Predicting the variation in exhaustivity of embedded questions*

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Abstract

Different question-embedding predicates (e.g., *know* vs. *surprise*) vary in the strength of exhaustivity involved in the interpretation of their interrogative complements (Heim 1994; Beck and Rullmann 1999). This observation has led theories to allow flexibility in the semantics of question-embedding (Beck and Rullmann 1999; George 2011), but no theory have succeeded in *predicting* the strength of exhaustivity given the lexical semantics of the embedding predicates. This paper presents a semantics of question-embedding that achieves this prediction, building on the idea that intermediate exhaustivity (Klinedinst and Rothschild 2011; Cremers and Chemla to appear) can be derived only for monotonic predicates, and that strong exhaustivity is parasitic on intermediate exhaustivity.

1 Introduction

Predicates vary with respect to the strength of exhaustivity involved in the interpretation of their interrogative complements. Specifically, most question-embedding predicates including epistemic 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, which is weaker than an SE reading. This observation led authors to adopt 'flexible' approaches to question-embedding, i.e., to allow 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 will discuss in section 6. 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).

* [Acknowledgement to be added]

In this paper, 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 the application of a version of the exhaustivity operator, which I will refer to as X, above the predicate (Klinedinst and Rothschild 2011). (§3)

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

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

(iii) Emotive predicates are non-monotonic. (§4)

(iv) X always scopes above the embedding predicate (pace Klinedinst and Rothschild) (§5.1).

(v) SE readings are derived from IE, via strengthening given an opinionatedness assumption with respect to the attitude holder. (§5.2)

Given these claims, we will see that the lack of SE readings for emotive factives falls out as the consequence of the combination of the non-monotonicity of these predicates and the claim that SE is derived from IE via strengthening.

2 Exhaustivity of question-embedding sentences

Before going into the individual claims previewed above, I will introduce the 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 kind of exhaustivity.

2.1 Three kinds of exhaustivity

It is easier to illustrate the three kinds of exhaustivity with an example. Suppose the sentence *John reported who came* was uttered in a the 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 sentece 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 Hamblin denotation) of the interrogative complement to be true. Under the IE reading, (1) is true iff John predicted all the true answers to be true while he didn't predict all the false answers 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.

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

(2) $[\![\text{who came}]\!] = \{p \mid \exists x[p = \lambda w.\textbf{came}(w)(x)]\}$

WE and SE readings can then be characterized in terms of the kind of *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 (cf. Heim 1994):

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

(4) **Strongly-exhaustive (SE) answer of** Q **in** w: $\mathsf{A}_{\mathsf{SE}}(Q)(w) := \lambda w'\forall p \in Q[p(w) \leftrightarrow p(w')]$
(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. $[\![\text{who came}]\!] = \{A, B, C\}$
   b. $\mathsf{A}_{\mathsf{WE}}([\![\text{who came}]\!])(w) = A \wedge B$ (WE-answer of (5a) in w)
   c. $\mathsf{A}_{\mathsf{SE}}([\![\text{who came}]\!])(w) = A \wedge B \wedge \neg C$ (SE-answer of (5a) in w)

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

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'.

IE readings of question-embedding sentences involve the requirement that the agent does not have the relevant attitude toward false answers (No-false-attitude condition e.g., 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 (Klinedinst and Rothschild 2011).

(7) **Intermediately-exhaustive (IE) reading** of *x Vs Q* is true in *w* iff[1] (to be revised)
$[\![V]\!](\mathsf{A}_{\mathsf{WE}}(Q)(w))(x)(w) \wedge \forall p \in Q[p(w) = 0 \rightarrow \neg[\![V]\!](p)(x)(w)]$

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 reading

Having defined WE, SE and IE readings of question-embedding sentences, let us move on to an empirical generalization about available readings of question-embedding sentences for different embedding predicates. Predicates vary in which kind of reading they are compatible with. Specifically, it has been observed that cognitive attitude predicates, such as *know* and *predict*, as well as communication predicates, such as *report*, are compatible with SE and IE readings (e.g., Groenendijk and Stokhof 1984; Cremers and Chemla to appear) whereas EMOTIVE FACTIVES, such as *be surprised*, *be happy*, *be annoyed* etc., only allow WE readings (cf. Heim 1994; Beck and Rullmann 1999). Below, we will see the readings allowed by the two classes of predicates in detail.

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 of the three students came.
⇒ (ii) John knows which of the three 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 of the three students came*) and that of (ii) (i.e., *which of the three students didn't come*) are equivalent. On the other hand, both WE and IE readings of (i) are compatible with John not knowing anything about 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*.[2]

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).[3]

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

[2] In section 5.3, 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).

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

(9) John knows/reported which of the three students came. (T under (9a); F 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 its IE or WE reading 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 while WE readings are less robust. In fact, Cremers and Chemla show that a large part of apparent effects of WE readings disappears when the implicit domain restriction for the *wh*-phrase is controlled.

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 involves a presupposition failure or is false, 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 readings for *know* involves 'believe' in the second clause of the paraphrase, as in (10b) (Spector 2005, 2006; Cremers and Chemla to appear).

Égré and Spector (to appear) 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:

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

where $[\![V]\!]_{-\mathrm{fac}}$ is equivalent to $[\![V]\!]$ except that if the latter involves a factivity presupposition, the former lacks it.

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

2.2.2 Emotive factives

Heim (1994) observes that EMOTIVE FACTIVES like *surprise* do not license an SE reading. 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. [F]It surprised John who came.
([F] indicates that the sentence is false in the given situation.)

b. It surprised John who didn't come.

If *surprise* allowed an SE reading, (12a) would be true, contrary to the fact, since the SE answer of *who 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 *who came*, i.e., 'Ann and Bill came', was *not* surprising to John while the WE answer to *who didn't come*, i.e., 'Chris didn't come' was surprising to John.

