

# Predicting the variation in exhaustivity of embedded questions\*

Wataru Uegaki

February 24, 2015

## 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 posit flexibility in the semantics of question-embedding (Beck and Rullmann 1999; George 2011), but no theory has 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 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 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 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 monotonic.
  - Vacuous if the embedding predicate is non-monotonic.
- (iii) Emotive predicates are non-monotonic. (§4)
- (iv) There is no exhaustification in the embedded clause (pace Klinedinst and Rothschild) (§??).
- (v) SE readings are derived from IE, via the mechanism of neg-raising. (§??)

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 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 kind of exhaustivity.

### 2.1 Three kinds of exhaustivity

It is easier to illustrate the three kinds of exhaustivity with examples. 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 sentence 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 reported all the true answers to be true while he didn’t report 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. 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 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 Hamblin denotation of *who came* is the set of propositions of the form ‘*x came*’ as in the following:

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

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***:  $A_{WE}(Q)(w) := \lambda w' \forall p \in Q[p(w) \rightarrow p(w')]$   
(i.e., the conjunction of all propositions in *Q* that are true in *w*.)
- (4) **Strongly-exhaustive (SE) answer of *Q* in *w***:  $A_{SE}(Q)(w) := \lambda w' \forall p \in Q[p(w) \leftrightarrow p(w')]$   
(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. The Hamblin denotation of *who came*:  $\{A, B, C\}$
  - b.  $A_{WE}(\{A, B, C\})(w) = A \wedge B$  (WE-answer of (5a) in *w*)
  - c.  $A_{SE}(\{A, B, C\})(w) = A \wedge B \wedge \neg C$  (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. The Hamblin denotation of *who didn't come*:  $\{\neg A, \neg B, \neg C\}$
  - b.  $A_{WE}(\{\neg A, \neg B, \neg C\})(w) = \neg C$  (WE-answer of (6a) in  $w$ )
  - c.  $A_{SE}(\{\neg A, \neg B, \neg C\})(w) = A \wedge B \wedge \neg C$  (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  $P$ ' (given a fixed domain and *de re* readings).

IE readings of question-embedding sentences involve the requirement that the agent does not have the relevant attitude toward false answers (which I will refer to as the '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.

- (7) **Intermediately-exhaustive (IE) reading** of  $x \text{ Vs } Q$  is true in  $w$  iff<sup>1</sup> (to be revised)
- $$\llbracket V \rrbracket(A_{WE}(Q)(w))(x)(w) \wedge \forall p \in Q[p(w) = 0 \rightarrow \neg \llbracket V \rrbracket(p)(x)(w)]$$

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 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* and *predict*, 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 licenses WE readings. IE readings are relatively recent observations, discussed by Spector (2005) for *know* and by Klinedinst and Rothschild (2011) for *predict*. Finally, Cremers and Chemla (to appear) validated the existence of SE and IE readings for *know* and *predict*, controlling confounding factors such as domain restrictions. The possibility of IE readings for emotive predicates has not been considered in the previous literature, but will be discussed below.

<sup>1</sup>The variables  $x$  and  $Q$  in this formula are to stand both for object language expressions and for their semantic values, to aid readability.

### 2.2.1 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 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*.<sup>2</sup>

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).<sup>3</sup>

- (9) John knows/reported which 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 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

<sup>2</sup>In section 5.1, 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).

<sup>3</sup>I am assuming here that true belief constitutes knowledge, excluding any Gettier-like case.

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 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  $x \text{ Vs } Q$  is true in  $w$  iff

$$\llbracket V \rrbracket (A_{WE}(Q)(w))(x)(w) \wedge \forall p \in Q[p(w) = 0 \rightarrow \neg \llbracket V \rrbracket_{-fac}(p)(x)(w)]$$

where  $\llbracket V \rrbracket_{-fac}$  is equivalent to  $\llbracket V \rrbracket$  except that it lacks the factivity presupposition of *V*, if any.

Here, the notation  $\llbracket \dots \rrbracket_{-fac}$  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. <sup>F</sup>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 foods are 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. <sup>F</sup>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) would have the following paraphrase, assuming that the non-factive counterpart of *be happy that p* is 'would have been happy if *p*.'

