings given the ordinary semantic value and the alternative-semantic value of the complement in (29) and (30).

The alternative-semantic value (30) is further composed with the alternative-semantic values of the embedding predicate *predict* and *John*. Following the standard treatment from Hamblin (1973) and Kratzer and Shimoyama (2002), I assume that the alternative-semantic values of items that are not alternative-inducing are singleton sets of their ordinary-semantic values, as in the following:

(31) a. $[\![\text{predict}]\!]^{\text{Alt}} = \{\lambda p_{\langle s,t\rangle}\lambda x\lambda w.\mathbf{predict}(x,p,w)\}$
b. $[\![\text{John}]\!]^{\text{Alt}} = \{\mathbf{j}\}$

Alternative-semantic values are composed by either one of the rules in (33) whichever is defined (Hamblin 1973; Hagstrom 1998) (the first of which is commonly called the POINT-WISE FUNCTIONAL APPLICATION). Thus, the alternative-semantic value of the scope of X in (26) comes out as the set of propositions of the form 'John predicted *p*', where *p* is a member of (30):

(32) [[John predicts [Ans [which students will come]]]]$^{\text{Alt}}$

$$= \left\{ \lambda w.\mathbf{predict}(\mathbf{j},p,w) \;\middle|\; p \in \left\{ \begin{array}{c} A, B, C \\ A \wedge B, B \wedge C, C \wedge A \\ A \wedge B \wedge C \end{array} \right\} \right\}$$

(33) **Composition rules for alternative-semantic values**
Let γ be a node whose daughters are $\{\alpha,\beta\}$. Then, $[\![\gamma]\!]^{\text{Alt}} =$

$$\begin{cases} \{a(b) \mid a \in [\![\alpha]\!]^{\text{Alt}}, b \in [\![\beta]\!]^{\text{Alt}}\} & \text{if } \forall a \in [\![\alpha]\!]^{\text{Alt}} \forall b \in [\![\beta]\!]^{\text{Alt}}[b \in dom(a)] \\ \{a([\![\beta]\!]^{\text{Alt}}) \mid a \in [\![\alpha]\!]^{\text{Alt}}\} & \text{if } \forall a \in [\![\alpha]\!]^{\text{Alt}}[[\![\beta]\!]^{\text{Alt}} \in dom(a)] \end{cases}$$

Now that we know the ordinary and alternative-semantic values of the prejacent of X in (26), we can calculate its interpretation. Since X asserts its prejacent and negates all alternatives to the prejacent that are logically stronger, we derive the following truth conditions for (26) in the evaluation world *w* where only Ann and Bill came:

(34) $[\![(26)]\!]^{w} = 1$ iff $\mathbf{predict}(\mathbf{j}, A \wedge B, w) \wedge \neg\mathbf{predict}(\mathbf{j}, A \wedge B \wedge C, w)$

The first conjunct of the above truth-conditions simply says that John predicted the actual WE answer in *w* and the second conjunct says that it is not the case that John predicted $A \wedge B \wedge C$, which is the only alternative that is logically stronger than the ordinary-semantic value of the prejacent, i.e., 'John predicted $A \wedge B$'. The truth-conditions in (34) are equivalent to the following, given the distributivity of **predict**.

(35) $[\![(26)]\!]^{w} = 1$ iff $\mathbf{predict}(\mathbf{j}, A \wedge B, w) \wedge \neg\mathbf{predict}(\mathbf{j}, C, w)$

This is exactly the IE reading of *John predicts which students will came.*

Klinedinst and Rothschild (2011) do not assume Ans in their structure of interrogative complements, and stipulate that the alternative-semantic value of an interrogative complement is the set of its possible answers. In an analysis with Ans, the same result is achieved by stipulating that the alternative-semantic value of Ans is the set of its *possible extensions*. Here is how the composition goes in the case of (30). First, the alternative-semantic value of Ans is defined as follows:[8]

[8]Intuitively, this is to say that the ordinary and alternative-semantic values of Ans are the same as those of *the answer in [this world]$_F$*, where *this world* is focused and refers to the local evaluation world.

(36) $[\![\text{Ans}]\!]^{\text{Alt}} = \{\lambda Q_{\langle st,t\rangle}.[\![\text{Ans}]\!]^{w'}(Q) \mid w' \in W\}$

Second, regarding the alternative-semantic value of an interrogative clause, I assume that it is equivalent to its ordinary-semantic value, following Kratzer and Shimoyama (2002). That is, we have the following:

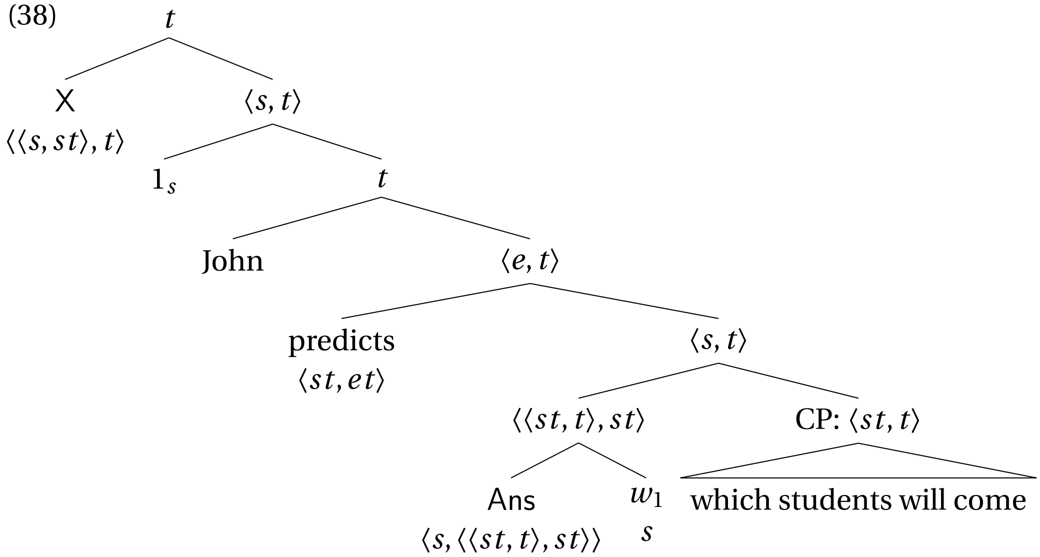
(37) $[\![\text{which students will come}]\!]^{\text{Alt}} = \{A, B, C, A \wedge B, B \wedge C, C \wedge A, A \wedge B \wedge C\}$

In the composition of the alternative-semantic values of Ans and *which students will come*, the second rule in (33) is used, yielding the resulting value in (30). The first rule cannot be used as each member of (37) is not in the domain of each member of (36).

3.2.2 X as a quantifier binding the world argument of Ans

In Klinedinst and Rothschild's (2011) analysis, the alternatives for X are specifically determined to be the set induced by different possible WE answers to the embedded question, which are generated by the different extensions of Ans in the formulation given in the previous section. In other words, X cannot be associated with arbitrary foci or alternative-inducing items *other than* Ans in its scope. Considering this feature of X, a possibility of another theoretical formulation suggests itself: X is simply a quantifier that binds into the world argument of Ans. If X is a quantifier that binds into the world argument position of Ans, we have the following kind of structure for (26), assuming that Ans takes a world as its internal argument, as in (39) below. One way to derive this LF is to assume that X is in fact generated in the argument position of Ans, and undergoes QR at LF.

(38)



(39) $[\![\text{Ans}]\!]^{w} = \lambda w' \lambda Q \lambda w''.\forall p \in Q[p(w') \to p(w'')]$ (Version 2/3)

Although Ans takes a world argument, I keep the semantics as a whole extensional, i.e., semantics maps expressions to their denotations under a given world parameter. In this sense, Ans is a special lexical item in that it has an additional argument position for worlds.

Given this structure, we can replicate the alternative-based analysis of X without invoking the notion of alternative-semantic values. What is important in this analysis is the fact that the *intension* of the scope of X in (38) corresponds to the propositional concept (a function from worlds to propositions) in (40), which can be used to 'reconstruct' the prejacent and the alternatives for X in the previous analysis.

(40) $\lambda w.[\![1\ [\text{John predicts }[[\text{Ans } w_1]\text{ which students will come}]]]\!]^w$
$= \lambda w \lambda w'.\mathbf{predict}(\mathbf{j}, [\![\text{Ans}]\!]^w(w')([\![\text{which students will come}]\!]^w), w)$

Here's how the prejacent and the alternatives are reconstructed using (40).

(41) a. **Prejacent:** $\lambda w.(40)(w)(w)$
b. **Alternatives:** $\{\lambda w.(40)(w)(w') \mid w' \in W\}$

What this means is that the meaning of X can be defined as a quantifier that asserts the prejacent in (41a) and negates the members of (41b) that are strictly stronger than (41a). Thus, formally, X can be defined as follows:

(42) $$[\![\text{X}]\!]^w = \lambda \mathscr{P}_{\langle s,st\rangle}.\mathscr{P}(w)(w) \wedge \forall w'' \left[\begin{array}{c} \{w' \mid \mathscr{P}(w')(w'')\} \subset \{w' \mid \mathscr{P}(w')(w)\} \\ \rightarrow \neg \mathscr{P}(w)(w'') \end{array} \right]$$

The top node of (38) is composed using the Intensional Functional Application (Heim and Kratzer 1998). That is, the denotation of (42) is applied to the intension of its sister, i.e., the propositional concept in (40). This yields the truth conditions of (38).

(43) $$[\![(38)]\!]^w = [\![\text{X}]\!]^w((40)) = 1 \text{ iff}$$
$$\mathbf{predict}(\mathbf{j}, [\![\text{Ans}]\!]^w(w)([\![\text{which students will come}]\!]^w), w) \wedge$$
$$\forall w'' \left[\begin{array}{c} \left[\begin{array}{c} \{w' \mid \mathbf{predict}(\mathbf{j}, [\![\text{Ans}]\!]^{w'}(w'')([\![\text{which students will come}]\!]^{w'}), w')\} \subset \\ \{w' \mid \mathbf{predict}(\mathbf{j}, [\![\text{Ans}]\!]^{w'}(w)([\![\text{which students will come}]\!]^{w'}), w')\} \end{array} \right] \\ \rightarrow \neg \mathbf{predict}(\mathbf{j}, [\![\text{Ans}]\!]^w(w'')([\![\text{which students will come}]\!]^w), w) \end{array} \right]$$

The truth conditions above roughly say that (i) John predicts the true-in-w answer to *which students will come* (i.e., the prejacent), and furthermore, (ii) for any proposition of the form 'John predicts the true-in-w'' answer' (i.e., the alternatives) that is stronger than 'John predicts the true-in-w answer', it is not the case that John predicts the true-in-w'' answer. Assuming that $[\![\text{Ans}]\!]^w(w)([\![\text{which students will come}]\!]^w) = A \wedge B$, (43) ends up being equivalent to the following:

(44) $\mathbf{predict}(\mathbf{j}, A \wedge B, w) \wedge \neg \mathbf{predict}(\mathbf{j}, A \wedge B \wedge C, w)$

Hence, the quantificational analysis of X correctly derives the IE reading. In section 4.2, I discuss more about the syntactic properties of X, where I will argue that X is obligatorily base-generated in the argument position of Ans and moves to the appropriate scope position.

Is there any reason to prefer the quantificational analysis over the alternative-based analysis? In section 4.2, I will argue that the quantification analysis is preferable on the basis of the fact that X does not associate with alternative-inducing expressions other than Ans. Here, I point out another, technical problem with the alternative-based account. Above, X as an alternative-sensitive operator is defined as follows:

(27) $[\![\text{X}\ \varphi]\!]^w \Leftrightarrow [\![\varphi]\!]^w \wedge \forall p \in [\![\varphi]\!]^{\text{Alt}}[p \subset [\![\varphi]\!] \rightarrow \neg p(w)]$

The problem is that, technically, $[\![\varphi]\!]$ (i.e., the intension of φ) and the members of the alternatives in $[\![\varphi]\!]^{\text{Alt}}$ are not in any logical relationship with each other even in our simplest example. Let's see this by taking (26) as an example.

(26) [X [John predicts Ans [which students will come]]].

In this case, the intension of the prejacent is (45a) and the alternatives are members of (45b).

(45) a. ⟦John predicts Ans [which students will come]⟧
$= \lambda w.\mathbf{predict}(\mathbf{j}, [\![\mathsf{Ans}]\!]^{w}(\{A, B, C, A \wedge B, B \wedge C, C \wedge A, A \wedge B \wedge C\}), w)$

b. ⟦John predicts [Ans [which students will come]]⟧$^{\mathrm{Alt}}$
$$= \left\{ \lambda w.\mathbf{predict}(\mathbf{j}, p, w) \,\middle|\, p \in \left\{ \begin{array}{c} A, B, C \\ A \wedge B, B \wedge C, C \wedge A \\ A \wedge B \wedge C \end{array} \right\} \right\}$$

The problem is that the proposition in (45a) is in fact locally *independent* from the propositions in (45b). The proposition in (45a) basically says that 'John predicts the correct answer' while the propositions in (45b) are of the form 'John predicts p' for any specific answer p of the question. The former is logically independent from each of the latter: 'John predicts the correct answer' entails 'John predicts p' if the correct answer entails p while it is not otherwise.

The problem is that, in the intension of the prejacnet, i.e., (45a), the evaluation world for Ans and the world parameter for *predict* are both bound by the same lambda-abstraction. Rather, what is intended as the prejacent in the analysis is the following:

(46) $\lambda w'.\mathbf{predict}(\mathbf{j}, [\![\mathsf{Ans}]\!]^{w}(\{A, B, C, A \wedge B, B \wedge C, C \wedge A, A \wedge B \wedge C\}), w')$

That is, we have to somehow 'fix' the world parameter of Ans, and only abstract over the world parameter for *predict*. This is precisely what is done in the quantificational analysis. However, it is not straightforward how this is done in the alternative-based analysis of X.

In the illustration in section 3.2.1, I implicitly assumed that (46) is the prejacent, but this technically does not follow from the analysis itself.[9] Hence, I conclude that the quantificational analysis of X is preferred over the alternative-based analysis for the above technical reason, and I will hereafter adopt the quantificational analysis of X in the following sections. However, I will also borrow the terms 'prejacent' and 'alternatives' from the alternative-based analysis to refer to the kind of proposition/proposition-set in (41a) and (41b).