Although Heim does not consider IE readings, we have to see if emotive factives allow IE readings in order to obtain the full empirical paradigm. The IE readings of (12a) and (12b) would be paraphrased as follows, assuming that the non-factive meaning component of *be surprised* is 'not expect':

(13) a. $A \wedge B$ was surprising to John, but it is not the case that he did not expect C.
$\Leftrightarrow$ $A \wedge B$ was surprising to John, but he expected C.

b. $\neg C$ was surprising to John, but it is not the case that he didn't expect $\neg A$ and $\neg B$.
$\Leftrightarrow$ $\neg C$ was surprising to John, but he expected $\neg A$ and $\neg B$.

The reading in (13a) is compatible with the fact that (12a) is intuitively false in the situation, but (13b) is incompatible with the fact that (12b) is intuitively true due to the second conjunct of (13b). This fact suggests that IE is at least not the obligatory reading for *surprise*. However, note that this does not tell us that IE is in fact unavailable for *surprise*. The facts at this point are perfectly compatible with the view that *surprise* allows both IE and WE, and that we are simply choosing the WE reading when we interpret (12b) because of the general principle of charity.

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

(14) [Situation: John's favorite food is ramen and sushi. When he goes to a new restaurant, he will be happy if either ramen or sushi is on the menu, but it doesn't matter to him if both are on the menu as long as either one of them is. Today, he went to a restaurant and found out that ramen but not sushi is on the menu.]

a. [F]John was happy about what wasn't on the menu.

b. John was happy about what was on the menu.

Similarly to the case of *surprise* above, an SE reading would make an incorrect prediction for (14a) since John was in fact happy about the SE answer of *what wasn't on the menu*, i.e., that ramen was on the menu but sushi wasn't. On the other hand, WE readings make correct predictions about both (14a) and (14b). Finally, IE readings correctly predict that (14a) is false, but it predicts that (14b) is false as well. This is so because the IE reading of (14b) has the following paraphrase, assuming that the non-factive counterpart of *be happy that p* is 'prefer p to $\neg p$':

(15) John was happy that ramen was on the menu, and it is not the case that John would have preferred if sushi was on the menu to sushi not being on the menu.

As I suggested above, the data up to this point under-determines whether emotive factives allow IE readings. The data are compatible with two hypotheses: (i) a hypothesis that emotive factives only allow WE, and (ii) another hypothesis in which they allow both WE and IE, together with a principle, such as Principle of Charity, which prefers the reading that validates a sentence to the other reading when they disagree on the truth value of the sentence. These two hypotheses can be teased apart by testing negated sentences, as follows:

(16) a. It didn't surprise John who didn't come. [**WE**: False; **IE**: True]
b. John wasn't happy about what was on the menu. [**WE**: False; **IE**: True]

The truth values written in the square brackets indicate the truth values predicted for the sentences under each reading given the situations in (12) and (14). Native speakers have robust intuitions that both of these sentences are false given the situations. This fact suggests that IE readings are in fact unavailable for emotive factives. An ambiguity between IE and WE together with a principle that favors True judgments do not capture the False judgments for the above examples.

2.2.3 Summary of the empirical generalization

Table 2.2.3 summarizes the empirical generalization about which class of predicates allows which reading:

	WE	**IE**	**SE**
Cognitive/communication	*	✓	✓
Emotive factives	✓	*	*

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. In the following sections, I will propose a theory of question-embedding that can systematically predict this generalization.

3 Klinedinst and Rothschild's (2011) theory of IE

In this section, I will review Klinedinst and Rothschild's (2011) theory of IE, on which my analysis of emotive factive will be built. Note that the discussion in this section only concerns how IE *can* be derived, and says nothing about other readings 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 next and subsequent sections.

3.1 IE via exhaustification above the predicate

Klinedinst and Rothschild (2011) K&R give an analysis of IE readings of non-factive predicates like *predict* by positing an exhaustification operator, which I call X,[4] at the matrix level, as in the following example.

(17) [X [John predicted who came]].

X asserts its prejacent and negates all alternatives that are stronger than the prejacent:

(18) $[\![\mathsf{X}\,\varphi]\!] := \lambda w.[\![\varphi]\!](w) \wedge \forall p \in [\![\varphi]\!]^{\mathsf{Alt}}[p \subset [\![\varphi]\!] \rightarrow p(w) = 0]$

As we can see from the formula in (18), I am assuming here that every expression α has its ORDINARY-SEMANTIC VALUE, $[\![\alpha]\!]$, and its ALTERNATIVE-SEMANTIC VALUE, $[\![\alpha]\!]^{\mathsf{Alt}}$ (cf. Rooth 1985). The ordinary semantic value and the alternative-semantic value of an interrogative clause are defined as follows:

(19) $[\![\text{who came}]\!](w) = \lambda w'.\forall x[\mathbf{came}(x)(w) \rightarrow \mathbf{came}(x)(w')]$

(20) $[\![\text{who came}]\!]^{\mathsf{Alt}} = \{p \mid \exists w[p = \lambda w'.\forall x[\mathbf{came}(x)(w) \rightarrow \mathbf{came}(x)(w')]\}$

In other words, the ordinary-semantic value of *who came* is its *actual* WE answer, and its alternative-semantic value is the set of *possible* WE answers. Thus, when the domain of *who* is Ann, Bill and Chris, and only Ann and Bill came in w, the two types of semantic values will be (21) and (22), respectively. Note that the alternative-semantic value of an interrogative clause is equivalent to the closure under conjunction of the Hamlin denotation.

(21) $[\![\text{who came}]\!](w) = A \wedge B$

(22) $[\![\text{who came}]\!]^{\mathsf{Alt}} = \{A, B, C, A \wedge B, B \wedge C, C \wedge A, A \wedge B \wedge C\}$

Alternative-semantic values are composed by the rule of Point-wise Functional Application (Hamblin 1973).[5] Thus, the alternative-semantic value of the scope of X in (17) comes out as the set of propositions of the form 'John predicted p', where p is a member of (20) or, equivalently, (22):

(23) $[\![\text{John predicted who came}]\!]^{\mathsf{Alt}}$
$= \{p \mid \exists w[p = \lambda w''.\mathbf{predicted}(\mathbf{j}, \lambda w'\forall x[\mathbf{came}(x)(w) \rightarrow \mathbf{came}(x)(w')], w'')\}$

Let us see how an IE reading is derived from the structure in (17). Since X asserts its prejacent and negates all alternatives to the prejacent that are logically stronger, we derive the following truth conditions for (17) in the evaluation world w where only Ann and Bill came:

(24) $[\![(17)]\!](w) = 1$ iff $\mathbf{predicted}(\mathbf{j}, A \wedge B, w) \wedge \neg\mathbf{predicted}(\mathbf{j}, A \wedge B \wedge C, w)$

The first conjunct of the above truth-conditions simply says that John predicted the actual WE answer in w and the second conjunct states that it is not the case that John predicted $A \wedge B \wedge C$,

[4] Klinedinst and Rothschild themselves call the operator EXH, following the literature on grammatical theory of scalar implicature (e.g., Chierchia et al. 2012). However, since the definition and the syntactic properties of the relevant operator in this paper crucially differs from the operator assumed in the the literature on scalar implicature, I use a different symbol for the operator.