- (15) John was happy that ramen was on the menu, and it is not the case that John would have been happy if sushi was 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) the hypothesis that emotive factives only allow WE, and (ii) the hypothesis that they allow both WE and IE, together with a principle, such as Principle of Charity, which prefers a reading that makes a sentence true over other readings that make it false. 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 report 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 of charity would not capture the False judgments for the above examples.

### 2.2.3 Summary of the empirical generalization

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

	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 capture this generalization.

### 3 Analyzing WE and IE

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 next and 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 basic interpretation. Thus, interrogative complements denote their WE answers, as follows:

$$(17) \quad \llbracket \text{which students will come} \rrbracket (w) = A \wedge B$$

This denotation can be directly combined with embedding predicates such as *know* and *predict* in (18) to derive WE readings, as in (19).<sup>4</sup>

$$(18) \quad \text{a. } \llbracket \text{know} \rrbracket = \lambda p_{\langle st, t \rangle} \lambda x_e \lambda w_s. \mathbf{know}(x, p, w)$$

$$\text{b. } \llbracket \text{predict} \rrbracket = \lambda p_{\langle st, t \rangle} \lambda x_e \lambda w_s. \mathbf{predict}(x, p, w)$$

$$(19) \quad \llbracket \text{John predicted which students would come} \rrbracket (w) = 1 \text{ iff } \mathbf{predicted}(x, A \wedge B, w)$$

Of course, this is not the whole story. We need a way to derive IE and SE readings in addition to WE readings. In fact, we will ultimately need to account for the fact that WE readings are unavailable under cognitive predicates. In the next section, we will begin discussing the analysis of stronger readings based on [Klinedinst and Rothschild’s \(2011\)](#) analysis of IE.

<sup>4</sup>The denotations of question-embedding predicates will be defined in the appendix.



### 3.2 IE via matrix exhaustification

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  $X$ ,<sup>5</sup> at the matrix level, as in the following example.

$$(20) \quad [X [\text{John predicted who came}]].$$

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

$$(21) \quad [X \varphi] := \lambda w. [\varphi](w) \wedge \forall p \in [\varphi]^{\text{Alt}} [p \subset [\varphi] \rightarrow p(w) = 0]$$

As we can see from the formula in (21), I am assuming here that every expression  $\alpha$  has its ORDINARY-SEMANTIC VALUE,  $[\alpha]$ , and its ALTERNATIVE-SEMANTIC VALUE,  $[\alpha]^{\text{Alt}}$  (cf. Rooth 1985). The ordinary semantic value of an interrogative complement is its actual WE reading, as discussed in the previous section. For example, *who came* has the following ordinary-semantic denotation:

$$(22) \quad [\text{who came}](w) = \lambda w'. \forall x [\text{came}(x)(w) \rightarrow \text{came}(x)(w')]$$

On the other hand, alternative-semantic value of an interrogative clause is defined as the set of its *possible* WE answers. Thus, the alternative-semantic value of *who came* would be the following:

$$(23) \quad [\text{who came}]^{\text{Alt}} = \{p \mid \exists w [p = \lambda w'. \forall x [\text{came}(x)(w) \rightarrow \text{came}(x)(w')]]\}$$

Thus, when the domain of relevant individuals is Ann, Bill and Chris, and only Ann and Bill came in  $w$ , the two types of semantic values will be (24) and (25), respectively. Note that the alternative-semantic value of an interrogative clause is equivalent to the closure under conjunction of the Hamlin denotation.

$$(24) \quad [\text{who came}](w) = A \wedge B$$

$$(25) \quad [\text{who came}]^{\text{Alt}} = \{A, B, C, A \wedge B, B \wedge C, C \wedge A, A \wedge B \wedge C\}$$

Alternative-semantic values are composed by the rule of Point-wise Functional Application (Hamblin 1973).<sup>6</sup> Thus, the alternative-semantic value of the scope of  $X$  in (20) comes out as the set of propositions of the form ‘John predicted  $p$ ’, where  $p$  is a member of (23) or, equivalently, (25):

$$(26) \quad [\text{John predicted who came}]^{\text{Alt}} \\ = \{p \mid \exists w [p = \lambda w''. \text{predicted}(\mathbf{j}, \lambda w' \forall x [\text{came}(x)(w) \rightarrow \text{came}(x)(w')], w'')]\}$$