3.3 A decompositional treatment of factivity

As we briefly discussed in section 2.2.1, IE readings of factive predicates involve a non-factive counterpart of the relevant attitude expressed by the embedding predicate. Klinedinst and Rothschild's (2011) analysis does not obviously capture this fact since the X-operator is defined to simply negate the alternative values of its prejacent, which already involves the presuppositions triggered by the embedding predicate. For example, the predicted truth conditions (in w) of the IE reading of *John knows which students came* will be the following:

(47) ⟦X [John knows which students came]⟧$^{w} = 1$
iff $[\![\mathrm{know}]\!]^{w}(A \wedge B)(\mathbf{j}) \wedge \neg [\![\mathrm{know}]\!]^{w}(A \wedge B \wedge C)(\mathbf{j})$

[9] Klinedinst and Rothschild (2011) avoid this problem by assuming that the relevant alternatives to be negated by X in the kind of structure in (26) are those alternatives whose *complement* is stronger than the complement of the prejacent (Klinedinst and Rothschild 2011: 13, (27)). However, this assumption does not generally hold because the embedding contexts are not necessarily upward monotonic.

The second conjunct above involves a factive predicate *know*. Thus, given that $A \wedge B \wedge C$ is false in w, the conjunct either ends up in a presupposition failure or a tautology, depending on the presupposition-projection property of the negation.

In this section, I present an analysis of factivity, according to which exhaustification above *know* is predicted to give rise to the attested IE reading discussed in section 2.2, without running into the same problem as Klinedinst and Rothschild described above. My analysis is based on two claims: one is that factive predicates are decomposed into a non-factive 'core' predicate and the answerhood operator adapted from Dayal (1996).[10] For example, *know* is decomposed as follows, where the answerhood operator is written as Ans.

(48) know $\rightsquigarrow$ 'believe' + Ans

The other claim is that declarative complements denote singleton sets of propositions (Uegaki to appear). As we will see in detail below, the presupposition associated with Dayal's (1996) answerhood operator—specifically, that the question it operates on contains a true answer—boils down to factivity if and only if the set of propositions it operates on is a singleton. Thus, factivity arises when a factive predicate combines with a declarative complement (which denotes a singleton set of propositions) while it doesn't when the predicate combines with an interrogative complement (which denotes a non-singleton set of propositions).

The system consisting of these two components will be discussed in detail shortly. Before that, let me informally illustrate how this system manages to work around the problem of X-exhaustification above factive predicates, using the example in (49) below.

(49) a. X [John knows which students came]
$\rightsquigarrow$ X [John believes [Ans w] [which students came]]

b. $[\![$X [John believes [Ans w] [which students came]]$]\!]^w$
- **presupposes** that some student came. (Presupposition of Ans)
- **asserts** $[\![\text{believe}]\!]^w(A \wedge B)(\mathbf{j}) \wedge \neg [\![\text{believe}]\!]^w(A \wedge B \wedge C)(\mathbf{j})$

Here, (49a) represents the decompsition of *know* into *believe* + Ans. The predicted interpretation of this LF is shown in (49b), which (i) presupposes that some member of the embedded question is true (as a result of the presupposition triggered by Ans), and (ii) asserts that John *believes* the true WE answer (i.e., $A \wedge B$) and does not *believe* the stronger potential WE answer (i.e., $A \wedge B \wedge C$). Since what is negated in (49b) does not involve a factive presupposition, we don't encounter the problem existing with Klinedinst and Rothschild's (2011) account.

3.3.1 The existential presupposition of Ans and factivity

A detailed derivation of the interpretation of question-embedding sentences under *know* is illustrated in the following. The crucial ingredient is the presuppositional analysis of the Ans-operator (cf. Dayal 1996), defined as in (50) below. This definition of Ans replaces our earlier definition in (39).

(50) $$[\![\text{Ans}]\!]^w := \lambda w' \lambda Q_{\langle st,t\rangle}. \begin{cases} \lambda w''. \forall p \in Q[p(w') \rightarrow p(w'')] & \text{if } \exists p \in Q[p(w')] \\ \text{undefined} & \text{otherwise} \end{cases}$$ (Version 3/3)

[10] Klinedinst and Rothschild (2011: 17) briefly mentions a possibility of accounting for IE of factives in terms of lexical decomposition. The account presented here can be thought of as a concrete formulation of the decompositional account alluded to by Klinedinst and Rothschild (2011).

Unlike the previous version of the Ans-operator in (39), (50) presupposes that the proposition-set it combines with contains a true member. This existential presupposition turns out to be crucial in capturing the behavior of factivity in question-embedding.[11]

Ans encodes the presupposition that the proposition-set it operates on contains a true member. This captures the existential presupposition of an interrogative clause, i.e., that *some* answer to the question expressed by the clause is true (e.g., Katz and Postal 1964; Karttunen and Peters 1979; Comorovski 1989; Dayal 1996). I will illustrate this using the example in (51a) below, which has the semantic interpretation in (51c) according to the denotation of Ans in (50).

(51) a. [[Ans w] [which students came]].

b. $[\![\text{which students came}]\!]^w = \left\{ \begin{array}{c} A, B, C \\ A \wedge B, B \wedge C, C \wedge A, \\ A \wedge B \wedge C \end{array} \right\}$ (Let this meaning be **Q**)

c. $[\![(51a)]\!]^w$
$= \begin{cases} \lambda w''.\forall p \in \mathbf{Q}[p(w) \to p(w'')] & \text{if } \exists p \in \mathbf{Q}[p(w)] \\ \text{undefined} & \text{otherwise} \end{cases}$
$= \begin{cases} \lambda w''.\forall p \in \{A,B,C\}[p(w) \to p(w'')] & \text{if } \exists p \in \{A,B,C\}[p(w)] \\ \text{undefined} & \text{otherwise} \end{cases}$

As one can see from (51c), (51a) presupposes that some of the question denotation of *which students came* is true in w, i.e., that some student came in w. As a result, we derive the following truth conditions for the prejacent of X in (49a).

(52) $[\![\text{John believes [[Ans } w\text{] [which students came]]}]\!]^w =$
$\begin{cases} 1 & \text{if } \mathsf{DOX}_{\mathbf{j}}^{w} \subseteq \{w'' \mid \forall p \in \{A,B,C\}[p(w) \to p(w'')]\} \wedge \exists p \in \{A,B,C\}[p(w)] \\ 0 & \text{if } \mathsf{DOX}_{\mathbf{j}}^{w} \not\subseteq \{w'' \mid \forall p \in \{A,B,C\}[p(w) \to p(w'')]\} \wedge \exists p \in \{A,B,C\}[p(w)] \\ \text{undefined} & \text{if } \neg\exists p \in \{A,B,C\}[p(w)] \end{cases}$

Here, the presupposition of the complement in (51c) is inherited as a presupposition of the whole sentence.[12] This way, we correctly derive the existential presupposition for interrogative complements reported in the literature. I will illustrate what happens when X is applied to this structure later. Before that, I illustrate how the decompositional analysis captures factivity as a limiting case of the existential presupposition.

It turns out that the lexical decomposition and the presupposition of Ans automatically capture factivity, given that declarative complements are singleton sets of propositions. Here is why. Factive responsive predicates are decomposed into the non-factive core and Ans. This

[11]Following Dayal (1996), we could also encode the *uniqueness presupposition* to Ans, and define it so that it returns the unique most informative true member of the input proposition-set. Such a formulation would have an advantage of correctly capturing the uniqueness presupposition in singular *which*-questions, but I adopt the weaker formulation involving only the existential presupposition in (50) since it would be sufficient for the current purpose, i.e., to analyze factivity in question-embedding sentences.

[12]This is so since the result of a Functional Application is undefined if either the function or the argument in the application is undefined. The relevant definition of Functional Application can be stated as follows (Heim and Kratzer 1998: 49):

(i) **Functional Application (FA)**

For all $w \in W$ and assignment functions $g \in D^{\mathbb{N}}$, if the node α has $\{\beta, \gamma\}$ as the set of its daughters and $[\![\beta]\!]^{w,g} \in D_\sigma$ and $[\![\gamma]\!]^{w,g} \in D_{\langle\sigma,\tau\rangle}$, $[\![\alpha]\!]^{w,g}$ is defined if both $[\![\beta]\!]^{w,g}$ and $[\![\gamma]\!]^{w,g}$ are. In this case, $[\![\alpha]\!]^{w,g} = [\![\gamma]\!]^{w,g}([\![\beta]\!]^{w,g})$

means that not only their interrogative complements but also their declarative complements are treated as an argument for Ans. For example, *know* with a declarative complement has the following decomposition:

(53) John knows that Ann came. $\rightsquigarrow$ John believes [Ans w [that Ann came]]

Following Uegaki (to appear), I treat declarative complements of responsive predicates to be denoting a singleton set of a proposition.[13] The declarative complement *that Ann came* in (53), for instance, denotes the singleton set of the proposition that Ann came, i.e., $\{A\}$. Give this, the semantic value of the argument of *believe* in (53) is derived as follows:

(54) $[\![[\text{Ans } w] \text{ [that Ann came]}]\!]^w$

$$= \begin{cases} \lambda w''.\forall p \in \{A\}[p(w) \rightarrow p(w'')] & \text{if } \exists p \in \{A\}[p(w)] \\ \text{undefined} & \text{otherwise} \end{cases}$$

$$= \begin{cases} \lambda w''.A(w'') & \text{if } A(w) \\ \text{undefined} & \text{otherwise} \end{cases}$$

In prose, this means that Ans +*that Ann came* presupposes that Ann came, and asserts that Ann came. Just as in the case of interrogative complements discussed above, Functional Application then inherits the presupposition. As a result, we derive the factivity and the assertive meaning of (53) as follows:

(55) $$[\![\text{John believes [[Ans } w] \text{ [that Ann came]]}]\!]^w = \begin{cases} 1 & \text{if DOX}_{\mathbf{j}}^w \subseteq A \wedge A(w) \\ 0 & \text{if DOX}_{\mathbf{j}}^w \not\subseteq A \wedge A(w) \\ \text{undefined} & \text{if } \neg A(w) \end{cases}$$

In other words, factivity is captured as the *limiting case* of the existential presupposition triggered by Ans. When Ans operates on a singleton set of a proposition, the existential presupposition boils down to the presupposition that the unique member of the set is true. My claim is that this is exactly what is happening in the case of declarative complements.

This picture provides us with a way to deal with the problem having to do with exhaustification above factive predicates. When X is applied above *know* embedding an interrogative clause, the result of the exhaustification by X looks like the following. (**Q** refers to the question denotation in (51b); the denotation of X is given in (42).)

(56) $[\![\text{X}_1 \text{ [John believes [[Ans } w_1] \text{ [which students came]]]]}]\!]^w \Leftrightarrow$

$$\text{DOX}_{\mathbf{j}}^w \subseteq [\![\text{Ans}]\!]^w(w)(\mathbf{Q}) \wedge$$
$$\forall w'' \left[\begin{array}{c} \{w' \mid \text{DOX}_{\mathbf{j}}^{w'} \subseteq [\![\text{Ans}]\!]^{w'}(w'')(\mathbf{Q})\} \subset \{w' \mid \text{DOX}_{\mathbf{j}}^{w'} \subseteq [\![\text{Ans}]\!]^{w'}(w)(\mathbf{Q})\} \\ \rightarrow \neg[\text{DOX}_{\mathbf{j}}^w \subseteq [\![\text{Ans}]\!]^w(w'')(\mathbf{Q})] \end{array} \right]$$

That is, (56) asserts that John believes the true WE answer, and for all possible WE answers that are stronger than the true WE answer, John does not believe them. In addition, the sentence inherits the presupposition triggered by X, i.e., that some of the propositions in **Q** is true. Here, what is negated does not involve factivity. Instead, what is negated involves the existential

[13] See Uegaki (to appear) for an independent argument for this view, based on the interpretations of nominal complements of responsive predicates. Moreover, this view is compatible with alternative semantics (Hamblin 1973; Kratzer and Shimoyama 2002; Alonso-Ovalle 2006) and inquisitive semantics (Ciardelli et al. 2013) (modulo downward-closure in the latter case).

presupposition triggered by Ans, but this is harmless, as it simply means that some of the answers of the embedded question is true.

Will there be a problem in the case of X above *know* + a declarative complement? It turns out that there isn't, either. In the declarative case, X would be vacuous since there would be no alternative which would be stronger than the prejacent. The predicted meaning of X above *know* + a declarative complement is exemplified below.

(57) $[\![\mathsf{X}_1$ [John believes [[Ans w_1] [that Ann came]]]$]\!]^w \Leftrightarrow$

$$\mathsf{DOX}^w_{\mathbf{j}} \subseteq [\![\mathsf{Ans}]\!]^w(w)(\{A\}) \wedge$$
$$\forall w'' \left[\begin{array}{c} \{ w' \mid \mathsf{DOX}^{w'}_{\mathbf{j}} \subseteq [\![\mathsf{Ans}]\!]^{w'}(w'')(\{A\}) \} \subset \{ w' \mid \mathsf{DOX}^{w'}_{\mathbf{j}} \subseteq [\![\mathsf{Ans}]\!]^{w'}(w)(\{A\}) \} \\ \to \neg[\mathsf{DOX}^w_{\mathbf{j}} \subseteq [\![\mathsf{Ans}]\!]^w(w'')(\{A\})] \end{array} \right]$$

The second conjunct above is vacuous since there is no proposition p in $\{A\}$ such that 'John believes p' is stronger than 'John believes A'. Since the whole sentence inherits the presupposition of Ans, there is a factivity presupposition that A is true. Hence, we have succeeded in deriving the IE reading of factive predicates from matrix exhaustification without encountering the problem that Klinedinst and Rothschild (2011) face.

3.3.2 Non-factive responsive predicates

Above, I presented an analysis of factivity as a limiting case of the existential presupposition contributed by the Ans-operator, which is a decompositional element of factive responsive predicates. The analysis in fact applies to *predict* and other communication predicates as well. That is, they are decomposed into the non-factive core and Ans. Following Spector and Egré (2015), I assume that communication predicates are ambiguous between the factive version and the non-factive version. The communication predicates that are said to exhibit the IE/SE readings in section 2.2 are the factive versions of these predicates.