[5] Point-wise Functional Application is defined as follows: If $[\![\alpha]\!]^{\mathsf{Alt}} \subseteq D_{\langle\sigma,\tau\rangle}$ and $[\![\beta]\!]^{\mathsf{Alt}} \subseteq D_{\sigma}$, then $[\![\alpha\ \beta]\!]^{\mathsf{Alt}} := \{d \in D_{\tau} \mid \exists a \in [\![\alpha]\!]^{\mathsf{Alt}} \exists b \in [\![\beta]\!]^{\mathsf{Alt}}[d = a(b)]\}$

which is the only possible WE answer that is logically stronger than the actually true one, i.e., $A \wedge B$. The truth-conditions in (24) are equivalent to the following, given the distributivity of **predicted**. This is exactly the IE reading of *John predicted who came* in w.

(25) $[\![(17)]\!](w) = 1$ iff $\textbf{predicted}(\textbf{j}, A \wedge B, w) \wedge \neg\textbf{predicted}(\textbf{j}, C, w)$

3.2 The case of factive predicates

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 who came* will be the following:

(26) $[\![\mathsf{X}\,[\text{John knows who came}]]\!](w) = 1$ iff $[\![\text{know}]\!](A \wedge B)(\textbf{j})(w) \wedge \neg[\![\text{know}]\!](A \wedge B \wedge C)(\textbf{j})(w)$

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 Appendix A, I will give a semantics of factive predicates that does not encounter this problem, which systematically derives the fact that the members of $[\![\text{know } p]\!]^{\mathsf{Alt}}$ do not presuppose p. However, since going into the details of this issue disrupts the main discussion, I will simply assume a brute-force solution of the issue at this point. The brute-force solution is to follow the descriptive generalization from section 2.2 and redefine X using the semantic interpretation function $[\![\alpha]\!]_{-\text{fac}}$, which returns a non-factive counterpart of $[\![\alpha]\!]$ (see Égré and Spector to appear for a similar formulation):

(27) $[\![\mathsf{X}\,\varphi]\!] := \lambda w.[\![\varphi]\!](w) \wedge \forall p \in [\![\varphi]\!]^{\mathsf{Alt}}_{-\text{fac}}[p \subset [\![\varphi]\!]_{-\text{fac}} \rightarrow p(w) = 0]$

This definition achieves the outcome that what is negated in IE readings of factive predicates are their non-factive counterparts. Again, note that this is a formulation posited solely for expository purposes, and the 'official' formulation given in Appendix A achieves the same result without positing a special semantic interpretation function like $[\![\alpha]\!]_{-\text{fac}}$.

4 Prediction for emotive factives

The previous section only mentioned *know* and *predict*, but what does the theory of IE predict for emotive factives? To see this, let us first consider the general property of X. Since X is defined to negate *logically stronger* alternatives, the outcome of an X-application depends on the monotonicity property of the embedding predicate.[6] In particular, if the embedding predicate

[6] Monotonicity and non-monotonicity can be defined as follows:

(1) a. A proposition-embedding predicate α is MONOTONIC iff one of the following holds:
- for any p, p' such that $p \subset p'$, $[\![\alpha]\!](p) \subset [\![\alpha]\!](p')$ (UPWARD MONOTONICITY)
- for any p, p' such that $p \subset p'$, $[\![\alpha]\!](p') \subset [\![\alpha]\!](p)$ (DOWNWARD MONOTONICITY)

b. A predicate α is NON-MONOTONIC iff α is not monotonic.

is non-monotonic, the application of X can be vacuous. This is so because the alternative-semantic values of the prejacent for X can be *logically independent* from the prejacent when the embedding predicate is non-monotonic.

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

(28) [X [α [who came]]].

In the world w where Ann came, but Bill didn't, the truth conditions of (28) will be the following:

(29) $[\![(28)]\!](w) = 1$ iff $[\![\alpha]\!](A)(w) \wedge \forall p \in \{[\![\alpha]\!](A), [\![\alpha]\!](B), [\![\alpha]\!](A \wedge B)\}[p \subset [\![\alpha]\!](A) \rightarrow p(w) = 0]$

What is crucial here is that, if the embedding predicate α is non-monotonic, it is not guaranteed that any proposition in the set of alternatives, $\{[\![\alpha]\!](A), [\![\alpha]\!](B), [\![\alpha]\!](A \wedge B)\}$, is logically stronger than the prejacent, $[\![\alpha]\!](A)$. If in fact no alternative is stronger than the prejacent, the second conjunct of (29) will be tautological, meaning that the application of X is vacuous in such a case.

I argue that this is exactly what happens with emotive factives: emotive factives are non-monotonic, and the logical relationship between sentences with emotive factives cannot be determined by the logical relationship between the embedded propositions. For instance, *be happy* is non-monotonic in that the following inferences are invalid:

(30) John is happy that Ann and Bill came. $\not\models$ John is happy that Bill came.

(31) John is happy that Ann came. $\not\models_s$ John is happy that Ann and Bill came.