Let us see how an IE reading is derived from the structure in (20). Since  $X$  asserts its prejacent and negates all alternatives to the prejacent that are logically stronger, we derive the following truth conditions for (20) in the evaluation world  $w$  where only Ann and Bill came:

$$(27) \quad [(20)](w) = 1 \text{ iff } \text{predicted}(\mathbf{j}, A \wedge B, w) \wedge \neg \text{predicted}(\mathbf{j}, A \wedge B \wedge C, w)$$

<sup>5</sup>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, since the definition and the syntactic properties of the relevant operator in this paper crucially differs from the operator assumed in the literature on scalar implicature, I use a different symbol for the operator.

<sup>6</sup>Point-wise Functional Application is defined as follows: If  $[\alpha]^{\text{Alt}} \subseteq D_{\langle \sigma, \tau \rangle}$  and  $[\beta]^{\text{Alt}} \subseteq D_{\sigma}$ , then  $[\alpha \beta]^{\text{Alt}} := \{d \in D_{\tau} \mid \exists a \in [\alpha]^{\text{Alt}} \exists b \in [\beta]^{\text{Alt}} [d = a(b)]\}$

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 possible WE answer that is logically stronger than the actually true one, i.e.,  $A \wedge B$ . The truth-conditions in (27) are equivalent to the following, given the distributivity of **predicted**.

$$(28) \quad \llbracket (20) \rrbracket(w) = 1 \text{ iff } \mathbf{predicted}(\mathbf{j}, A \wedge B, w) \wedge \neg \mathbf{predicted}(\mathbf{j}, C, w)$$

This is exactly the IE reading of *John predicted who came*.

### 3.3 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:

$$(29) \quad \llbracket X [\text{John knows who came}] \rrbracket(w) = 1 \text{ iff } \llbracket \text{know} \rrbracket(A \wedge B)(\mathbf{j})(w) \wedge \neg \llbracket \text{know} \rrbracket(A \wedge B \wedge C)(\mathbf{j})(w)$$

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 give a semantics of factive predicates which systematically derives the fact that the members of  $\llbracket \text{know } p \rrbracket^{\text{Alt}}$  do not presuppose  $p$ , and hence does not encounter the above problem. 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  $\llbracket \alpha \rrbracket_{\text{-fac}}$ , which returns a non-factive counterpart of  $\llbracket \alpha \rrbracket$  (see [Égré and Spector to appear](#) for a similar formulation):

$$(30) \quad \llbracket X \varphi \rrbracket := \lambda w. \llbracket \varphi \rrbracket(w) \wedge \forall p \in \llbracket \varphi \rrbracket^{\text{Alt}}_{\text{-fac}} [p \subset \llbracket \varphi \rrbracket_{\text{-fac}} \rightarrow p(w) = 0]$$

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  $\llbracket \dots \rrbracket_{\text{-fac}}$ .

## 4 X and monotonicity

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 application of X depends on the monotonicity property of the embedding predicate.<sup>7</sup> In particular, if the embedding predicate is non-monotonic, the application of X is vacuous. This is so because the alternative-semantic

<sup>7</sup>Monotonicity and non-monotonicity is defined as follows:

values of the prejacent for  $X$  are *logically independent* from the prejacent when the embedding predicate is non-monotonic.

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

(31)  $[X [\alpha [\text{who came}]]]$ .

In the world  $w$  where Ann came, but Bill didn't, the truth conditions of (31) will be the following:

(32)  $\llbracket (31) \rrbracket(w) = 1$  iff  $\llbracket \alpha \rrbracket(A)(w) \wedge \forall p \in \{\llbracket \alpha \rrbracket(A), \llbracket \alpha \rrbracket(B), \llbracket \alpha \rrbracket(A \wedge B)\} [p \subset \llbracket \alpha \rrbracket(A) \rightarrow p(w) = 0]$

What is crucial here is that, if the embedding predicate  $\alpha$  is non-monotonic, it is not guaranteed that any proposition in the set of alternatives,  $\{\llbracket \alpha \rrbracket(A), \llbracket \alpha \rrbracket(B), \llbracket \alpha \rrbracket(A \wedge B)\}$ , is logically stronger than the prejacent,  $\llbracket \alpha \rrbracket(A)$ . If in fact no alternative is stronger than the prejacent, the second conjunct of (32) 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:

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

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

( $\models_s$ : STRAWSON-ENTAILMENT)<sup>8</sup>

In (33), we see that *be happy* is not upward monotonic. The counterexample to the inference can easily be constructed with a case where John wanted Ann to come, but didn't want Bill to come. In (34), 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 wanted Ann to come, but didn't want Bill to come. 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 hold 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) (see also von Stechow 1999 and Crnić 2011 for monotonic analyses that 'explains away' 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).

(1) a. A proposition-embedding predicate  $\alpha$  is MONOTONIC iff one of the following holds:

- for any  $p, p'$  such that  $p \subset p'$ ,  $\llbracket \alpha \rrbracket(p) \subset \llbracket \alpha \rrbracket(p')$  (UPWARD MONOTONICITY)
- for any  $p, p'$  such that  $p \subset p'$ ,  $\llbracket \alpha \rrbracket(p') \subset \llbracket \alpha \rrbracket(p)$  (DOWNWARD MONOTONICITY)

b. A predicate  $\alpha$  is NON-MONOTONIC iff  $\alpha$  is not monotonic.

<sup>8</sup>Strawson-entailment  $\models_s$  is defined as follows, where  $\psi_\pi$  is  $\psi$  with the presupposition  $\pi$  (von Stechow 1999):

(i)  $\varphi \models_s \psi_\pi \Leftrightarrow \varphi \wedge \pi \models \psi$

(35)  $\llbracket \text{be happy} \rrbracket^{\text{Sim}}(p)(x)(w)$  is

- defined only if  $p(w) = 1$  and  $x$  believes that  $p$ , and
- True iff  $\forall w' \in \text{DOX}_w^x [\text{Sim}_{w'}(p) \leq_{x,w} \text{Sim}_{w'}(\neg p)]$ <sup>9</sup>

(36)  $\text{Sim}_w(p) := \{w' \in W \mid w' \in p \text{ and } w' \text{ resembles } w \text{ no less than any other world in } p\}$

(37)  $p \leq_{x,w} p'$  iff  $\forall w' \in p' \exists w'' \in p : x \text{ considers } w'' \text{ at least as desirable as } w' \text{ in } w$

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.<sup>10</sup> A similar ordering-based semantics can be given for *surprise* based on the expectedness ordering.

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 are upward monotonic as seen by the validity of the following inference:

- (38) John {knows/predicted/told me} that Ann and Bill would come.  
 $\models$  John {knows/predicted/told me} that Ann 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 (35). 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

<sup>9</sup>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 sushi is on the menu* is true even if it would have been desirable for him to the same extent if ramen but not sushi was on the menu, and that the worlds in which ramen but not sushi is on the menu are the closest worlds in which sushi is not on the menu. This contrasts with *John wants sushi to be on the menu*, which is empirically false in the above situation.

<sup>10</sup>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.

predicates are upward monotonic, the matrix application of X derives an IE reading. On the other hand, since emotive factives are non-monotonic, 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 quite 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. Thus, I further propose that X is *obligatory*, following similar claims for the exhaustification operator in other domains by Chierchia (2004, 2006) and Magri (2009). We will discuss the syntactic property of X in the next section and section 5.2.

## 5 Analyzing SE readings

Having accounted for the distribution of IE readings, I now move on to the account of SE readings. After Groenendijk and Stokhof (1984) SE readings are analyzed as arising from an independent semantic derivation of an interrogative complement. For example, Klinedinst and Rothschild (2011) derive SE readings by placing X in an embedded position, as in (39) below:

(39) John predicted [X who came].

However, allowing SE readings as arising from an independent derivation of a complement 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.<sup>11</sup>

My analysis thus does not posit an independent semantic derivation for SE readings. This involves syntactically banning X from appearing in an embedded complement as in (39). That is, the only syntactic position for X is the matrix position, as follows:<sup>12</sup>

(40) 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 attitude holder. 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 (40), the assumption states that John had determinate prediction about whether each person came. Below is an illustration of how the IE reading of (40), conjoined with the opinionatedness assumption, leads to an SE reading:

- (41) 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.