A question that I have left open up to this point is what to do with *non-factive* responsive predicates, such as *be certain*, (the non-factive version of) *tell* and *agree*. We cannot extend the kind of decompositional analysis as presented in the previous section to all responsive predicates, for such an analysis would incorrectly predict all question-embedding predicates to be factive, including *be certain*, the *tell* and *agree*.

In this paper, I do not attempt to give a comprehensive lexical semantics for non-factive responsive predicates, as it would go beyond the scope of the paper. However, I will illustrate how non-factive predicates can be treated by implementing Spector and Egré's (2015) semantics for non-factive responsive predicates within the current analysis, taking the non-factive *tell* as an example. The general idea is that non-factive predicates, too, are decomposed into core predicates and Ans, but the core predicates are *intensional* (cf. Groenendijk and Stokhof 1984; Roelofsen et al. 2014) in the case of non-factive predicates. This means that the core predicates operate on *propositional concepts* mapping worlds to the Ans-proposition—the WE answer—evaluated in each world. This treatment allows the existential presupposition of Ans to be evaluated in a non-actual world, allowing the predicate to be non-factive.

The non-factive *tell* can be analyzed as follows, where the R_{tell} is the core predicate with the denotation in (58b).

(58) a. $\text{tell}_{[-\text{fac}]} \rightsquigarrow R_{tell[-\text{fac}]} + \mathsf{Ans}$

b. $[\![R_{tell[-\text{fac}]}]\!]^w = \lambda \mathscr{P}_{\langle s,st\rangle}\lambda x.\exists w'[\textbf{tell}(x, \mathscr{P}(w'), w)]$

The core predicate operates on a propositional concept of type $\langle s, st\rangle$, and is assumed to bind the world argument of Ans. That is, the LF and the interpretation of the sentence with a non-factive *tell*, as in (59), are analyzed as in (60).

(59) John tells$_{[-\text{fac}]}$ Mary which students came (but he turned out to be wrong).

(60) $[\![$John $R_{tell[-\text{fac}]}$ Mary [1 [[Ans w_1] which students came]]$]\!]^w$
$\Leftrightarrow \exists w'[\textbf{tell}(\textbf{j}, \textbf{m}, [\![\text{Ans}]\!]^w(w')([\![\text{which students came}]\!]^w), w)]$

The meaning in (60) entails that there is a possible answer to *which students came* such that John tells Mary. This existential semantics for *tell-wh* is something that is advocated by Spector and Egré (2015), for example. Note that the presupposition of Ans in (60) is not evaluated with respect to the actual world; rather, it is evaluated with respect *some* world, which may or may not be actual. Following the standard view that presuppositions triggered in the scope of an existentially quantified statement existentially projects (Beaver 2001), we derive a rather weak presupposition for (60) as a whole: it would presupposes that it is logically possible that some answer of *which students came* is true.

On the other hand, if the complement is declarative, as in (61), we would derive the meaning as in (62).

(61) John tells$_{[-\text{fac}]}$ Mary that Ann came (but he turned out to be wrong).

(62) $[\![$John $R_{tell[-\text{fac}]}$ Mary [1 [[Ans w_1] that Ann came]]$]\!]^w$
$\Leftrightarrow \exists w'[\textbf{tell}(\textbf{j}, \textbf{m}, [\![\text{Ans}]\!]^w(w')(\{A\}), w)]$

The assertive meaning of (62) states that John tells Mary that Ann came. Furthermore, it presupposes that it is possible that Ann came, due to the existential projection of the presupposition triggered by Ans. Although further empirical work is needed to evaluate these predictions regarding the presuppositions of (61) and (59), I submit that they are not in obvious contradiction with the intuitive judgments about these sentences.

To wrap up section 3.3, I discussed a decompositional analysis of responsive predicates, where factive predicates are decomposed into a non-factive 'core' and the presuppositional Ans-operator. In this analysis, factivity is analyzed as a limiting, singleton, case of the existential presupposition triggered by Ans. This analysis enables exhaustification above factive predicates embedding an interrogative complement, unlike in Klinedinst and Rothschild (2011). This is so since what would be negated by exhaustification above factives is now a non-factive core of the factive predicate, and Ans would simply project the existential presupposition that some answer of the embedded question is true. Finally, I also discussed how the analysis can be extended to non-factive predicates, adopting the extensional/intensional distinction from Groenendijk and Stokhof (1984).

4 Capturing the distributions of WE and IE

The previous section discussed how WE and IE readings *can* be derived, but the goal of the current paper is to explain why certain readings do not arise under certain classes of predicates, as discussed in section 2.2. In this section, I start embarking on this task. Specifically, I will present an account of why IE readings do not occur under (the literal reading of) emotive factives. I will discuss how an SE reading and its distribution can be derived in the next section.

4.1 X and the monotonicity property of embedding predicates

As a starting point of my discussion on the distribution of IE readings, I focus on a general property of X concerning its dependence on the *monotonicity* of its scope. That is, since X is defined to negate *logically stronger* alternatives, the outcome of an application of X depends on the monotonicity property of the embedding predicate. In particular, if the embedding predicate has the property satisfied by α in the following, the application of X is vacuous.

(63) For any p, p' such that $p \neq p'$, $[\![\alpha]\!](p) \not\models [\![\alpha]\!](p')$ and $[\![\alpha]\!](p') \not\models [\![\alpha]\!](p)$

This is so because the alternatives of the prejacent for X would be *logically independent* from the prejacent when the embedding predicate has this property.

This point can be illustrated with the following schematic example, using α as a variable over an arbitrary embedding context.

(64) [X [α [who came]]].

In the world w where Ann came, but Bill didn't, the truth conditions of (64) would be the following:

(65) $[\![(64)]\!]^w \Leftrightarrow [\![\alpha]\!]^w(A) \wedge \forall p \in \{[\![\alpha]\!](A), [\![\alpha]\!](B), [\![\alpha]\!](A \wedge B)\}[p \subset [\![\alpha]\!](A) \rightarrow \neg p(w)]$

What is crucial here is that, if the embedding predicate α has the property in (63), no proposition in the set of alternatives, $\{[\![\alpha]\!](A), [\![\alpha]\!](B), [\![\alpha]\!](A \wedge B)\}$, is logically stronger than the prejacent, $[\![\alpha]\!](A)$. Thus, the second conjunct of (65) will be tautological, meaning that the application of X is vacuous in such a case. Also, if α is a factive predicate, what matters is the non-factive counterpart of α given the decompositional picture suggested in the previous section. That is, if the non-factive counterpart of α has the property in (63), the application of X is vacuous.

I argue that this is exactly what happens with emotive factives with the literal reading (I will discuss the deductive reading of emotive factives in the next section).[14] Following the terminology of the literature (e.g., Lassiter 2011; Anand and Hacquard 2013), I will call the relevant property of these predicates NON-MONOTONICITY although what is intended here is not merely the negation of (upward or downward) monotonicity, but the stronger property in (63).[15]

At least under their literal reading, non-factive counterparts of emotive factives are non-monotonic in this stronger sense. For instance, the non-monotonicity of *be happy* can be seen by the invalidity of the inferences as in (66).

(66) a. Ann and Bill came, and John is happy that Ann and Bill came.
$\not\Rightarrow$ John is happy that Bill came.

[14]Footnote 47 of Spector and Egré (2015) briefly discusses the prediction of Klinedinst and Rothschild's (2011) analysis when applied to *surprise*, which they take to be non-monotonic. The current analysis generalizes this observation to emotive factives in general, including those with 'positive' meanings such as *be happy*, and connects it to the general analysis of the distribution of WE, IE and SE readings.

[15]Technically, a predicate α fails to be monotonic as soon as there is *some* pair of proposition p and p' such that $[\![\alpha]\!](p) \not\models [\![\alpha]\!](p')$ and $[\![\alpha]\!](p') \not\models [\![\alpha]\!](p)$. This property would not be sufficient to derive the prediction that the application of X is vacuous since it allows for some alternative to be stronger than the prejacent.

b. Ann and Bill came, and John is happy that Ann came.
$\not\Rightarrow$ John is happy that Ann and Bill came.

In the above examples of (non-)inferences, an extra premise is added which entails the complement of *be happy* in the conclusion. This is to make sure that the factivity presupposition of the conclusion is satisfied, and to test the monotonicity of the non-factive component of *be happy*. In other words, we are using STRAWSON-ENTAILMENT (von Fintel 1999) to test the relevant monotonicity property of emotive factives.

In (66a), we see that *be happy* is not (Strawson) upward-monotonic. The counterexample to the inference can be constructed with a case where John wanted Bill *not* to come, but wanted Ann to come, and the extent to which he wanted Ann to come is greater than the extent to which he wanted Bill not to come. In this situation, the antecedent of (66a) is true since he is happy that Ann came regardless of whether Bill came, but the consequent of (66a) is false since John wanted Bill *not* to come. In (66b), we see that *be happy* is not (Strawson) downward monotonic. The counterexample of the entailment can be constructed with a scenario where John wanted Ann to come, but wanted Bill not to come. This time, the extent to which he wanted Bill not to come is greater than the extent to which he wanted Ann to come. In this scenario, the antecedent of (66b) is true, but the consequent is false. I will discuss the monotonicity property of *be surprised* separately below.

Parallel facts hold for adversative emotive factives, such as *annoy*.[16]

(67) a. Ann and Bill came, and John is annoyed that Ann and Bill came.
$\not\Rightarrow$ John is annoyed that Ann came.

b. Ann and Bill came, and John is annoyed that Bill came.
$\not\Rightarrow$ John is annoyed that Ann and Bill came.

Here, the counterexample to the inference in (67a) can be constructed with a situation where John wanted Ann to come, but wanted Bill not to come, and the extent to which he is annoyed by Bill's coming exceeds the extent to which he is happy that Ann came. On the other hand, the counterexample to (67b) can be constructed with a scenario where, again, John wanted Ann to come, but wanted Bill not to come. This time, the extent to which John is happy that Ann came exceeds the extent to which he is annoyed that Bill came.

Non-monotonicity of emotive predicates has been defended by Asher (1987), Heim (1992), and more recently, Lassiter (2011) and Anand and Hacquard (2013) (see also von Fintel 1999 and Crnič 2011 for monotonic analyses that explains the apparent lack of monotonic inferences based on context shift). Here, I formulate a non-monotonic semantics for *be happy* based on the ordering-based semantics for desire predicates by Heim (1992) (see Villalta 2008 and Rubinstein 2012 for refined versions of the counterfactual semantics of desire predicates).

(68) $[\![\text{be happy}]\!]^{w,Sim}(p)(x)$ is

- defined only if $p(w) = 1$ and x believes that p, and
- True iff $\forall w' \in \mathrm{DOX}^x_w[Sim_{w'}(p) \leq^{\mathsf{pref}}_{x,w} Sim_{w'}(\neg p)]$[17]

[16]See fn. 20 for a discussion on the monotonicity of *surprise*.

[17]This semantics for *be happy* is crucially different from Heim's (1992) semantics of *want* in requiring the preference ordering between the two sets of worlds to be *non-strict* rather than *strict*. This is necessary to capture the fact that *John is happy that Ann and Bill came* is true even if it would have been equally desirable for him if only Chris

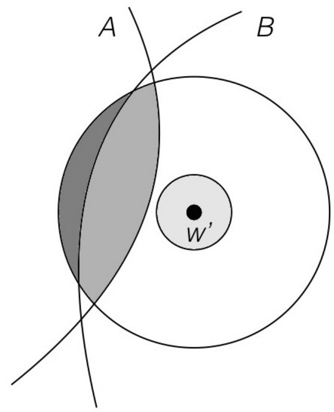


Figure 1: A counter-model for the inference in (66a). The spheres around w' represent the similarity of worlds to w'. The shaded areas represent, from the least darkest to the darkest, $Sim_{w'}(\neg[A \wedge B])/Sim_{w'}(B)$, $Sim_{w'}(A \wedge B)$ and $Sim_{w'}(\neg B)$

(69) $Sim_w(p) := \{ w' \in W \mid w' \in p$ and w' resembles w no less than any other world in $p \}$

(70) $p \leq^{\text{pref}}_{x,w} p'$ iff $\forall w' \in p' \exists w'' \in p : x$ considers w'' at least as desirable as w' in w

In this semantics, non-monotonicity is achieved by the counterfactual component in the meaning of *be happy*. For example, John is happy that p and q does not entail *John is happy that* p since the similarity relation among worlds can be such that the closest p-worlds are disjoint from the closest $p \wedge q$-worlds. In such a case, the fact that John prefers the closest $p \wedge q$-worlds over closest $\neg(p \wedge q)$-worlds does not imply anything about whether he prefers the closest p-worlds over closest $\neg p$-worlds.[18] More concretely, below is an example of a counter-model for the inference in (66a), which is also represented in Figure 1.

(71) a. **John's belief:** $\text{DOX}^w_{\mathbf{j}} = \{w'\}$

b. **Similarity relations**

- $Sim_{w'}(A \wedge B) \subseteq A \wedge B$
- $Sim_{w'}(\neg[A \wedge B]) \subseteq B \wedge \neg A$
- $Sim_{w'}(B) \subseteq B \wedge \neg A$
- $Sim_{w'}(\neg B) \subseteq A \wedge \neg B$

c. **Preference ordering:** $[A \wedge \neg B] <^{\text{pref}}_{\mathbf{j},w} [A \wedge B] <^{\text{pref}}_{\mathbf{j},w} [B \wedge \neg A]$

More generally, we can show that the semantics for *happy* in (68) satisfies the property in (63) since, for any pair of distinct propositions p and p', we can find a similarity relation and

came (and that these two propositions are similarly close to the actual world). This contrasts with *John wanted Ann and Bill to come*, which is empirically false in this situation.