($\models_s$: STRAWSON-ENTAILMENT)[7]

In (30), we see that *be happy* is not upward monotonic. The counterexample to the inference can easily be constructed with a case where John cares about Ann, but not about Bill. In (31), we see that *be happy* is not downward monotonic. Here, we use the notion of Strawson-entailment because the presupposition of the consequent potentially disrupts the entailment. What we see is that even if we use Strawson-entailment, which is a weaker notion of entailment than the ordinary entailment, the entailment is not valid. The counterexample of the entailment can be constructed with a scenario where John likes Ann, but hates Bill. The lack of entailment relations between *be happy that p* and *be happy that p'* also holds for any logically independent pair p and p'. Parallel facts holds for *be surprised* as well.

Non-monotonicity of emotive predicates has been defended by Asher (1987), Heim (1992), and more recently, Lassiter (2011) and Anand and Hacquard (2013). Here, I formulate a non-monotonic semantics for *be happy* based on the ordering-based semantics for desire predicates by Heim (1992):

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

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

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

[7] Strawson-entailment $\models_s$ is defined as follows, where ψ_π is ψ with the presupposition π (von Fintel 1999):

$$\varphi \models_s \psi_\pi \Leftrightarrow \varphi \wedge \pi \models \psi$$

(34) $p >_{x,w} p'$ iff $\forall w' \in p' \exists w'' \in p$: x perfers w'' to w' in w

In this semantics, the 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.[8] A similar ordering-based semantics can be given for *surprise* based on the expectedness scale.

We thus predict that the application of X above emotive factives is vacuous, and that they lack IE readings. More generally, I claim that this picture accounts for the contrast between cognitive/communication predicates and emotive factives in the availability of IE readings. Cognitive/communication predicates have lexical semantics involving a *universal quantification* over certain accessible worlds. Thus, these predicates are monotonic and 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 (32). 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.

5 SE readings

5.1 X in an embedded position?

Having accounted for the distribution of IE readings, I now move on to the account of SE readings. Klinedinst and Rothschild (2011) derive SE readings by placing X in an embedded position, as in (35) below:

(35) John predicted [X who came].

However, allowing this possibility would predict that SE readings are available regardless of embedding predicates. In particular, it would run into the incorrect prediction that emotive factives allow SE readings. 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 **?** for an argument against this approach.

[8] Thus, technically, the monotonicity property of emotive factives depends on the similarity relation among worlds. This means, in order to predict the vacuity of X-application above emotive factives, X has to be defined so that it negates alternatives that are stronger than the prejacent *under any similarity relation*. Since no pair of propositions p and p' is such that *be happy* p is logically stronger than *be happy* p' under any similarity relation, the application of X above *be happy* is predicted to be vacuous in this formulation.

5.2 SE readings via IE readings

Thus, allowing the structure as in (35) in principle while blocking X from appearing below emotive factives seems difficult. Given this difficulty, I claim that X is syntactically banned from appearing in an embedded complement as in (35). That is, the only syntactic position for X is the matrix position, as follows:[9]

(36) X [John predicted who came].

How do we then derive SE readings? I argue that *SE readings are derived from IE readings via strengthening* mediated by the opinionatedness assumption with respect to the subject. Here, an opinionatedness assumption refers to the assumption that an agent's relevant attitude is determinate for each answer of the relevant question. That is, in the case of (36), the assumption states that John had determinate prediction about whether each person came. Below is an illustration of how the IE reading of (36), conjoined with the opinionatedness assumption, leads to an SE reading:

(37) X [John predicted who came]. [Situation: Ann and Bill came, but Chris didn't.]

(i) **IE:** John predicted that Ann and Bill came and it is not the case that he predicted that Chris came.

(ii) **Opinionatedness**: John had determinate predictions about whether Ann came, whether Bill came and whether Chris came.

(i) & (ii) **Conclusion**: John predicted that Ann and Bill came and he predicted that Bill didn't come. (= **SE**)

Evidence for SE readings discussed in the previous literature can be treated similarly. For example, the assumption of the inference of the form in (38) discussed by Groenendijk and Stokhof (1984) is analyzed as involving an IE structure as in (36) and the opinionatedness assumption that John had determinate predictions about whether each person came.

(38) John predicted who came. ⇒ John predicted who didn't come.

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 argument for the current theory of SE against a more standard theory in which SE is generated as a semantic value comes from embedding under downward-entailing (DE) operators. The difference arises from the fact that strengthening with opinionatedness is a *global* operation, i.e., it projects beyond DE operators. On the other hand, SE as a semantic value does not project out of DE operators. Following is an example of such embedding structures: negation embeds the question-embedding predicate *predict*.

(39) [Situation: Ann and Bill came, but Chris didn't. John predicted that Ann and Bill would come, but didn't make any prediction about whether Chris would come.]
John didn't predict who would come.

[9] In a later section, I will refine this restriction and claim that X in fact can only scope at the matrix VP level.

Under the current theory, (39) would have the LF structure in (40a).[10] On the other hand, a theory that derives SE as a semantic value (implemented here with an embedded X) would have the structure as in (40b).

(40) a. $[\![$Neg [X John predicted [who would come]]$]\!](w) = 1$
iff $\neg$**predict**(**j**, $A \wedge B, w) \vee$ **predict**(**j**, $C, w)$

b. $[\![$Neg [John predicted [X who would come]]$]\!](w) = 1$
iff $\neg$**predict**(**j**, $A \wedge B, w) \vee \neg$**predict**(**j**, $\neg C, w)$

As can be seen above, we derive a stronger reading for (40a) than for (40b). Strengthening with opinionatedness does not collapse the two readings because strengthening can only apply globally. The predictions of the IE + strengthening theory and the semanticized SE theory (for example with embedded X) are summarized in the following table:

(41)

	Truth conditions of (39)	**Truth value of (39)**
(40a) + strengthening	**predict**(**j**, $\neg(A \wedge B), w) \vee$ **predict**(**j**, $C, w)$	False
(40b)	$\neg$**predict**(**j**, $A \wedge B, w) \vee \neg$**predict**(**j**, $\neg C, w)$	True

Empirically, speakers have a strong intuition that (39) is *false* in the given situation. This fact strongly favors the current account of SE over semanticized accounts of SE.[11]

5.3 Source of strengthening

Above, I remained fairly vague about the what the exact source of opinionatedness assumptions is, except that they have to apply globally. In this section, I propose a concrete theory of opinionatedness in terms of lexical presuppositions. I propose that certain attitude predicates are ambiguous between the version with the 'excluded-middle' presupposition, and the version without such a presupposition. Below, (42a) is the lexical entry of *predict* without the presupposition, and (42b) is the one with the excluded middle presupposition.