<sup>11</sup>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 6.2 for an argument against this approach.

<sup>12</sup>In a later section, I will refine this restriction and claim that X in fact can only scope at the matrix VP level.

- (i) & (ii) **Conclusion:** John predicted that Ann and Bill came and he predicted that Chris 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 (42) discussed by Groenendijk and Stokhof (1984) is analyzed as involving an IE structure as in (40) and the opinionatedness assumption that John had determinate predictions about whether each person came.

- (42) John predicted who came.  $\Rightarrow$  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 can scope below DE operators. Following is an example of such embedding structures: negation embeds the question-embedding predicate *predict*.

- (43) [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.

Under the current theory, (43) would have the LF structure in (44a).<sup>13</sup> 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 (44b).

- (44) a.  $\llbracket \text{Neg } [X \text{ John predicted } [\text{who would come}]] \rrbracket (w) = 1$   
iff  $\neg \text{predict}(j, A \wedge B, w) \vee \text{predict}(j, C, w)$   
b.  $\llbracket \text{Neg } [\text{John predicted } [X \text{ who would come}]] \rrbracket (w) = 1$   
iff  $\neg \text{predict}(j, A \wedge B, w) \vee \neg \text{predict}(j, \neg C, w)$

As can be seen above, we derive a stronger reading for (44a) than for (44b). 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:

<sup>13</sup>I am here ruling out the structure as follows:

- (i)  $X [\text{Neg } [\text{John predicted } [\text{who would come}]]]$

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.



(45)		<b>Truth conditions of (43)</b>	<b>Truth value of (43)</b>
	(44a) + strengthening	$\mathbf{predict}(j, \neg(A \wedge B), w) \vee \mathbf{predict}(j, C, w)$	False
	(44b)	$\neg \mathbf{predict}(j, A \wedge B, w) \vee \neg \mathbf{predict}(j, \neg C, w)$	True

Empirically, (43) is *false* in the given situation. This fact favors the current account of SE over semanticized accounts of SE.<sup>14</sup>

## 5.1 Source of strengthening

Above, I remained fairly vague about the what the exact source of strengthening is, except that they have to apply globally. In this section, I propose that the mechanism of strengthening is a so-called ‘excluded-middle inference’ which is argued to also underlie neg-raising for certain attitude predicates. ‘Excluded-middle’ inference can be described in the case of John’s past prediction about a relevant set of propositions as follows:

(46) **Excluded-middle inference with respect to John’s prediction in  $w$**

For any relevant proposition  $p$ ,  $\mathbf{predicted}(p)(j)(w) \vee \mathbf{predicted}(\neg p)(j)(w)$

This kind of inference is supplied by the context as well as the lexical meaning of the predicate, and will be the source of the strengthening from IE to SE. For example, the IE reading of *John predicted who would come* would have the following truth conditions before the strengthening.

$$(47) \quad \llbracket X \text{ John predicted [who would come]} \rrbracket(w) = 1 \\ \text{iff } \mathbf{predicted}(A \wedge B)(j)(w) \wedge \neg \mathbf{predicted}(C)(j)(w)$$

Given the excluded middle inference in (46), we can strengthen the second conjunct of the above truth conditions, and derive an SE reading, as follows:

$$(48) \quad \mathbf{predicted}(j, A \wedge B, w) \wedge \mathbf{predicted}(j, \neg C, w)$$

The excluded-middle presupposition as in (46) 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 (??). 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 (for the reasons discussed in section 3.3), and its effect cannot be seen as a neg-raising property of the predicate itself. 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*, *publicize* and *read*, are known to resist neg-raising, as shown below.

<sup>14</sup>Of course, the data alone is compatible with a WE reading of (43), but we have already ruled out WE readings for *predict* in section 2.2.1. Also, a theory with a constraint on the distribution of X/EXH is discussed and rejected in section 6.2.