[18] Thus, technically, the monotonicity property of emotive factives depends on the similarity relation among worlds, which I take to be a contextual parameter. This means, in order to predict that X-application above emotive factives is always vacuous, X has to be sensitive to the *logical* entailment relation between the prejacent and the alternatives rather than the *contextual* entailment relation. Following Magri (2009), I take the blindness to contextual entailment to be a general property of exhaustification.

a preference ordering such that $[\![\text{happy}]\!]^{w,Sim}(p)(x)$ and $[\![\text{happy}]\!]^{w,Sim}(p')(x)$ do not entail each other.[19]

A similar ordering-based semantics can be given for *be annoyed* based on the preference ordering, as follows:

(72) $[\![\text{be annoyed}]\!]^{w,Sim}(p)(x)$ is

- defined only if $p(w) = 1$ and x believes that p, and
- True iff $\forall w' \in \mathsf{DOX}^x_w[Sim_{w'}(\neg p) <^{\mathsf{pref}}_{x,w} Sim_{w'}(p)]$

That is, the semantics for *be annoyed* is based on the preference ordering just as *be happy* is, but the type of inequality relations between the relevant worlds is different from *be happy*: *x is annoyed that p* is true iff, for all x believes, the closest $\neg p$-worlds are more preferable to the closest p-worlds. It turns out that exactly the same model as (71), which serve as a counterexample to the upward-monotonic inference for *be happy* ((66a)), serves as a counterexample to the downward-monotonic inference for *be annoyed* ((67b)).

Given the non-monotonicity of emotive factives, we predict that the application of X above them is vacuous, and that they lack IE readings.[20] More generally, I claim that this picture

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[19]X and accordingly (63) is defined to compare the *logical* relationship that holds regardless of contextual parameters like Sim. Such a logical relationship does not hold between sentences containing the predicate in (68) with distinct complements since the entailment doesn't hold under some Sim and a preference ordering.

[20]Among adversative emotive predicates, *surprise* seems to be special in that it apparently exhibits a downward-monotonic behavior, even if we construct a scenario parallel to the one for *annoy* above (see Linebarger 1987, von Fintel 1999 and Theiler 2014 for discussion on the monotonicity of *surprise* in previous literature).

For example, it seems very difficult to construct a scenario in which the following inference does *not* hold:

(i) Ann and Bill came. John is surprised that Ann came. ⇒ John is surprised that Ann and Bill came.

The inference seems to hold even if John didn't expect Ann to come, and expected Bill to come. The fact that it is surprising for John that Ann came seems to guarantee that any fact including Ann's coming is surprising for him.

This is a potential problem for my account since *surprise* disallows IE readings, just like other emotive factives. I suggest a following solution to this problem: the semantic schema for *surprise is* non-monotonic just like other emotive factives, but the extra-grammatical constraints on its parameters (the similarity relation over worlds and the underlying 'expectedness' ordering) make it behave like a monotonic predicate, as I will discuss in detail shortly. In other words, *surprise* is *grammatically* non-monotonic, but behaves as a monotonic predicate due to extra-grammatical factors. Since X is blind to extra-grammatical factors, and only negates logically stronger alternatives (see fn. 19), an application of X above *surprise* is vacuous, as is the case with other emotive factives.

Here is why *surprise* behaves as a monotonic predicate even with a non-monotonic lexical semantic schema: *surprise* has the counterfactual semantics in (ii) with the expectedness ordering in (iii).

(ii) $[\![\text{be surprised}]\!]^{w,Sim}(p)(x)$ is

- defined only if $p(w) = 1$ and x believes that p, and
- True iff $\forall w' \in \mathsf{DOX}^x_w[Sim_{w'}(\neg p) >^{\mathsf{exp}}_{x,w} Sim_{w'}(p)]$

(iii) $p >^{\mathsf{exp}}_{x,w} p'$ iff $\forall w' \in p' \exists w'' \in p : x$ considers w'' more likely as w' in w

This makes *surprise* grammatically non-monotonic. However, the Sim-relation and the 'expectedness' ordering are related by extra-grammatical (logical or perhaps metaphysical) factors. When a world is closer than another world according to Sim, the former is more expected than the latter. This extra-grammatical constraint makes it impossible to construct scenarios where *surprise* would behave non-monotonically, for, such a scenario would require closer worlds (e.g, closest B-worlds in Figure 1) being less expected than further-away worlds (e.g., $A \wedge B$-worlds in Figure 1).

accounts for the contrast between cognitive/communication predicates and emotive factives in the availability of IE readings. Cognitive/communication predicates are upward monotonic as seen by the validity of the following inference:

(73) John {knows/predicted/told me} that Ann and Bill would come.
⇒ John {knows/predicted/told me} that Bill would come.

This is natural under the Hintikkan semantic analysis of these predicates involving *universal quantification* over relevant accessible worlds. Thus, being upward monotonic, these predicates are subject to a non-vacuous application of X. On the other hand, emotive factives always involve the counterfactual, ordering-based semantics as given in (68). Thus, they are non-monotonic and an application of X above them is predicted to be vacuous. Similar lexical semantic distinction between cognitive/communication predicates and emotive predicates have been shown to account for other selectional properties of attitude predicates, such as mood selection in Romance languages (Villalta 2008) and the acceptability of embedded epistemic modals (Anand and Hacquard 2013). According to the present proposal, the existence/absence of IE readings can be seen as another empirical domain where this distinction is significant.

To summarize, a matrix application of X is non-vacuous if the embedding predicate is upward monotonic while it is vacuous if it is non-monotonic. Since cognitive and communication predicates are upward monotonic, a matrix application of X derives an IE reading. On the other hand, since emotive factives (at least in the literal reading) are non-monotonic, a matrix application of X would be vacuous, hence we would predict a WE reading for such a derivation.

How does the analysis so far fare with the empirical generalization? The analysis has accounted for the distribution of IE, but it has not yet accounted for the distribution of WE. In particular, the analysis so far does not capture the lack of WE readings for cognitive/communication predicates. WE readings could be derived in a structure that simply lacks X. In the next section, I discuss the syntactic properties of X and address this problem as well as other issues related to the status of X.

4.2 Syntactic properties of X

4.2.1 Obligatoriness and the scope of X

Several syntactic properties of X have to be stipulated to derive the correct empirical generalization. Specifically, X has to be *obligatory* and cannot scope above the subject or adverbs scoping above the VP headed by the question-embedding responsive predicate. In this section, I discuss why these stipulations are necessary, and how they can be restated in a conception of X that encodes it in the lexical semantics of responsive predicates.

First, in order to capture why WE readings are unavailable with cognitive and communication predicates, one needs to syntactically stipulate that X is obligatory. Question-embedding sentences involving responsive predicates are always exhaustified, and hence WE readings are unavailable for cognitive/communication predicates. This stipulation is harmless for the analysis of emotive factives since the effect of X would be vacuous when it scopes above emotive factives, as discussed in the previous section.

Second, X cannot scope above the subject or other operators scoping above the VP headed by the responsive predicate. This has already been discussed by Klinedinst and Rothschild (2011) using the following example.

(74) At least one student predicted who came. (K&R: 16)

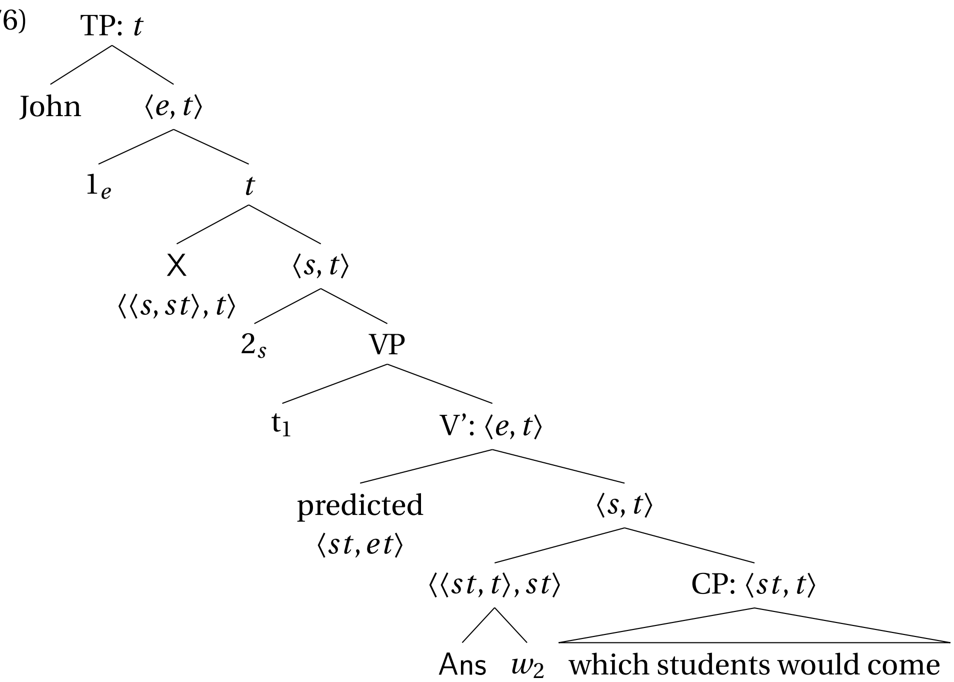
If X is globally applied to (74), it is predicted to be true only if no student made any actually false prediction about which student came. This reading seems to be unavailable. Also, the following example shows that X cannot scope above the adverb *frequently*.

(75) John frequently predicted which students would come.

If X took scope above *frequently* in the above example, it would be true if John frequently made true predictions about who would come and not frequently made false predictions about who would come. Again, this reading seems to be unavailable. The weakest reading (75) can get is the reading where *frequently* scopes over the IE reading, i.e., the reading where it was frequently the case that John made true predictions about who would come and didn't make false predictions about who would come.

These data suggest that the highest scope of X is the VP headed by the responsive predicate. That is, the LF of *John predicted which students would come* would look something like the following (see Klinedinst and Rothschild 2011: fn. 15 for a similar proposal):

(76)



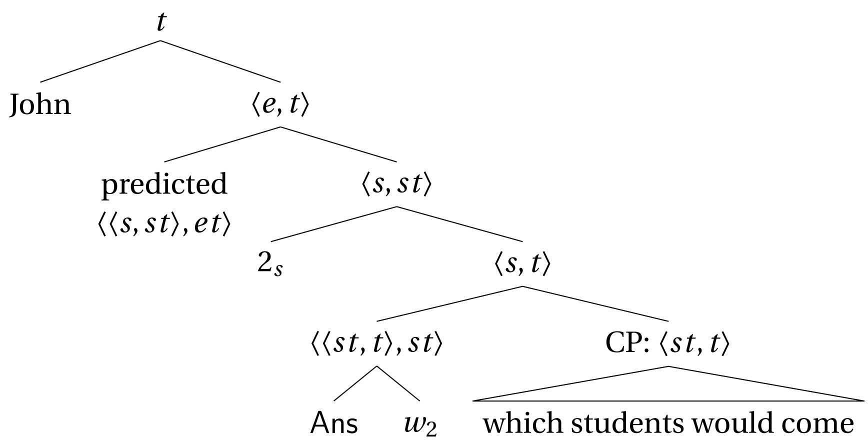
In the formulation of the analysis where X is a syntactic operator—as the one I have been developing in this paper—the above two syntactic properties of X have to be stipulated. Another way to formulate the analysis is to do away with the idea that X is a free-standing syntactic operator, and encode X in the lexical semantics of responsive predicates. In this formulation, for example, the denotation of *predict* will be defined as follows, where X is now a metalanguage abbreviation of the exhaustive operator in (78).

(77) $[\![\text{predict}]\!]^w = \lambda\mathscr{P}_{\langle s,st\rangle}\lambda x.\mathsf{X}(w)(\lambda w\lambda w'.\mathbf{predict}(x, \lambda w''.\mathscr{P}(w'')(w'), w)$

(78) $\mathsf{X}(w) := \lambda\mathscr{P}_{\langle s,st\rangle}.\mathscr{P}(w)(w) \wedge \forall w'' \begin{bmatrix} \{w' \mid \mathscr{P}(w')(w'')\} \subset \{w' \mid \mathscr{P}(w')(w)\} \\ \to \neg\mathscr{P}(w)(w'') \end{bmatrix}$

Here, *predict* itself is a quantifier that binds into the world argument position of Ans, as illustrated in the following LF in (79).

(79)



Thus, we could think that *predict* originates from the sister position of Ans and undergoes QR to the closest type $\langle s, t\rangle$ node.

In this formulation, too, one has to stipulate the obligatoriness of X. The stipulation is simply shifted from syntax to lexical semantics. That is, it is stipulated in the lexical semantics that (77) is the correct denotation of *predict* and not the one below.

(80) $[\![\text{predict}]\!]^{w} = \lambda p_{\langle s,t\rangle} \lambda x_e.\textbf{predict}(x, p, w)$

However, the second property of X discussed above—that its highest scope is the VP level—naturally falls out from the formulation itself. If X is something encoded in the lexical semantics of responsive predicates (and *only* in responsive predicates), the highest position where X can take scope is the position of the responsive predicate itself. Despite this slight conceptual advantage to the latter formulation, however, I will formulate the analysis using X as a syntactic operator for expository purposes in the rest of this paper.

4.2.2 Proliferation of exhaustivity operators?

A concern one might have with the current analysis related to the above point is that the current analysis proliferates the inventory of exhaustivity operators. The operator X used in the current analysis is crucially different from the exhaustivity operator EXH used in the literature of the grammatical theory of exhaustivity (Chierchia 2004, 2006; Chierchia et al. 2012; Fox 2007): the former negates strictly *stronger* alternatives while the latter negates *non-weaker* alternatives. Indeed, it would be more desirable if the exhaustivity of embedded questions can be derived in the general theory of exhaustivity, without invoking a different exhaustivity operator. However, the claim of the current analysis is that the operator X—whether it is a syntactic operator or is encoded in the lexical semantics—is necessary to capture the whole range of empirical facts concerning the exhaustivity of embedded questions.

There are at least two empirical facts about exhaustivity in embedded questions that does not seem to be captured by the standard EXH-operator. One is the restriction on the scope of exhaustification discussed above. The scope of EXH is generally not limited syntactically. Rather, it is restricted by global pragmatic constraints like the Strongest Meaning Hypothesis (SMH) (Dalrymple et al. 1998; Chierchia et al. 2012). In Appendix A.2, I will discuss a problem with an analysis of exhaustivity of embedded questions in terms of EXH and a constraint on its distribution based on the SMH, in relation to Nicolae's (2013) analysis.