(42) a. $[\![\text{predict}]\!] = \lambda p_{\langle s,t\rangle}\lambda x\lambda w.$**predict**$(x, p, w)$

b. $[\![\text{predict}_{\text{EM}}]\!] = \lambda p_{\langle s,t\rangle}\lambda x\lambda w : [$**predict**$(x, p, w) \vee$ **predict**$(x, \neg p, w)].$**predict**(x, p, w)

I argue that this kind of presupposition is the source of opinionatedness that drives the strengthening of IE into SE. For example, when (42b) embeds a question and X scopes above it, we predict the following truth conditions in w, where John and Bill came but Bill didn't:

(43) $[\![$X John predicted$_{\text{EM}}$ [who would come]$]\!](w) = 1$
iff $[\![\text{predicted}_{\text{EM}}]\!](A \wedge B)($**j**$)(w) \wedge \neg[\![\text{predicted}_{\text{EM}}]\!](C)($**j**$)(w)$

[10] I am here ruling out the structure as follows:

(i) X [Neg [John predicted [who would come]]]

since it makes an implausible prediction that the sentence is contradictory as soon as there are multiple people who came. When A and B are true, the prejacent of X in (i) states that 'John didn't predict $A \wedge B$'. X furthermore negates all stronger alternatives, which include 'John didn't predict A' and 'John didn't predict B'. Overall, this results in a contradiction.

[11] Of course, the data alone is compatible with a WE reading of (39), but we have already ruled out WE readings for *predict* in section 2.2.1.

Because of the excluded middle presupposition of $predicted_{\mathrm{EM}}$, we can strengthen the second conjunct of the above truth conditions, and derive an SE reading, as follows:

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

In this formulation, the fact that the opinionatedness projects negation, as discussed in the previous subsection follows from the presuppositional nature of the assumption.

The excluded-middle presupposition as in (42b) is shown to capture the neg-raising behavior of some attitude predicates (Bartsch 1973; Gajewski 2005) (see also Romoli 2013 for problems with a presuppositional account of neg-raising). Thus, the current account predicts that there should be a correlation between a tendency for a predicate to neg-raise and a tendency for the same predicate to allow an SE reading. This is so because both of these tendencies arise from the preference between two lexical entries as in (42). It is worth noting, however, that factive predicates are not good test cases here since relevant excluded-middle presuppositions for factive predicates concerns the *non-factive* component of the semantics of these predicates, and its effect cannot be seen as a neg-raising property. Factivity always disrupts neg-raising. Whether this prediction actually holds for a large scale of data is an empirical question that I have to leave for another occasion, but preliminary support comes from communication predicates.

Some communication predicates that encode manners of conveying information, such as *write down*, *indicate* and *read*, are known to resist neg-raising, as shown below.

(45) a. John didn't **write down** that Ann came. $\not\Rightarrow$ John **wrote down** that Ann didn't come.
b. John didn't **indicate** that Ann came. $\not\Rightarrow$ John **indicated** 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:

(46) a. John **wrote down** which of the ten students came. $\not\Rightarrow$ John **wrote down** which of the ten students didn't come.
b. John **indicated** which of the ten students came. $\not\Rightarrow$ John **indicated** which of the ten students didn't come.
c. John **read** which of the ten students came. $\not\Rightarrow$ John **read** which of the ten students didn't come.

This is in contrast to cognitive predicates, such as *predict* and *guess* which licenses neg-raising more readily than we see in (45):

(47) a. John didn't **predict** that Ann would come. $\overset{?}{\Rightarrow}$ John **predicted** that Ann wouldn't come.
b. John didn't **guess** that Ann came. $\overset{?}{\Rightarrow}$ John **guessed** that Ann didn't come.

(48) a. John **predicted** which of the ten student would come. $\Rightarrow$ John **predicted** which of the ten students wouldn't come.
b. John **guessed** which of the ten students came. $\Rightarrow$ John **guessed** which of the ten students didn't come.

This correlation between the neg-raising property and the tendency to allow an SE reading receives a natural explanation in the current account: neg-raising and SE readings arise from

the same source, i.e., the excluded-middle presupposition associated with the predicates. In fact, it is intuitively plausible that the communication predicates, such as *write down*, *indicate* and *read* do not involve the excluded-middle presupposition. As argued by Heim (1994), Beck and Rullmann (1999) and Theiler (2014), communication predicates have a 'literal' component in their meaning which concerns manners of communication. This meaning component is intuitively less plausible to be subject to an excluded-middle presupposition, compared to cognitive predicates. For example, the following presupposition does not seem to be triggered by the use of the predicate *write down* for any relevant proposition p.

(49) John wrote down p or John wrote down $\neg p$

It is totally conceivable that John simply didn't write down p nor $\neg p$. This is in contrast to cognitive predicates. It is more conceivable that the use of the predicate *guess* triggers the following presupposition for any relevant proposition p.

(50) John guessed p or John guessed $\neg p$

That is, John's cognitive state has to be determinate about whether p or $\neg p$ when p is relevant.

In sum, I propose that the source of opinionatedness that drives the strengthening from IE to SE is excluded-middle presuppositions encoded in some embedding predicates. This formulation predicts that a predicate's neg-raising property and its tendency to allow SE readings correlate. This prediction is shown to be borne out in a contrast between certain communication predicates and cognitive predicates.

5.4 Interim summary and the syntactic properties of X

So far, the current theory of exhaustivity of embedded questions accounts for the distribution of WE, IE and SE readings except for the lack of WE readings for cognitive/communication predicates. The empirical generalization stated in section 2.2.1 is repeated in the following table:

(51)

	WE	**IE**	**SE**
cognitive/communication	*	✓	✓
emotive factives	✓	*	*

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, either. The only interpretation available for emotive factives is the default reading, which is the WE reading.