- (49) a. John didn't **write down** that Ann came.  $\nRightarrow$  John **wrote down** that Ann didn't come.  
 b. John didn't **publicized** that Ann came.  $\nRightarrow$  John **publicized** that Ann didn't come.  
 c. John didn't **read** that Ann came.  $\nRightarrow$  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:

- (50) a. John **wrote down** which students in the list came.  $\nRightarrow$  John **wrote down** which students in the list didn't come.  
 b. John **publicized** which students in the list came.  $\nRightarrow$  John **publicized** which students in the list didn't come.  
 c. John **read** which students in the list came.  $\nRightarrow$  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 (49):

- (51) 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.  
 (52) 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.  $\Rightarrow$  John **guessed** which students in the list 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 inference associated with the predicates.<sup>15</sup>

In sum, I propose that the source of the strengthening from IE to SE is excluded-middle inferences associated with 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.

---

<sup>15</sup>In fact, it is intuitively plausible that the communication predicates, such as *write down*, *publicize* and *read* are not associated with excluded-middle inferences. 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 inference, compared to cognitive predicates. For example, the following inference does not seem to be associated with the use of the predicate *write down* for any relevant proposition *p*.

- (1) 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* is associated with the following presupposition for any relevant proposition *p*.

- (2) 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.

## 5.2 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:

(53)

	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. 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. For cognitive/communication verbs, the structure with X results in an IE reading, which can be strengthened into an SE reading. For emotive factives, the structure always results in a 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 ??, X scopes below negation. Furthermore, as [Klinedinst and Rothschild \(2011\)](#) point out, X seems to scope below subject quantifiers. Consider the following example:

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

If X is globally applied to (54), 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 at the VP level and encoding it to the lexical semantics of predicates—cannot be empirically dissociated.

## 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:

- (55) 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, (55a) is felicitous while (55b) is odd. According to Guerzoni and Sharvit (2007), this is due to the speaker factivity triggered by *realize*, i.e., that (55b) presupposes speaker's knowledge of the answer to the embedded question *who came*. That is, the oddness of (55b) arises because the context violates the speaker factivity. In contrast, (55a) 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:

- (56) 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)
- (57) 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 (56), the sentence with *find out*, (56a), is felicitous while the sentence with *surprise*, (56b), is odd. This contrast disappears in (57), 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  $p$ ').<sup>16</sup>

- (58) 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:**  $\neg \mathbf{KS}_j(A \wedge \neg B) \wedge \neg \mathbf{KS}_j(\neg A \wedge B) \wedge \neg \mathbf{KS}_j(A \wedge B)$

<sup>16</sup>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:**  $\mathbf{K}(\exists p[\exists w[p = A_{SE}(Q)(w)] \wedge \mathbf{S}_x(p)])$
- b. **Speaker Factivity:**  $\exists p[\exists w[p = A_{SE}(Q)(w)] \wedge \mathbf{K}(p)]$
- c. **Primary Scalar Implicature:**  $\forall p[\exists w[p = A_{SE}(Q)(w)] \rightarrow \neg \mathbf{K}(\mathbf{S}_x(p))]$

The conjunction of (58a) and (58b) results in the following statement in (59) (see Guerzoni 2007 for a proof), which contradicts the statement in (58c).

$$(59) \quad \mathbf{KS}_j(A \wedge \neg B) \vee \mathbf{KS}_j(\neg A \wedge B) \vee \mathbf{KS}_j(A \wedge B)$$

Here, the primary scalar implicature arises as the result of neo-Gricean quantity implicature with the following set of alternatives.<sup>17</sup>

- (60) 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 (58), 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:

- (61) 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 (61) can be seen by the fact that the conjunction of (61a) and (61b) does not entail the following, assuming that  $A$  and  $B$  are logically independent.

$$(62) \quad \mathbf{K}(\mathbf{S}_j(A)) \vee \mathbf{K}(\mathbf{S}_j(B)) \vee \mathbf{K}(\mathbf{S}_j(A \vee B))$$

Stated in more general terms, Guerzoni's (2007) analysis makes use of the following logical fact: a conjunction of (63-i) and (63-ii) entails the proposition where the  $\mathbf{K}$ -operator in (63-i) is distributed over the two disjuncts, as in (64), if the operator  $O$  is veridical, i.e., (63-iii), and that propositions  $p$  and  $q$  are mutually exclusive, i.e., (63-iv).