The second fact that is problematic for the analysis in terms of EXH is that the alternatives needed for exhaustivity of embedded questions is special in the sense that they do not follow from the general assumptions about focus alternatives (Rooth 1985) or structural alternatives (Katzir 2007). The alternatives relevant for the exhaustivity of embedded questions are limited to those corresponding to possible WE answers of the question, and do not include other alternatives generated by other alternative-inducing expressions. For example, the sentence in (81) shows that focus is not relevant for the exhaustivity of embedded questions.

(81) [**Situation**: There are three students, Ann, Bill and Chris. Professor Jones only invited Ann and Bill and Professor Lee only invited Chris.]
John predicted [which students [Professor Jones]$_F$ would invite].
a. $\rightsquigarrow$ ¬[John predicted that **Professor Jones** would invite Ann, Bill and Chris].
b. ??$\rightsquigarrow$ ¬[John predicted that **Professor Lee** would invite Ann and Bill].

The fact that the sentence does not give rise to the inference in (81b) suggests that focus alternatives are not relevant for the exhaustivity of embedded questions, contrary to what would be expected if the general mechanism of alternative-generation is responsible for the exhaustivity of embedded questions. In the current proposal, on the other hand, it is expected that X does not associate with focus alternatives because X is a quantifier that binds the world argument of Ans.[21]

5 Analyzing SE readings

5.1 SE is derived from IE via the excluded-middle assumption

Having accounted for the distribution of WE and IE readings, I now move on to the account of SE readings. Since Groenendijk and Stokhof (1984), SE readings have been analyzed as arising from an independent semantic derivation of an interrogative complement. For example, Heim (1994) and Beck and Rullmann (1999) derive SE readings by applying a special Answerhood operator (their 'Answer2') to the embedded complement. Also, Klinedinst and Rothschild (2011) and Nicolae (2013) derive SE readings by placing EXH below the question-embedding predicate, as in (82) below:

(82) John predicted [EXH which students would come].

However, allowing SE readings as arising from an independent derivation of a complement along these lines would predict that SE readings are available regardless of embedding predicates.

[21] Indeed, (81) gives rise to the inference in (i) below, but this inference arises from quantity implicature that is independent from the exhaustivity of embedded questions.

(i) ¬[John predicted who **Professor Lee** would invite].

That is, under the current proposal, this inference is generated by the structure like the following (assuming a grammatical theory of quantity implicature):

(ii) EXH [X [2 [John predicted [[Ans w_2] [which students [Professor Jones]$_F$ would invite]]]]]

In (ii), X is associated with w_2, the world argument of Ans while EXH is associated with the focus *Professor Jones.*

In particular, it would run into the incorrect prediction that emotive factives allow SE readings.[22]

My analysis does not posit an independent semantic derivation for SE readings. Rather, as argued in the previous section, the only syntactic position for X is the position adjoining to the VP headed by the responsive predicate, as in the following.

(83) John [X [$_{\text{VP}}$ t predicted [Ans [which students came]]]].

How do we then derive SE readings? I argue that SE readings are derived from IE readings via an 'excluded-middle' assumption in a way similar to how neg-raising is derived in the semantic accounts by Bartsch (1973), Gajewski (2007) and Romoli (2013). Here, an exluded-middle assumption refers to the assumption that the subject's relevant attitude is determinate for each answer of the relevant question. That is, in the case of (83), the assumption states that John had determinate predictions about whether each person came. Below, I will offer a formalization of this analysis following recent semantic accounts of neg-raising. Informally, (84) is an illustration of how the IE reading of (83), conjoined with the excluded-middle assumption, leads to an SE reading:

(84) [**Situation**: Ann and Bill came, but Chris didn't.]
X [John predicted which students came].
(i) **IE:** John predicted that Ann and Bill came and it is not the case that he predicted that Chris came.
(ii) **Excluded-middle assumption**: John had determinate predictions about whether Ann came, whether Bill came and whether Chris came.
(i) & (ii) John predicted that Ann and Bill came and he predicted that Chris didn't come. (= **SE**)

As suggested above, this derivation of SE readings from IE readings parallels the interpretation of neg-raising predicates in the semantic analysis of neg-raising (Bartsch 1973; Gajewski 2007; Romoli 2013). In this line of analysis of neg-raising, the narrow-scope negation interpretation of sentences like (85) is derived by assuming an extra excluded-middle assumption (although analyses differ in how this assumption is semantically and pragmatically derived, as I will discuss later). The derivation of the narrow-scope negation interpretation of (85) is illustrated in the following.

(85) John doesn't think that Ann came.
(i) **The wide-scope negation interpretation**: It is not the case that John thinks that Ann came.
(ii) **Excluded-middle assumption**: John thinks that Ann came, or John thinks that Ann didn't come.
(i) & (ii) John thinks that Ann didn't come. (= **The 'neg-raising' interpretation**)

As one can see from (84) and (85), the current analysis of SE readings parallels the semantic analysis of neg-raising. Roughly speaking, an SE reading is derived by applying the semantic

[22] Indeed, one could posit a constraint on the distribution of X to avoid such predictions. A version of such a theory is advocated by Nicolae (2013), who constrains the distribution of her version of X in terms of STRONGEST MEANING HYPOTHESIS (SMH) (Dalrymple et al. 1998). See section A.2 for an argument against this approach.

analysis of neg-raising to the propositions negated by X in an IE readings, i.e., the propositions underlined in (84).

Under this picture, SE readings are parasitic on IE readings, and for this reason, SE readings arise only if IE readings are available. This automatically accounts for the distribution of SE readings now that we have established the distribution of IE readings. Since cognitive/communication (monotonic) predicates allow IE readings, they allow SE readings as well. On the other hand, since emotive (non-monotonic) predicates do not allow IE readings, they do not allow SE readings, either.

One desirable consequence of the current view is that it can make sense of Cremers and Chemla's (to appear) data on the Response Times of picture-matching tasks for IE and SE readings: Their experiment shows that it takes longer time for the participants to access SE readings than IE readings.[23] This result makes sense under the current analysis since SE readings are derived from IE readings, and thus the derivation of the former is more complex than that of the latter.

5.2 SE readings and neg-raising

In the previous section, I illustrated in informal terms how SE readings are derived from IE readings together with an excluded-middle assumption. In this section, I will provide details of the analysis including the formal implementation of how an excluded-middle assumption is semantically integrated with the IE reading, following the semantic literature on neg-raising (Bartsch 1973; Gajewski 2007; Romoli 2013). In section 5.2.1, I discuss the sources of the excluded-middle assumption and the formal implementation of the derivation of SE readings. In section 5.2.2, I discuss a particular prediction the current analysis makes about the relationship between predicates that allow SE readings and neg-raising predicates. Finally, in section 5.2.3, I will discuss an issue with deriving SE readings of factive predicates in the current analysis.

5.2.1 The excluded-middle assumption as a soft-presupposition

In this section, I will discuss how the excluded-middle assumption is integrated in the semantic derivation of SE interpretations, which I left vague in the above informal exposition. Following Gajewski (2007), I will treat the excluded-middle assumption as the SOFT PRESUPPOSITION of the relevant embedding predicate in the sense of Abusch (2010). Here, I use SOFT PRESUPPOSITIONS as a descriptive term for those presuppositions that can be suspended easily in a context that entails the speaker's ignorance about whether the presupposition holds. This contrasts with 'hard' presuppositions which would make an utterance simply infelicitous unless it is entailed by the speaker's knowledge state. A well-known example of a soft presupposition trigger is *win*, which presupposes 'to participate'. As shown below, the sentence *John won the race* gives rise to

[23] Here is more detail about Cremers and Chemla's (to appear) experimental design and result. Their participants are divided into the IE group and the SE group, and the experiment involves two phases: the 'training phase' and the 'experimental phase'. The crucial target item is a sentence-picture pair where the picture makes the sentence true under its WE and IE readings, but false in its SE reading. In the training phase, using explicit feedback, the participants in the IE group are trained to give the answer 'True' to the target item while those in the SE group are trained to give the answer 'False'. The participants' response times in the experimental phase are recorded, and the result indicated that the 'False' responses to the target by the SE group were slower than the 'True' responses to the target by the IE group, after confounding effects of the sentences and pictures are controlled.

the inference that John participated in the race, and this inference projects from under negation as in (86b) and also from the antecedent of a conditional as in (86c). (Following examples are taken from Romoli 2013.)

(86) a. Bill won the marathon.
b. Bill didn't win the marathon.
c. If Bill won the marathon, he will celebrate tonight.
⇒ Bill participated in the marathon.

This projection behavior parallels that of hard presupposition triggers. For example, the existential presupposition of the *it*-cleft patterns in the same way as above:

(87) a. It was Mary who broke that computer.
b. It wasn't Mary who broke that computer.
c. If it was Mary who broke that computer, she should repair it.
⇒ Someone broke that computer.

Despite this similarity, *win* and the *it*-cleft differ in the defeasibility of the presuppositions they trigger. This can be tested by using a context where the speaker is ignorant about whether the relevant presupposition holds (Simons 2001). In (88a) below, it is shown that the presupposition of *win* can be suspended if the speaker doesn't know whether the relevant individual participated in the race. On the other hand, (88b) shows that the existential presupposition of the *it*-cleft cannot be suspended in the similar way.

(88) a. I don't know whether Bill ended up participating in the Marathon yesterday, but if he won, he is certainly celebrating right now.
b. I don't know whether anybody broke that computer, #but if it is Mary who did it, she should repair it.

SOFT PRESUPPOSITION TRIGGERS refer to the kind of presupposition triggers that give rise to defeasible presuppositions like *win* in above examples. Other examples of soft presupposition triggers discussed in the literature include aspectual verbs such as *stop* and *start* (Abusch 2010; Simons 2001).

In his analysis of neg-raising, Gajewski (2007) argues that neg-raising predicates trigger excluded-middle presupposition, and further that it is a soft presupposition. This treatment reconciles the following two facts: (i) the lexical idiosyncrasy about which predicates allow a neg-raising interpretation (Horn 1989) and (ii) the defeasibility of excluded-middle inference associated with neg-raising predicates.[24] The triggering of soft presuppositions is a part of lexical properties of a predicate while the 'softness' of soft presuppositions allows defeasibility.

[24]The first fact, the lexical idiosyncrasy of neg-raising predicates, can be witnessed by the contrast between *want* and *desire*. Despite their semantic similarity, *want* is a neg-raiser while *desire* is not, as shown from the following:

(i) a. John doesn't want Mary to be around. ⇒ John wants Mary not to be around.
b. John doesn't desire that Mary was around. ⇏ John desires that Mary weren't around.

Other pairs of this sort can be found in Horn (1989), including cross-linguistic variations (e.g., English *hope* (neg-raiswer) vs. German *hoffen* (not a neg-raiser)). The second fact, the defeasibility of the excluded-middle inference, can be observed in (ii).

(ii) I don't know if John thinks one way or the other about whether Ann will come, but if John thinks that Ann

My claim is that a similar analysis can be given for question-embedding predicates. Some question-embedding predicates trigger the excluded-middle soft presupposition, and the IE readings can be strengthened into SE readings by virtue of this presupposition. Let me illustrate this using *guess* as an example, which is a neg-raiser at least in some English dialects. Although the analysis of the projection property of soft-presuppositions is itself an issue (Abusch 2010; Abrusán 2011; Romoli 2013), it suffices for our purpose here to analyze soft-presuppositions as definedness conditions that project from under negation unless they are explicitly negated (I will formalize the mechanism of suspension of soft presupposition in terms of local accommodation later). That is, the excluded-middle presupposition of *guess* is encoded in its denotation as follows:

(89) $[\![\text{guess}]\!]^w = \lambda p_{\langle s,t\rangle} \lambda x_e : [\mathbf{guess}(x, p, w) \vee \mathbf{guess}(x, \neg p, w)].\mathbf{guess}(x, p, w)$

With (89), we can derive the SE reading of *John guesses which students will come* from the LF in (90) as will be shown below.

(90) X [John guesses which students will come].

Given the semantic contribution of X, the interpretation of (90) can be restated as in (91) (As in the preceding examples, we assume that Ann and Bill will come, but Chris will not in w).

(91) $[\![\text{X John guesses which students will come}]\!]^w$
$= [\![\text{guess}]\!]^w (A \wedge B)(\mathbf{j}) \wedge \neg [\![\text{guess}]\!]^w (A \wedge B \wedge C)(\mathbf{j})$

Due to the excluded-middle presupposition triggered by *guess*, (91) presupposes that John guesses one way or the other about whether $A \wedge B$ is true, and that he guesses one way or the other about whether $A \wedge B \wedge C$ is true. The presuppositions are formally stated as follows:

(92) $[\mathbf{guess}(x, A \wedge B, w) \vee \mathbf{guess}(x, \neg[A \wedge B], w)]$
$\wedge [\mathbf{guess}(x, A \wedge B \wedge C, w) \vee \mathbf{guess}(x, \neg[A \wedge B \wedge C], w)]$

Given these presuppositions, (91) is defined and true if and only if the following holds:

(93) $[\![\text{X [John guesses which students will come]}]\!]^w = 1$
iff $\mathbf{guess}(\mathbf{j}, A \wedge B, w) \wedge \neg\mathbf{guess}(\mathbf{j}, A \wedge B \wedge C, w) \wedge$ (92)
iff $\mathbf{guess}(\mathbf{j}, A \wedge B, w) \wedge \mathbf{guess}(\mathbf{j}, \neg[A \wedge B \wedge C], w)$
iff $\mathbf{guess}(\mathbf{j}, A \wedge B, w) \wedge \mathbf{guess}(\mathbf{j}, \neg C, w)$

This is precisely the SE interpretation of *John guesses which students will come* in our world w. Thus, if the embedding predicate triggers the excluded-middle presupposition as in (89), an LF with the matrix X is predicted to have the SE reading unless the excluded-middle presupposition is suspended.

5.2.2 Correlation between the possibility of SE readings and the neg-raising property

In the previous section, I argued that SE interpretations arise from excluded-middle presuppositions, which underlie the neg-raising phenomena with certain clause-embedding predicates in the semantic analysis of neg-raising maintained by Gajewski (2007) and Romoli (2013).

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will come, then we will have to do something about it.

The example shows that the excluded-middle inference associated with *think*—that John thinks that Ann will come or he thinks that Ann won't come—can be suspended.