As I noted above, the theory at the current form does not account for the unavailability of WE readings for cognitive/communication predicates. I address this issue by simply stipulating that X is syntactically obligatory in the clause containing the question-embedding predicate. For cognitive/communication verbs, the structure with X results in either IE or SE readings while, for emotive factives, the structure results in WE readings since the effect of X is vacuous.

Another important syntactic property of X is that its scope is always at the matrix VP level. As we saw in section 5.2, X scopes below negation. Furthermore, as Klinedinst and Rothschild (2011) point out, X seems to scope below subject quantifiers. Consider the following example:

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

If X is globally applied to (52), it is predicted to be true only if no student made any actually false prediction about who came. This reading seems to be unavailable.

Hence, I conclude here that X obligatorily adjoins to the VP headed by question-embedding predicates. One way to derive this feature of X is to lexically encode its meaning in the semantics of question-embedding predicates. As far as the data considered in this paper are concerned, the two formulations—positing the obligatory operator X and encoding it to the lexical semantics of predicates—are equivalent.

6 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.

6.1 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:

(53) 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, (53a) is felicitous while (53b) is odd. According to Guerzoni and Sharvit (2007), this is due to the speaker factivity triggered by *realize*, i.e., that (53b) presupposes speaker's knowledge of the answer to the embedded question *who came*. That is, the oddness of (53b) arises because the context violates the speaker factivity. In contrast, (53a) is felicitous, suggesting that *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:

(54) 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)

(55) 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 (54), the sentence with *find out*, (54a), is felicitous while the sentence with *surprise*, (54b), is odd. This contrast disappears in (55), where the context validates the speaker factivity.

Guerzoni (2007) claims that speaker factivity automatically leads *surprise*-statements with an SE complement into a contradiction. The contradiction arises when speaker factivity is taken together with quality implicature and 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'.)[12]

(56) 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 (56a) and (56b) results in the following statement in (57) (see Guerzoni 2007 for a proof), which contradicts the statement in (56c).

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

Here, the primary scalar implicature arises as the result of neo-Gricean quantity implicature with the following set of alternatives.[13]

(58) 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 (56), 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:

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

[13] These alternatives are stipulated by Guerzoni, but the fact that (57) 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.

(59) 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 (59) can be seen by the fact that the conjunction of (59a) and (59b) does not entail the following, assuming that A and B are logically independent.

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

Stated in more general terms, Guerzoni's (2007) analysis makes use of the following logical fact: a conjunction of (61-i) and (61-ii) entails the proposition where the **K**-operator in (61-i) is distributed over the two disjuncts, as in (62), if we also assume that the operator O is veridical, i.e., (61-iii), and that propositions p and q are mutually exclusive, i.e., (61-iv).

(61) 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**]

(62) **Conclusion from (61i-iv)**: $\mathbf{K}(O(p)) \vee \mathbf{K}(O(q))$

The proposition in (62) contradicts the proposition in (63), which corresponds to the primary scalar implicature of the sentence that has (61-i) as its quality implicature.

(63) $\neg\mathbf{K}(O(p)) \wedge \neg\mathbf{K}(O(p))$ [**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:

(64) 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 fact in (64) 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 (64) 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.

(54) 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 agent knows the correct answer to the complement. That is, the oddness of (54b) 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.

(65) 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.

(66) 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 those who passed.

One might argue that what is happening in (65-66) 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 (65-66) still 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 *who was the winner* are mutually exclusive.

(67) 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. Systematic contradictions in natural language according to Gajewski (2002) are those based on *logical* vocabularies in the sentence, but (67) does give rise to a contradiction under such a 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 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:

(68) [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. ^{F}John knows who passed the exam.

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 (68) 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.

Realize* and *predict 100% correctly Before concluding the section, I discuss two predicates that Guerzoni and Sharvit (2007) and Guerzoni (2007) claim to behave in the same way as emotive factives, namely *realize* and *predict 100% correctly*.[14] I will start with *realize*. Guerzoni and Sharvit (2007) give the following example to illustrate the claim that *realize* selects for a WE reading.

(69) #John didn't realize which students came because he didn't realize that Bill didn't come.

The above example is true only under the SE reading of the first sentence. Thus, its oddity suggests that *realize* is not compatible with an SE reading. However, note that this evidence alone does not tell us that *realize* selects for a WE reading, as the possibility of an IE reading has not been considered yet. In fact, we see that an IE reading is possible for *realize* since a minimal variant of (69) with the *because*-clause specifying John's false belief sounds felicitous:

(70) John didn't realize which students came because he incorrectly thinks that Bill came.

Note that (70) can be true either under an SE or IE reading. Taken together with (69), the data suggest that an IE reading is possible for *realize*. Finally, the intuitive falsity of the following sentence in the given situation suggests that a WE reading is in fact impossible for *realize*.

[14] Guerzoni (2007) also mentions *anticipate* as a predicate in this class, citing Berman (1991). However, since *anticipate* seems to allow an SE complement empirically, I do not intend to classify it with emotive factives in this paper. The most natural interpretation of the following sentence is that it is possible for the speaker to (correctly) anticipate in advance whether each invitee will come to the party, which corresponds to the SE reading.

(i) I can anticipate who will come to the party.

(71) [Situation: Ann and Bill came to the party, but Chris didn't. John didn't participate in the party, and didn't know at all who was at the party. However, after some research, he concluded that Ann, Bill and Chris came to the party.]
F John realized who came to the party.

Thus, I submit that *realize* only allows an IE reading, contra Guerzoni and Sharvit's (2007) claim that it only allows a WE reading. Under the analysis proposed in this paper, this behavior of *realize* can be accounted for by analyzing the predicate as a (Strawson-)monotonic predicate that does not come with the excluded-middle presupposition. Strawson-monotonicity is in fact plausible for *realize* since the assertion of *x realizes that p* arguably consists of a monotonic doxastic attitude. The lack of the excluded-middle presupposition has to be lexically stipulated, and it is a task for a future research to investigate the connection between it and the evidence for speaker factivity of *realize*, as illustrated in (53) above.