This view predicts a correlation between neg-raising and SE readings. More precisely, given an out-of-the-blue context that does not support any excluded-middle assumption by itself, there should be a correlation between the possibility for a predicate to neg-raise and the possibility for the same predicate to allow an SE reading. This is so because both neg-raising and SE readings arise from the same mechanism: the soft excluded-middle presupposition associated with the predicate.

It is worth noting, however, that factive predicates are not good test cases to evaluate this prediction since relevant excluded-middle inference for factive predicates concerns the *non-factive* component of the semantics of these predicates (for the reasons discussed in section 3.3), and its effect cannot be seen as a neg-raising property of the factive predicate itself. Factivity always disrupts neg-raising. I will discuss the general issue of how to analyze the SE readings of factive predicates in the next subsection.

A preliminary support for the correlation comes from the contrast between certain communication predicates such as *write down*, *publicize* and *read* and cognitive predicates such as *estimate* and *guess*. The former class of predicates resist neg-raising as well as SE readings while the latter class of predicates readily allow both neg-raising and SE readings. The following is more detail about the two class of predicates. Some communication predicates that encode manners of conveying information, such as *write down*, *publicize* and *read*, are known to resist neg-raising, as shown below.

(94) a. John didn't **write down** that Ann came.
$\not\Rightarrow$ John **wrote down** that Ann didn't come.
b. John didn't **publicized** that Ann came.
$\not\Rightarrow$ John **publicized** that Ann didn't come.
c. John didn't **read** that Ann came.
$\not\Rightarrow$ John **read** that Ann didn't come.

This fact is mirrored by the observation by Beck and Rullmann (1999) that these predicates do *not* license SE readings, as shown by the lack of inferences of the following form:

(95) a. John **wrote down** which students in the list came.
$\not\Rightarrow$ John **wrote down** which students in the list didn't come.
b. John **publicized** which students in the list came.
$\not\Rightarrow$ John **publicized** which students in the list didn't come.
c. John **read** which students in the list came.
$\not\Rightarrow$ John **read** which students in the list didn't come.

This is in contrast to cognitive predicates, such as *estimate* and *guess* which licenses neg-raising more readily than we see in (94):

(96) a. John didn't **estimate** that Ann would come.
$^{?}\Rightarrow$ John **estimated** that Ann wouldn't come.
b. John didn't **guess** that Ann came.
$^{?}\Rightarrow$ John **guessed** that Ann didn't come.

(97) a. John **estimated** which students in the list would come.
$\Rightarrow$ John **estimated** which students in the list wouldn't come.

b. John **guessed** which students in the list came.
   ⇒ John **guessed** which students in the list didn't come.

As discussed above, this correlation between the neg-raising property and the possibility of an SE reading is predicted by the current analysis. If a non-factive predicate triggers an excluded-middle presupposition, it will allow a neg-raising interpretation as well as an SE reading. On the other hand, if a non-factive predicate does not trigger an excluded-middle presupposition, it will allow neither a neg-raising interpretation nor an SE reading out of the blue.

5.2.3 Factive predicates and neg-raising

Prima facie, factive predicates might look problematic for the current analysis since factives in general are not neg-raisers, while (at least) some factive responsive predicates such as *know* clearly allow SE readings. The non-neg-raising property of *know* is illustrated in the following:

(98) John doesn't know that Ann came. $\not\Rightarrow$ John knows that Ann didn't come.

That factives are not neg-raisers is natural under the analysis of neg-raising in terms of excluded-middle, as excluded-middle assumptions for factive predicates involve contradictory presuppositions, as seen in the following:

(99) #John knows that p or John knows that $\neg p$

Given the approach to factive predicates discussed in section 3.3, it turns out that they are not problematic for the current analysis of SE. What matters for the derivation of SE readings in the current analysis is not the neg-raising property of the responsive predicate itself, but rather whether the *alternatives* for X give rise to a neg-raising interpretation. In section 3.3, I presented the decompositional analysis for factive predicates, where they are decomposed into its non-factive counterpart and an answerhood operator. According to this analysis, the prejacent and the alternatives for *John knows which students came* would look like the following:

(100) John knows which students came.

a. **Prejacent**: $\lambda w'.[\![\text{John believes [[Ans } w\text{] which students came]}]\!]^{w'}$

b. **Alternatives**:
$$\left\{\lambda w'.[\![\text{John believes [[Ans } w''\text{] which students came]}]\!]^{w'} \middle| w'' \in W\right\}$$
$$= \left\{\lambda w'.\mathsf{DOX}_{\mathbf{j}}^{w'} \subseteq p \middle| p \in \left\{\begin{array}{c} A, B, C \\ A \wedge B, B \wedge C, C \wedge A \\ A \wedge B \wedge C \end{array}\right\}\right\}$$

Assuming that *believe* in (100) is associated with an excluded-middle presupposition as in (101), the negation of an alternative which looks like (102) is strengthened into the statement with a narrow scope negation as in (103).

(101) $\mathsf{DOX}_{\mathbf{j}}^{w} \subseteq p \vee \mathsf{DOX}_{\mathbf{j}}^{w} \subseteq \neg p$ (The excluded-middle assumption)

(102) $\mathsf{DOX}_{\mathbf{j}}^{w} \not\subseteq p$ ('John believes p'; the negation of an alternative)

(103) $\mathsf{DOX}_{\mathbf{j}}^{w} \subseteq \neg p$

5.2.4 The deductive reading of emotive factives

In section 4 above, I analyzed the behavior of the literal reading of emotive factives based on their non-monotonicity. In this section, I discuss the behavior of the deductive reading of emotive factives. Theiler (2014) argues that deductive readings of emotive factives are monotonic, citing following kind of inferences as valid.

(104) a. In effect, John is happy that Ann and Bill came.
⇒ In effect, John is happy that Ann came.

b. In effect, John was surprised that Ann came.
⇒ In effect, John was surprised that Ann and Bill came.

If true, the correlation between the literalness/deductiveness and monotonicity is an interesting phenomenon. However, it is not clear if the correlation is empirically robust. It seems to me, at least, that the kind of situations that constitute counterexamples to the parallel inferences in the literal case (e.g., John wanted Bill not to come, and he also wanted Ann to come even more so than he wants Bill not to come) serve as counterexamples to the inferences in (104a) as well.[25]

Then, how can we derive the SE readings of emotive factives under deductive readings? I argue that the deductive readings of *be happy* and *be surprised* have the paraphrases 'be happy to know/learn' and 'be surprised to know/learn', where the emotive factives in the paraphrases are to be understood as having their literal readings. More concretely, I propose the following decomposition of the deductive version of emotive factives:

(105) a. John is $\text{surprised}_{\text{deduc}}$ that p. ⇝ John is $\text{surprised}_{\text{lit}}$ to know that p.

b. John is $\text{happy}_{\text{deduc}}$ that p. ⇝ John is $\text{happy}_{\text{lit}}$ to know that p.

The 'deductive' flavor associated with the deductive reading of *be surprised/happy that p* reflects the fact that it conveys an emotion about one's *knowledge* about p, which entails knowledge about deductive consequences of p.

Given this analysis, the SE readings of the deductive emotive factives can be captured by the insertion of X immediately above the clause containing *know*. That is, the SE readings can be captured in the following LFs.

(106) a. John X [t is $\text{surprised}_{\text{lit}}$ [PRO to X [t know [Ans [which students came]]]]].

b. John X [t is $\text{happy}_{\text{lit}}$ [PRO to X [t know [Ans [which students came]]]]].

Due to the presence of the lower X, the embedded clauses of these LFs have the SE interpretation: John knows the SE answer to which students came, given an excluded-middle assumption associated with the non-factive component of *know*. As a result, the whole LFs are interpreted as 'John is surprised/happy that he knows the SE answer to which students came' (The higher X is vacuous due to the non-monotonicity of emotive factives).

5.3 Capturing the SE data: defeasibility and embeddability

Above, I discussed how SE readings are captured as a result of the strengthening of IE readings mediated by an excluded-middle assumption coming either from the context or a lexical presupposition associated with the embedding predicate. In this section, I discuss how the current

[25]Also, as argued in fn. 20, *surprise* seems to behave as a monotonic predicate regardless of the literal/deductive distinction.

analysis captures the detailed data concerning the distribution of SE readings, focusing on (i) the defeasibility of SE readings and (ii) whether the SE readings can embed under negation.

5.3.1 Defeasibility of SE readings

As illustrated in section 5.2.1, if a predicate triggers an excluded-middle presupposition, the current analysis predicts that matrix X-exhaustification yields an SE reading instead of an IE reading. On the other hand, if a predicate does not have an excluded-middle presupposition, an SE reading would not be possible unless the excluded-middle assumption is provided by the context. In section 2.2.1, we saw Groenendijk and Stokhof's (1984) evidence for the SE reading of *know*, which uses an inference of the following form:

(8) (i) John knows which students came.
⇒ (ii) John knows which students didn't come.

Under the current analysis, the fact that this inference goes through without any contextual support suggests that *know* triggers the soft excluded-middle presupposition with respect to its non-factive component. The relevant presupposition can be stated as in the following denotation of *know* (the presupposition is underlined):

(107) $[\![\text{know}]\!]^w = \lambda p \lambda x : [p(w) \wedge \underline{\mathsf{DOX}_x^w \subseteq p \vee \mathsf{DOX}_x^w \subseteq \neg p}].\mathsf{DOX}_x^w \subseteq p$

One might wonder if the current treatment is problematic as it seems to predict that SE readings are obligatory for *know*, and that IE readings are impossible contrary to the observations and experimental result by Cremers and Chemla (to appear). This worry is unwarranted since the excluded-middle presupposition can be suspended due to its 'softness'. That is, in a context that explicitly negates the subject's opinionatedness, the excluded-middle presupposition can be suspended. And, in such a case, IE readings are not strengthened into SE readings. This is precisely what happens in the data that shows the existence of IE readings for *know*, such as the following repeated from the data section:

(9a) [**Situation**: Ann and Bill came, but Chris didn't. John believes that Ann and Bill came, but he is unopinionated about whether Chris came.]
John knows which students came.

Here, the context makes it explicit that John is unopinionated about whether Chris came. Since the excluded-middle presupposition triggered by *know* is a soft soft-presupposition, it can be suspended in this kind of situation. As a result, we derive an IE reading in (9a) based on the LF with matrix exhaustification. In fact, it is a general characteristic of contexts that validate an IE reading without validating an SE reading that they explicitly deny the subject's opinionatedness (or the excluded-middle assumption in general) about a false answer. This is also the case with the pictures used in the picture-sentence matching task in Cremers and Chemla's (to appear) experiment. The crucial items they use to test the existence of IE readings of sentences like *John knows which squares are red* involve a picture that indicates that John has no idea whether some (non-red) square is red. As this kind of picture explicitly negates John's opinionatedness just like the context in (9a), we predict the excluded-middle presupposition to be suspended and an IE reading to be available. This accords with Cremers and Chemla result: majority of participants judged *John knows which squares are red* true when the picture indicates that its IE reading is true and that John is unopinionated about the color of some of the non-red squares.

To formalize the suspension of soft-presuppositions, I make use of the $\mathscr{A}$-operator from Beaver and Krahmer (2001), defined as follows:

(108) $[\![\mathscr{A}]\!]^w(p) = \begin{cases} 1 & \text{if } p = 1 \\ 0 & \text{otherwise} \end{cases}$

The basic function of this operator is to locally accommodate the presupposition of its scope. Thus, when this operator scopes immediately above a predicate that triggers an excluded-middle presupposition, the presupposition is effectively canceled (since the excluded-middle presupposition is entailed by the assertion). I submit that this is what happens when the excluded-middle presupposition is suspended. That is, when the context explicitly negates the excluded-middle presupposition, $\mathscr{A}$ is inserted immediately above the prejacent of X, as in the LF in (109).

(109) [X [$\mathscr{A}$ [John knows which students came]]].

As shown in the following, an IE reading is derived from this structure:

(110) $[\![\text{X } [\mathscr{A} \text{ [John knows which students came]]}]\!]^w$
$= [\![\mathscr{A}]\!]^w([\![\text{knows}]\!]^w(A \wedge B)(\mathbf{j}))$
$\wedge \neg [\![\mathscr{A}]\!]^w([\lambda p \lambda x : \underline{[\text{DOX}_x^w \subseteq p \vee \text{DOX}_x^w \subseteq \neg p]}.\text{DOX}_x^w \subseteq p](A \wedge B \wedge C)(\mathbf{j}))$
$= 1 \text{ iff } \text{DOX}_{\mathbf{j}}^w \subseteq [A \wedge B] \wedge \text{DOX}_{\mathbf{j}}^w \not\subseteq [A \wedge B \wedge C]$

Thus, the current analysis correctly captures the defeasibility of SE readings for predicates like *know* that give rise to SE readings in out-of-the-blue contexts. IE readings are available when the excluded-middle soft presuppositions triggered by these predicates are explicitly negated by the context.

5.3.2 Accommodation and SE readings under negation

Nevertheless, there is one aspect of Cremers and Chemla's (to appear) experimental result that the current analysis so far cannot capture. In their result, although a majority of responses judged target sentences (such as *John knows which squares are red*) true when paired with pictures that validates their IE readings but invalidate their SE readings (e.g., the picture indicating that John knows that all the red squares are red, and has no idea about some of the non-red squares), there are small but significant[26] rate of responses according to which the target sentences are *false* given the same pictures. This is unexpected in the current analysis so far. The false judgment for these items is expected only under their SE readings, but, as discussed in the previous section, my analysis so far maintains that SE readings are unavailable due to the suspension of the excluded-middle presupposition when the context/picture explicitly negates it.

To address this problem, I claim that there are two strategies to avoid presupposition failure in interpreting a sentence with an excluded-middle soft presupposition in a context that explicitly negates it. One strategy is to suspend the excluded-middle presupposition, or, to insert the $\mathscr{A}$-operator below X. The other strategy is to insert $\mathscr{A}$ above the X-operator, as in (111), which yields the truth-conditions in (112):

(111) [$\mathscr{A}$ [X [John knows which students came]]]

[26]The significance here means that the rate of 'False' responses is significantly higher than that of 'False' responses for the True control, i.e., the items that are true under any reading.

(112) $[\![\mathscr{A}\ [\mathsf{X}\ [\text{John knows which students came}]]]\!]^w$
$= [\![\mathscr{A}]\!]^w([\![\text{knows}]\!]^w(A \wedge B)(\mathbf{j})$
$\wedge \neg[\lambda p \lambda x : \underline{[\mathsf{DOX}_x^w \subseteq p \vee \mathsf{DOX}_x^w \subseteq \neg p]}.\mathsf{DOX}_x^w \subseteq p](A \wedge B \wedge C)(\mathbf{j}))$
$= \begin{cases} 1 & \text{if } \mathsf{DOX}_{\mathbf{j}}^w \subseteq [A \wedge B] \wedge \mathsf{DOX}_{\mathbf{j}}^w \subseteq \neg[A \wedge B \wedge C] \\ 0 & \text{otherwise} \end{cases}$

The interpretation in (112) is effectively an SE reading, and thus it would be false under the situation where John is unopinionated about C. Thus, there are these two strategies to avoid a failure of satisfying the excluded-middle presupposition: to suspend, i.e., to locally accommodate, the excluded-middle presupposition, or to accommodate it above X. Given the relevant situation in (9a) above, the sentence *John knows which students came* is predicted to be true under the former strategy while false under the latter strategy.

Here, the analogy with neg-raising is useful. It has been observed in the literature that the following sentence under the given situation can either be true or false (if not infelicitous).

(113) [**Situation**: John has no idea whether Chris came or not.]
John doesn't think that Chris came.

The reading under which the sentence is true is especially salient if the auxiliary+negation *doesn't* is stressed. As Gajewski (2007) argues, this reading can be derived by placing $\mathscr{A}$ below the negation as in the LF in (114a). On the other hand, the reading under which the sentence is false can be derived by the attachment of $\mathscr{A}$ above X in (114b).

(114) a. Not [$\mathscr{A}$ [John thinks that Chris came]]
b. $\mathscr{A}$ [Not [John thinks that Chris came]]

This ambiguity is parallel to the two possible readings of *John knows which students came*. One difference is that it is impossible to stress the negation in the question-embedding sentence since the negation is provided by the phonologically null operator X.

Now that we established the possibility of two readings, how can we make sense of the response pattern in Cremers and Chemla's (to appear) experimental result, i.e., that the majority of responses are 'True' while small but significant rate of responses are 'False'? I suggest that the pattern can be explained by the preference for True readings of ambiguous sentences, or the general Principle of Charity. That is, confronted with a task to determine the truth value of *John knows which squares are red*, whose presupposition is unsatisfied in the given situation/picture, participants tend to use the local accommodation strategy, as it accords with the Principle of Charity. However, since the global accommodation strategy is in principle possible and the Principle of Charity is only a pragmatic preference, we also observe a small rate of 'False' response based on the attachment of $\mathscr{A}$ above the X-operator. I have to leave open the question of why the Principle of Charity was overridden in individual 'False' responses.[27]

Next, we consider a consequence of the current analysis regarding whether SE readings can be 'embedded' under operators through which the excluded-middle presupposition normally projects, such as negation. The relevant example we consider is the following:

[27] What might be informative in this connection is the experimental study on the individual variation on the accommodation strategies by Sudo et al. (2012). They conjecture that a certain minority of speakers simply don't allow parses with the $\mathscr{A}$-operator. The participants who responded with 'False' to the relevant items in Cremers and Chemla's (to appear) experiment might also be grouped as lacking the parses with $\mathscr{A}$. If this is the case, the sentences are simply presupposition-failures for them, and they opted for 'False' given the forced choice.

(115) [**Situation**: Ann and Bill came, but Chris didn't. John believes that Ann and Bill came, but he is unopinionated about whether Chris came.]

John doesn't know which students came.

a. [Not [X [$\mathscr{A}$ [John knows which students came]]]]. (False)

b. [Not [$\mathscr{A}$ [X [John knows which students came]]]]. (True)

The background situation is exactly the same as (9a), and the sentence involves a matrix negation. Just as in the non-negated case above, there are two ways to avoid the presupposition failure: to insert $\mathscr{A}$ below X at LF, and to insert $\mathscr{A}$ below the negation and above X. (I will not discuss the possibility of inserting $\mathscr{A}$ above the negation since it will lead to the same interpretation as the first LF.) These two LFs give rise to the interpretations informally paraphrased as follows:

(116) a. $\neg$[John believes $[A \wedge B]$ $\wedge$ $\neg$ [John believes C]]
$\Leftrightarrow$ $\neg$[John believes $[A \wedge B]$] $\vee$ John believes C

b. $\neg$[John believes $[A \wedge B]$ $\wedge$ [John believes $\neg C$]]
$\Leftrightarrow$ $\neg$[John believes $[A \wedge B]$] $\vee$ $\neg$[John believes $\neg C$]

In other words, the first reading is a negation of IE while the second reading is a negation of SE. In the situation in (115), the first reading is false whereas the second reading is true.

Again, the analogy with neg-raising is illustrative. A neg-raising example that is parallel to (115) is the one involving double negation, as in (117). The inner negation corresponds to the negation provided by the obligatory X in (115).

(117) [**Situation**: John has no idea whether Chris came or not.]

It is not the case that John doesn't think that Chris came.

a. Not [Not [$\mathscr{A}$ [John thinks that Chris came]]] (False)

b. Not [$\mathscr{A}$ [Not [John thinks that Chris came]]] (True)

Two LFs corresponding to the ones in (115a) and (115b) are given above. The reading derived from the LF in (117a), i.e., the (most) local accommodation reading, is false. On the other hand, the reading derived from the LF in (117b), i.e., the one with accommodation immediately below the higher negation, is true.

Native speakers report mixed judgments on the truth-value of (115) in the given situation, and this is unsurprising given their mixed judgments about (117). It is also worthwhile to note that, when the negation is stressed in (115), the sentence tends to be judged as true. This is compatible with the observation by Gajewski (2007) that the insertion of $\mathscr{A}$ is associated with a stress on the negation immediately above it. In this view, the LF in (115b) would be associated with a stress on the negation while the one in (115a) would not have a similar phonological consequence since X is phonologically null.

Summarizing section 5.3, the possibility of IE readings with predicates that trigger an excluded-middle presupposition (and thus 'select for' SE readings by default) is accounted for by a suspension of the soft presupposition. The suspension of a presupposition is formalized in terms of local accommodation of the excluded-middle presupposition below X, using the $\mathscr{A}$-operator. In addition to locally accommodating the presupposition, we can also accommodate it above X. This accounts for the (dispreferred but available) possibility of deriving an SE reading even in the context that explicitly negates the excluded-middle presupposition (Cremers and Chemla to appear). The same mechanism can be applied to a sentence with negation above X. Two possible readings can be derived depending on the position of $\mathscr{A}$.

5.4 Summary

The current theory of exhaustivity of embedded questions accounts for the distribution of WE, IE and SE readings. The empirical generalization stated in section 2.2.1 is repeated in the following table:

(118)

	WE	**IE**	**SE**
cognitive/communication	*	✓	✓
emotive factives ('literal')	✓	*	*

In the case of cognitive/communication predicates, an application of X above the predicates derives IE readings, which can be strengthened into SE readings given an excluded-middle presupposition of the predicate. On the other hand, an application of X is vacuous for emotive factives because of their non-monotonicity. This accounts for the fact that they do not receive IE readings, and hence the fact that they do not receive SE readings. The only interpretation available for emotive factives is the baseline reading, which is the WE reading.

As I noted above, X is syntactically obligatory in the clause containing the question-embedding predicate. This accounts for the lack of WE readings for cognitive/communication predicates. This syntactic assumption does not concern the prediction for emotive factives since WE readings would be predicted for these predicates regardless of the presence of X.

One thing that should be noted at this point is that the non-monotonicity of emotive predicates, which the current analysis is relying on, is not entirely uncontroversial. As mentioned above, von Fintel (1999) and Crnič (2011) argue for a monotonic analysis of emotive predicates based on evidence concerning NPI-licensing in predicates like *be sorry* and *be surprised*. Thus, in a more neutral standpoint, the current analysis can be seen as providing an argument for the non-monotonic analysis of emotive predicates (although a theory-internal one), together with an existing argument from the licensing of epistemic modals by Anand and Hacquard (2013). That is, the distribution of exhaustive readings make sense only under the non-monotonic analysis of emotive factives. On the other hand, the NPI-licensing under *surprise*, for example, remains as a puzzle in the current analysis whereas it is straightforwardly accounted for under the (downward-)monotonic analysis. It is yet to be seen how future advancement on the semantics of emotive predicates will affect the current analysis.

6 Conclusions

In this paper, I presented an analysis of embedded questions under factive predicates which is properly constrained to capture the variation in their exhaustive interpretations. The analysis assumes only one semantic derivation for question-embedding sentences, i.e., that with matrix exhaustification. The variation in readings falls out from this derivation once we take into account the lexical semantics of the relevant embedding predicates. The crucial difference between the two relevant classes of predicates—cognitive/communication predicates and emotive factives—is their monotonicity property. This difference predicts the presence and absence of a semantic effect of the X-operator applied above the predicates. Another important claim in the analysis is that SE readings are derived from IE readings via strengthening. This accounts for the fact that cognitive/communication predicates in principle allow SE as well, and that emotive factives don't allow SE.

The strengthening analysis of SE is supported by a correlation between the tendency to license neg-raising and the tendency to allow SE among question-embedding predicates. Furthermore, the proposed perspective on SE readings as being parasitic on IE readings is in line with Cremers and Chemla's (to appear) report on the Response Time of truth-value judgment tasks for the two readings: IE readings are accessed faster than SE readings. If SE readings are derived from IE readings, as proposed in this paper, this result receive a natural explanation since the computations required to derive an IE reading are subset of the computations required to derive an SE reading.

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A Existing analyses

There are two semantic accounts of the variation in exhaustivity of embedded questions in the literature, i.e., those presented in Guerzoni (2007) and Nicolae (2013). In this section, I review each analysis and point out their problems.

A.1 Guerzoni (2007)

Summary of the analysis Guerzoni (2007) analyzes the incompatibility of emotive factives with SE readings based on the interaction between the assertion, implicature and the SPEAKER FACTIVITY of the relevant question-embedding sentences. SPEAKER FACTIVITY is a presupposition of certain question-embedding sentences (first observed by Guerzoni and Sharvit 2007) according to which the speaker knows the true answer of the embedded question. It is most robust with the predicate *realize*. Consider the following minimal pair:

(119) [**Context**: Mary doesn't know who was at the party she missed the night before. Her friend John wasn't there either. Mary picks up the phone, calls John, and starts inquiring...]

a. Mary: Hi John, so have you **found out** who was at the party?

b. Mary: #Hi John, have you **realized** who was at the party? (Guerzoni 2007: 119)

In the given context where Mary does not know who was at the party, (119a) is felicitous while (119b) is odd. According to Guerzoni and Sharvit (2007), this is due to the speaker factivity triggered by *realize*, i.e., that (119b) presupposes speaker's knowledge of the answer to the embedded question *who came*. That is, the oddness of (119b) arises because the context violates the speaker factivity. In contrast, (119a) is felicitous because *find out* does not trigger speaker factivity. Guerzoni and Sharvit (2007) claim that speaker factivity is triggered also by emotive factives like *surprise*. Following examples illustrate this:

(120) [**Situation**: The speaker doesn't know who passed the exam.]

a. Will John **find out** who passed the exam?

b. #Will it **surprise** John who passed the exam? (Guerzoni 2007: 119, adapted)

(121) [**Situation**: The speaker knows who passed the exam.]

a. Will John **find out** who passed the exam?

b. Will it **surprise** John who passed the exam?

Under the context that validates the speaker's knowledge of the answer to the embedded question, as in (120), the sentence with *find out*, (120a), is felicitous while the sentence with *surprise*, (120b), is odd. This contrast disappears in (121), where the context validates the speaker factivity.

Guerzoni (2007) claims that speaker factivity automatically leads sentences involving *surprise* with an SE complement into a contradiction. The contradiction arises when speaker factivity is taken together with the quality implicature and the primary scalar implicature (in the sense of Sauerland 2004). For an illustration, let us take the sentence *It surprised John who passed the exam*, and assume that the domain of exam-takers is Ann and Bill. The quality implicature, speaker factivity and primary scalar implicature of this sentence are described below. ($\mathbf{K}(p)$ abbreviates 'the speaker knows that p' and $\mathbf{S}_x(p)$ abbreviates 'x is surprised that p'.)[28]

(122) It surprised John who passed the exam. [domain of individuals: Ann and Bill]

a. **SE Quality Implicature**: $\mathbf{K}(\mathbf{S_j}(A \wedge \neg B) \vee \mathbf{S_j}(\neg A \wedge B) \vee \mathbf{S_j}(A \wedge B))$

b. **SE Speaker Factivity**: $\mathbf{K}(A \wedge \neg B) \vee \mathbf{K}(\neg A \wedge B) \vee \mathbf{K}(A \wedge B)$

c. **SE Primary Scalar Implicature**: $\neg\mathbf{KS_j}(A \wedge \neg B) \wedge \neg\mathbf{KS_j}(\neg A \wedge B) \wedge \neg\mathbf{KS_j}(A \wedge B)$

The conjunction of (122a) and (122b) results in the following statement in (123) (see Guerzoni 2007 for a proof), which contradicts the statement in (122c).

(123) $\mathbf{KS_j}(A \wedge \neg B) \vee \mathbf{KS_j}(\neg A \wedge B) \vee \mathbf{KS_j}(A \wedge B)$

Here, the primary scalar implicature arises as the result of neo-Gricean quantity implicature with the following set of alternatives.[29]

(124) a. It surprised John that Ann but not Bill passed the exam.

b. It surprised John that Bill but not Ann passed the exam.

c. It surprised John that Ann and Bill passed the exam.