As for obligatory WE readings under *predict 100% correctly*, I treat them as an instance of the general phenomenon of QUANTIFICATIONAL VARIABILITY EFFECT (QVE; Berman 1991; Lahiri 2002). If we assume that X is in complementary distribution with Q(uantificational)-adverbs, we predict that question-embedding sentences with Q-adverbs give rise to WE readings. In this paper, I follow Lahiri's (2002) analysis of QVE based on INTERROGATIVE RAISING. Interrogative raising is an LF-movement operation proposed by Lahiri (2002) which moves an interrogative complement above a Q-adverb like *mostly* adjoining to the matrix VP. The complement leaves a propositional trace behind, and creates a binder index *below* the Q-adverb. The movement is illustrated in the following:

(72) [[**who came**] [{mostly/100% correctly} [2 [John predicted p_2]]] (Interrogative Raising)

Assuming that *100% correctly* is a quantifier over propositions having the denotation in (73), the LF in (72) is predicted to have the semantic value in (74).[15]

(73) $[\![100\%\text{ correctly}]\!] = \lambda P_{\langle st,t\rangle}\lambda Q_{\langle s,st\rangle}\lambda w.\forall p[[\exists w'[p = Q(w')] \wedge p(w)] \rightarrow P(p)]$

(74) $[\![(72)]\!] = \lambda w.\forall p[[\exists w'[p = [\![\text{who came}]\!](w')] \wedge p(w)] \rightarrow [\![\text{predicted}]\!](p)(\mathbf{j})(w)]$

This semantics correctly predicts that (72) only talks about John's predictions about true answers to *who came*, and says nothing about false answers and false predictions. That is, (72) gives rise to a WE readings rather than IE or SE readings.

6.2 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

[15] The definition in (73) states that propositions in the restrictor of *100% correctly* have to be *true* propositions. This does not work in the general case, since Q-adverbs like *mostly* in sentences with non-veridical predicates like *agree* have to be able to quantify over non-true propositions as well. Lahiri (2002) treats this issue by making restrictors of Q-adverbs sensitive to a contextual variable, and making embedding predicates determine this contextual value through intermediate accommodation. I have to leave the general issue of how QVE can be incorporated in the current analysis for future research.

suggestion by Chierchia et al. (2012). In their grammatical analysis of scalar implicature, Chierchia et al. (2012) account for the fact that 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:

(75) **Strongest Meaning Hypothesis** (Chierchia et al.'s formulation)
Let S be a sentence of the form $[_S \ldots O(X) \ldots]$. Let S' be the sentence of the form $[_{S'} \ldots X \ldots]$, i.e., the one that is derived from S by replacing $O(X)$ with X, i.e. by eliminating this particular occurrence of O. 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 implicature 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.

7 Conclusions

In this paper, I presented a semantic theory of question-embedding which is properly constrained to capture the variation in their exhaustive interpretations. 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 when it is 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 with data involving negation as well as a correlation between the tendency to license neg-raising and the tendency to allow SE among question-embedding predicates.

The current analysis shows another empirical domain in which the distinction between REPRESENTATIONAL and NON-REPRESENTATIONAL/emotive attitudes (e.g., *know* vs. *be happy*) (Bolinger 1968) is crucial in accounting for selectional properties of attitude predicates, along with recent results by Villalta (2008) and Anand and Hacquard (2013). 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

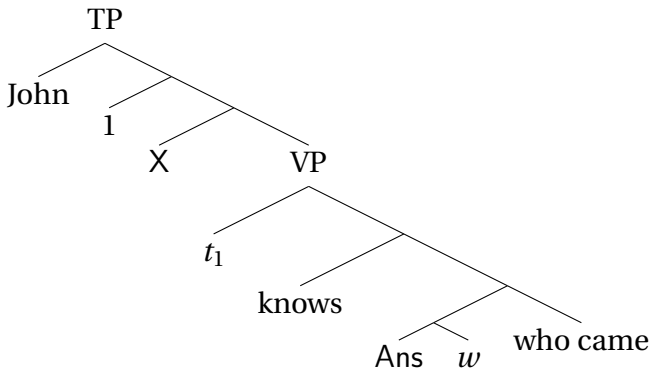
readings are accessed faster than SE readings. If SE readings are derived from IE readings, as proposed in this paper, this result receive a natural explanation since the computations required to derive an IE reading are subset of the computations required to derive an SE reading.

A Dealing with factive predicates

As discussed in section 3.2, Klinedinst and Rothschild's (2011) original definition of X doesn't account for IE readings of factive predicates. In this section, I provide a semantics of factive predicates that avoids this problem, partly following Theiler (2014). The crucial idea is to make an operator applying to embedded clauses, i.e., the Ans-operator from Dayal (1996), responsible for factivity, rather than the embedding predicate. This treatment effectively makes the alternatives for X embedding factive predicates 'deprived of' factivity, offering a solution to the problem discussed in 3.2. Note that the compositional system that will be proposed in this section partly overwrites the simpler system introduced in the main text.

I will first illustrate a solution for the problem of factivity in alternatives, and then move on to show how factivity is captured in declarative-embedding. In this analysis, the structure involving a factive predicate and an interrogative complement looks like the following (I will use an LF syntax with explicit world variables to make the illustration simpler):

(76)



Denotations of factive predicates like *know*, Ans-operator and the interrogative clause *who came* are defined as follows:

(77) $[\![\text{know}]\!] = \lambda p_{\langle s,t\rangle}\lambda x\lambda w.\text{JDOX}_x^w \subseteq p$
(JDOX_x^w := the set of worlds compatible with x's justifiable belief in w)

(78) $[\![\text{Ans}]\!](w)(Q)$ is defined if $\exists! p \in Q[p(w) \wedge \forall p' \in Q[p'(w) \rightarrow p \subseteq p']]$.
If defined, $[\![\text{Ans}]\!](w)(Q) = \iota p \in Q[p(w) \wedge \forall p' \in Q[p'(w) \rightarrow p \subseteq p']]$

(79) $[\![\text{who came}]\!] = \{p \mid \exists X[p = \lambda w.\forall x < X[\textbf{came}(x, w)]]\}$

The predicate *know* in (77) does *not* trigger factivity. Instead, it just means 'justifiably believe'. $\text{Ans}(w)(Q)$ presupposes that Q includes a unique most informative true answer, and returns the answer when defined. Assuming that only Ann and Bill came in w, the result of applying Ans to w and *who came* results in the following proposition, which can then be the first argument of *know*.

(80) $[\![[\text{Ans } w] \text{ who came}]\!] = A \wedge B$

The alternative-semantic value of embedded complements are generated by varying the world variable in the sister position of Ans. This simply creates the set of possible weakly exhaustive answers, as was the case in section 3. Combining this set with the alternative-semantic value of *know* with Point-wise Functional Application, we get the following set of alternatives for the VP in (76).

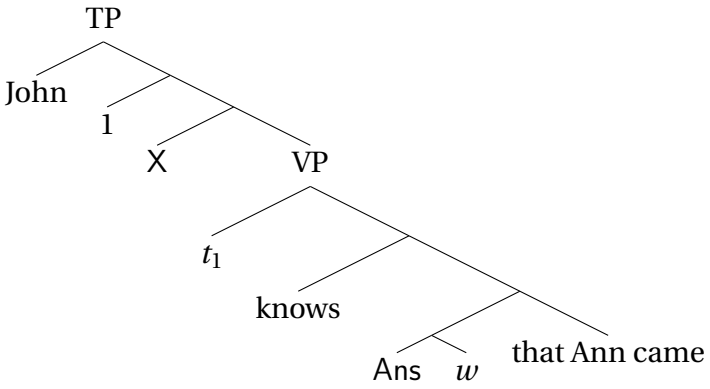
(81) $[\![\text{VP}]\!]^{\text{Alt},g} = \{p \mid \exists w'[p = \lambda w.\text{JDOX}^{w}_{g(1)} \subseteq [\![\text{Ans}]\!](w')([\![\text{who came}]\!])]\}$

Note that propositions in this set do *not* presuppose factivity crucially because the embedding predicate is simply defined as 'justfiably believe'. Negation of alternatives from this set that are stronger than the prejacent results in the appropriate IE reading of (76).

How does this analysis capture factivity? A crucial idea behind the analysis is that declarative complements of question-embedding predicates are trivial cases of embedded questions (Uegaki 2014). That is, a declarative clause denotes a singleton proposition-set and occupies the same structural position as an interrogative complement, as illustrated below:

(82) $[\![\text{that Ann came}]\!] = \{A\}$

(83)



When Ans is applied to w and a *singleton* set of a proposition, the presupposition of Ans ends up presupposing that the unique proposition in the set is true in w. This presupposition is projected by the embedding predicate. For example, *know* in (84) below projects the presupposition that A is true in w.

(84)
$$\begin{aligned}[\![\text{know [[Ans } w\text{] [that Ann came]]}]\!] &= [\![\text{know}]\!]([\![\text{Ans}]\!](w)(\{A\})) \\ &= \lambda x \lambda w'.\text{JDOX}^{w'}_{x} \subseteq [\![\text{Ans}]\!](w)(\{A\})\end{aligned}$$

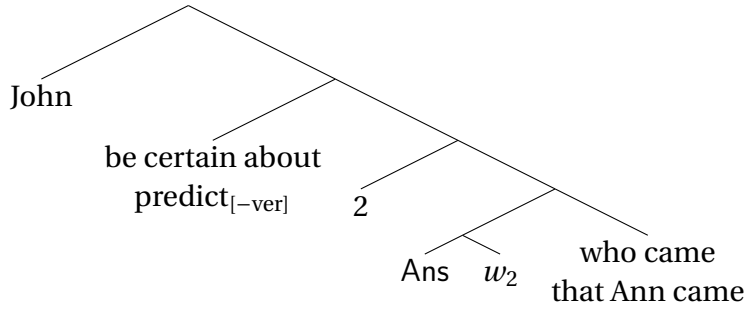
Since the free variable w ends up becoming the evaluation world, the presupposition that A is true in w is equivalent to factivity. In other words, by analyzing declarative-embedding as a limiting, singleton, case of question-embedding, we can analyze factivity as a limiting case of veridicality presupposed by the Ans-operator.

The account does not overgenerate factivity to non-factive predicates. This is so because non-factive predicates are analyzed as *intensional* predicates that can evaluate the Ans-operator in a non-evaluation world. That is, non-factive predicates like *be certain about* or (non-factive version of) *predict* have the following kind of denotation that takes a propositional concept as its first argument:

(85) $[\![\text{predicted}_{[-\text{ver}]}]\!]^{w} = \lambda \mathscr{P}_{\langle s,st\rangle} \lambda x.\exists w'[\text{PRD}^{w}_{x} \subseteq \mathscr{P}(w')]$

The propositional concept which will be the first argument of non-factive predicates is created by abstracting over the world argument of Ans, as in the following structure:

(86)



Given this formulation, it is correctly predicted that declarative embedding in (86) does not trigger factivity, as *predict that Ann came* has the following semantic value:

(87) $[\![\text{predict [2 [[Ans } w_2\text{] [that Ann came]]]}]\!] = [\![\text{predict}]\!](\lambda w'.[\![\text{Ans}]\!](w')(\{A\})) = \lambda x \lambda w.\exists w'[\text{PRD}^x_w \subseteq [\![\text{Ans}]\!](w')(\{A\})]$

Assuming that existential quantification projects presuppositions existentially, the presupposition of (87) is that *A can* be true. This is certainly not factivity, and is in fact a plausible presupposition assuming that the domain of the existential quantification in (87) is *x*'s doxastic alternatives.

Thus, the account proposed here treats the distinction between factive and non-factive predicates as the distinction between extensional and intensional predicates. Given the definition of Ans, the former class of predicates derive veridicality when they embed an interrogative complement, which boils down to factivity in the case of declarative-embedding. The latter class of predicates are defined to be able to evaluate Ans in a non-actual world. This results in non-veridicality when they embed an interrogative complement and non-factivity when they embed a declarative complement. It is worth noting that this formulation correctly captures Égré and Spector's (to appear) generalization that a predicate is factive with respect to declarative-embedding iff it is veridical with respect to interrogative-embedding.

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