Due to the contradiction that arises from the combination of the three kinds of inference in (122), an SE reading is ruled out. On the other hand, a WE reading of *surprise*-statements does not lead to a contradiction. The WE versions of the quality implicature, the speaker factivity and the primary scalar implicature of *It surprised John who passed the exam* are given below:

(125) It surprised John who passed the exam. [domain of individuals: Ann and Bill]

a. **WE Quality Implicature**: $\mathbf{K}(\mathbf{S_j}(A) \vee \mathbf{S_j}(B) \vee \mathbf{S_j}(A \wedge B))$

b. **WE Speaker Factivity**: $\mathbf{K}(A) \vee \mathbf{K}(B) \vee \mathbf{K}(A \wedge B)$

c. **WE Primary Scalar Implicature**: $\neg\mathbf{KS_j}(A) \wedge \neg\mathbf{KS_j}(B) \wedge \neg\mathbf{KS_j}(A \wedge B)$

The consistency of the three statements in (125) can be seen by the fact that the conjunction of (125a) and (125b) does not entail the following, assuming that A and B are logically independent.

(126) $\mathbf{K}(\mathbf{S_j}(A)) \vee \mathbf{K}(\mathbf{S_j}(B)) \vee \mathbf{K}(\mathbf{S_j}(A \vee B))$

[28] In Guerzoni's (2007) analysis, generally, the quality implicature, speaker factivity and primary scalar implicature of a sentence of the form *It surprised x Q* under its SE reading can be stated as follows:

(i) It surprised x Q.

a. **Quality Implicature**: $\mathbf{K}(\exists p[\exists w[p = \mathsf{A}_{\mathsf{SE}}(Q)(w)] \wedge \mathbf{S}_x(p)])$

b. **Speaker Factivity**: $\exists p[\exists w[p = \mathsf{A}_{\mathsf{SE}}(Q)(w)] \wedge \mathbf{K}(p)]$

c. **Primary Scalar Implicature**: $\forall p[\exists w[p = \mathsf{A}_{\mathsf{SE}}(Q)(w)] \rightarrow \neg\mathbf{K}(\mathbf{S}_x(p))]$

[29] These alternatives are stipulated by Guerzoni, but the fact that (123) is contradictory with the primary scalar implicature is preserved even if we choose the following set of alternatives based on WE answers.

(i) a. It surprised John that Ann passed the exam.

b. It surprised John that Bill passed the exam.

c. It surprised John that Ann and Bill passed the exam.

Stated in more general terms, Guerzoni's (2007) analysis makes use of the following logical fact: a conjunction of (127-i) and (127-ii) entails the proposition where the **K**-operator in (127-i) is distributed over the two disjuncts, as in (128), if the operator O is veridical, i.e., (127-iii), and that propositions p and q are mutually exclusive, i.e., (127-iv).

(127) i. $\mathbf{K}(O(p) \vee O(q))$ [**Quality Implicature**]
ii. $\mathbf{K}(p) \vee \mathbf{K}(q)$ [**Speaker factivity**]
iii. $\forall p[O(p) \rightarrow p]$ [**Veridicality of** O]
iv. $p \wedge q = \varnothing$ [p **and** q **are mutually exclusive**]

(128) **Conclusion from (127i-iv)**: $\mathbf{K}(O(p)) \vee \mathbf{K}(O(q))$

The proposition in (128) contradicts the proposition in (129), which corresponds to the primary scalar implicature of the sentence that has (127-i) as its quality implicature.

(129) $\neg\mathbf{K}(O(p)) \wedge \neg\mathbf{K}(O(p))$ [**Primary Scalar Implicature**]

Before pointing out problems with Guerzoni's (2007) analysis, I would like to mention that the goal of Guerzoni (2007) is in fact more ambitious than just accounting for the incompatibility of emotive factives and SE readings. She also aims to account for the fact that emotive factives are incompatible with *whether*-complements, as shown below:

(130) a. ??John is surprised by whether Mary drank coffee.
b. ??John is surprised by whether Mary drank $[\text{coffee}]_F$ or $[\text{tea}]_F$

This fact is interesting in its own right, and it would certainly be desirable if the impossibility of SE readings under emotive factives and the observations in (130) are given a unified explanation. However, in this paper, I will focus on the constraint on exhaustivity of embedded questions and leave the issue illustrated in (130) for a future research. See Sæbø (2007) and Herbstritt (2014) for more empirical data and recent perspectives on the (in)compatibility between emotive factives and *whether*-complements.

Problems Guerzoni's (2007) analysis is problematic in several respects. The first problem concerns the empirical robustness of speaker factivity for emotive factives. The crucial contrast illustrating speaker factivity for *surprise* is repeated below.

(120) [**Situation**: The speaker doesn't know who passed the exam.]
a. Will John **find out** who passed the exam?
b. #Will it **surprise** John who passed the exam? (Guerzoni 2007: 119, adapted)

Although the contrast does exist, I suspect that it can in large part be explained away as the result of another less controversial presupposition of emotive factives, namely that the subject knows the correct answer to the complement. That is, the oddness of (120b) stems from the fact that the context does not support the presupposition that John will know who passed the exam. In fact, if we modify the context so that this presupposition is satisfied, we see that a *surprise*-sentence becomes better.

(131) I don't know who passed the exam, but John will find it out anytime soon. It will be interesting to see whether it will surprise John who passed the exam.

Also, as Guerzoni herself points out, *surprise* in past indicative sentences does not seem to trigger speaker factivity robustly, as shown in the felicity of the following example.

(132) I don't know who passed the exam, but I know that it surprised John who passed the exam. So, there might be some interesting names on the list of students who passed.

One might argue that what is happening in (131-132) is an accommodation of speaker factivity. However, given the nature of speaker factivity, it is difficult to see how the accommodation is possible at all. That is, since the context makes it explicit that the speaker does not know the actual true answer to the embedded question, it is impossible for the speaker to even *suppose* that he/she knows the actual answer. One possible way out is to reanalyze speaker factivity as a definiteness presupposition of the answer to the embedded question. In this case, the accommodation of speaker factivity amounts to the supposition that the common ground entails a unique existence of the answer to the embedded question.

This is an interesting domain of investigation, but the fact that speaker factivity can be suspended in any way leads to a problem with Guerzoni's (2007) analysis of exhaustivity under emotive factives. The problem is that it is not clear why speaker factivity cannot be suspended in the situation where it leads to a contradiction when it is taken together with quality implicature and primary scalar implicature. Guerzoni's (2007) account of the impossibility of SE readings for emotive factives crucially relies on the assumption that each of speaker factivity, quality implicature and primary scalar implicature is an *obligatory* inference. If speaker factivity is in fact suspendable, as pointed out above, the account predicts that SE reading is in principle possible in cases where speaker factivity is suspended. This prediction does not seem to be empirically validated as the sentences in (131-132) still seem to require WE readings of the complements.

Another problem concerns cases where the possible WE answers to the embedded question are mutually exclusive. Recall that the analysis predicts a question-embedding sentence to be contradictory whenever (i) the embedding predicate triggers speaker factivity, (ii) the embedding predicate is veridical, and (iii) the possible answers are mutually exclusive, assuming that quality implicature and primary scalar implicature are obligatory inferences for any question-embedding sentence. This means that a question-embedding sentence with *surprise* ends up infelicitous when the possible WE answers are mutually exclusive, regardless of the exhaustivity of embedded questions. This prediction again is not borne out. The following sentence is perfectly felicitous even if the possible WE answers to the embedded question are mutually exclusive.

(133) It surprised John who was the winner.

One possible response to this issue is to say that the mechanism that determines whether the interpretation of an embedded question is SE or WE (or IE) is not sensitive to the semantic contributions of particular embedded questions except for the SE/WE(/IE)-ness (ie., the choice of an answerhood operator in Guerzoni's (2007) implementation). That is, what is crucial is that SE readings *necessarily* result in contradiction regardless of the choice of specific words in the complement. This seems to be in line with Gajewski's (2002) formulation of the relationship between ungrammaticality and contradiction/analyticity in natural language. However, it is not clear how the details of such an analysis can be worked out. Contradictions that lead to ungrammaticality in natural language according to Gajewski (2002) are those based on *logical* vocabularies in the sentence, but (133) does give rise to such a contradiction under this formulation since the copular and the definite determiner are arguably logical vocabularies, and their semantic contributions alone can make sure that the possible WE answers of *who was the NP* are mutually exclusive, for an arbitrary NP. The same argument can be made with singular-*which* questions as long as the singular feature of NPs is considered to be a logical vocabulary.

The third problem with Guerzoni's (2007) analysis concerns cases where speaker factivity is explicitly supplied to sentences with other veridical predicates, as in the following example:

(134) [**Situation**: Ann and Bill passed the exam, but Chris didn't. John knows that Ann and Bill passed the exam, but has no idea about whether Chris did.]

Ann and Bill passed the exam, but Chris didn't. Also, John knows who passed the exam.
(**Judgment on the second sentence**: False)

In the above example, although *know* does not trigger speaker factivity, the first sentence explicitly states the speaker's knowledge of the answer to the embedded question. Since *know* is a veridical predicate, we predict a contradiction if the second sentence is interpreted with an SE reading. Thus, Guerzoni (2007) would predict that the second sentence in (134) lacks an SE reading, which does not seem to be empirically correct. The sentence in fact seems to *prefer* an SE reading, as indicated by the fact that it is false in the given situation.

In sum, Guerzoni's (2007) analysis of the incompatibility of emotive factives with an SE reading relies on the contradiction that an SE reading would give rise to, when they are conjoined with other inferences of sentences involving emotive factives. The first problem with this approach is that one type of inference she relies on, i.e., speaker factivity, is not an *obligatory* inference, and thus the analysis incorrectly predicts SE readings to be available when speaker factivity is suspended. The second problem is that the approach predicts that mutual exclusivity of answers is sufficient for a *surprise*-statement to be contradictory. This feature of the analysis incorrectly predicts that *surprise* is incompatible with WE embedded questions with inherently mutually exclusive answers. The third problem is that it incorrectly predicts a contradiction to arise in an SE reading of questions embedded under non-emotive veridical predicates when speaker factivity is explicitly supplied in the context.

These problems are non-existent in the current approach since it is not based on a *semantic anomaly* (whether tautology or contradiction) of the truth conditions resulting from the compositional mechanism that derives an IE/SE reading, i.e., the application of X. The application of X to emotive factives does not create any semantic anomaly, it simply does not add any extra semantic effect. Thus, a sentence with emotive factives and X would have the same truth conditions as the sentence without X, namely its WE reading.

A.2 Nicolae (2013)

Summary of the analysis Nicolae (2013) treats SE readings as the semantic result of the application of the EXH operator in the embedded interrogative complement, along the lines of Klinedinst and Rothschild's (2011) analysis of SE. She further maintains that the variation of exhaustivity can be explained by a general constraint on the distribution of EXH, following a suggestion by Chierchia et al. (2012). In their grammatical analysis of scalar implicatures, Chierchia et al. (2012) account for the fact that a scalar implicature does not arise with scalar items in Downward Entailing (DE) context based on STRONGEST MEANING HYPOTHESIS (SMH; Dalrymple et al. 1998), which is defined as follows:

(135) **Strongest Meaning Hypothesis** (Chierchia et al.'s formulation)
Let S be a sentence of the form $[_S \ldots EXH(X) \ldots]$. Let S' be the sentence of the form $[_{S'}$ ...X...], i.e., the one that is derived from S by replacing $EXH(X)$ with X, i.e. by eliminating this particular occurrence of EXH. Then, everything else being equal, S' is preferred to S if S' is logically stronger than S. (Chierchia et al. 2012: 2327)

When a sentence contains a downward monotonic operator, and the sentence is ambiguous between the parse with and without EXH below the operator, SMH prefers the parse without EXH because that would give us the logically stronger reading. This accounts for the lack of scalar implicatures in the scope of DE-operators.

Arguing for a (Strawson) downward-monotonic semantics for *surprise*, Nicolae (2013) accounts for the lack of SE readings for *surprise* in a similar way. Since inserting EXH under *surprise* would lead to an LF whose assertion is logically weaker than that of the LF without EXH, SMH predicts that *surprise* lacks an SE reading.

Problems The problem with this account is that it does not extend to other emotive factives such as *be happy* and *be pleased*, which would be *upward* monotonic if we are giving them a monotonic semantics at all. It does not help to analyze all emotive factives as non-monotonic as I have done in the previous section, either. This is so since a parse with EXH under non-monotonic predicates leads to *logically independent* readings from the parses without, and SMH does not apply to LFs that are logically independent from each other. Given that SMH does not constrain the two LFs, we would predict that both LFs with and without EXH would be available.

Generally, an approach that aims to predict exhaustivity of embedded questions in terms of a monotonicity-based *global* constraint on the distribution of (some version of) the exhaustivity operator is problematic since the empirical availability of *IE* readings are not sensitive to the monotonicity of global environments while they are sensitive to the monotonicity of the embedding predicate. Observe (136) below, where *know* embedding an interrogative complement is further embedded in DE-environments (specifically, negation and *doubt*):

(136) **IE in DE environments**

a. [**Situation**: Ann and Bill came, but Chris didn't. John believes that Ann, Bill and Chris came.]
John doesn't know which students came to the party.

b. [**Situation**: I know that Ann and Bill came, but Chris didn't. I suspect that John believes that everyone of Ann, Bill and Chris came.]
I doubt that John knows which students came to the party because I think he incorrectly believes that Chris came.

The sentences can have IE readings, as indicated by the fact that they can be judged true given the situations. This is not predicted by a global principle like SMH since IE readings under DE operators would lead to weaker readings globally than the readings without exhaustification. This is also true of a variant of SMH, which says that EXH can be inserted only if the resulting reading globally strengthens the truth conditions.

Note that the availability of IE readings in DE environments has a distinct empirical status from the availability of scalar implicature in DE environments. In the following examples, strengthened interpretations of the scalar items *some* and *or* seem to be marginal at best unless the relevant scalar item is stressed:

(137) **Scalar implicature with *some* in DE environments**

a. John doesn't know some of the students because he knows all of them.

b. I doubt that John knows some of the students because I think he knows all of them.

(138) **Scalar implicature with *or* in DE environments**

a. John doesn't know Ann or Bill because he knows both of them.

b. I doubt that John knows Ann or Bill because I think he knows both of them.

The contrast between (136) and (137-138) suggests that whatever the constraint on IE readings is of different nature from the global constraint governing scalar implicature of *some* and *or*. In the current analysis, the locality of the constraint on IE readings is formulated in terms of the restriction that X always scopes at VP, as discussed in section 5.4.