- (63) 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.  $p \wedge q = \emptyset$  [ $p$  and  $q$  are mutually exclusive]

$$(64) \quad \text{Conclusion from (63i-iv): } \mathbf{K}(O(p)) \vee \mathbf{K}(O(q))$$

The proposition in (64) contradicts the proposition in (65), which corresponds to the primary scalar implicature of the sentence that has (63-i) as its quality implicature.

$$(65) \quad \neg \mathbf{K}(O(p)) \wedge \neg \mathbf{K}(O(q)) \quad [\text{Primary Scalar Implicature}]$$

---

<sup>17</sup>These alternatives are stipulated by Guerzoni, but the fact that (59) 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.

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:

- (66) a. ??John is surprised by whether Mary drank coffee.  
 b. ??John is surprised by whether Mary drank [coffee]<sub>F</sub> or [tea]<sub>F</sub>

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 (66) 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 (66) 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.

- (56) 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 (56b) 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.

- (67) 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.

- (68) 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 (67-68) 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 (67-68) 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 the embedded question are mutually exclusive.

(69) 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/analyticsity 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 (69) 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:

(70) [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, <sup>F</sup>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 (70) 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.

**Realize and predict 100% correctly in the current analysis** 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*.<sup>18</sup> I will start with *realize*. Guerzoni and Sharvit (2007) give the following example to illustrate the claim that *realize* selects for a WE reading.

(71) #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 (71) with the *because*-clause specifying John's false belief sounds felicitous:

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

Note that (72) can be true either under an SE or IE reading. Taken together with (71), 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*.

(73) [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

---

<sup>18</sup>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.

concluded that Ann, Bill and Chris came to the party.]

<sup>F</sup>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 is difficult to be associated with the excluded-middle inference. Strawson-monotonicity is in fact plausible for *realize* since the assertion of *x realizes that p* arguably consists of a monotonic doxastic attitude. The difficulty of an excluded-middle inference with respect to (the non-factive counterpart of *realize*) has to be 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 (55) 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:

(74)  $[[\text{who came}]] \{ \text{mostly/100\% correctly} \} [2 [\text{John predicted } p_2]]$  (Interrogative Raising)

↑

Assuming that *100% correctly* is a quantifier over propositions having the denotation in (75), the LF in (74) is predicted to have the semantic value in (76).<sup>19</sup>

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

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

This semantics correctly predicts that (74) only talks about John's predictions about true answers to *who came*, and says nothing about false answers and false predictions. That is, (74) 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

<sup>19</sup>The definition in (75) 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:

(77) **Strongest Meaning Hypothesis** (Chierchia et al.'s formulation)

Let  $S$  be a sentence of the form  $[_S \dots O(X) \dots]$ . Let  $S'$  be the sentence of the form  $[_{S'} \dots X \dots]$ , 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. 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 sensitive to the monotonicity of the embedding predicate, but not to the monotonicity of the global environment. Observe (78) below, where *know* embedding an interrogative complement is further embedded in DE-environments (specifically, negation and *doubt*):

(78) **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 are judged true given the situations (see (43) and the discussion associated with it for the possibility of SE readings under DE operators). 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:

(79) **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.

(80) **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 (78) and (79-80) 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 5.2.

## 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 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 receives a natural explanation since the computations required to derive an IE reading are subset of the computations required to derive an SE reading.

## References

- Anand, Pranav and Valentine Hacquard. 2013. Epistemics and attitudes. *Semantics and Pragmatics* 6(8):1–59.
- Asher, Nicholas. 1987. A typology for attitude verbs and their anaphoric properties. *Linguistics and Philosophy* 10(2):125–97.
- Bartsch, Renate. 1973. “Negative transportation” gibt es nicht. *Linguistische Berichte* 27:1–7.
- Beck, Sigrid and Hotze Rullmann. 1999. A flexible approach to exhaustivity in questions. *Natural Language Semantics* 7:249–298.
- Berman, Stephen. 1991. *On the semantics and logical form of WH-clauses*. Ph.D. thesis, University of Massachusetts, Amherst.
- Bolinger, Dwight. 1968. Post-posed main phrases: An English rule for the Romance subjunctive. *Canadian Journal of Linguistics* 14:3–30.
- Chierchia, Gennaro. 2004. Scalar implicatures, polarity phenomena, and the syntax/pragmatics interface. In A. Belletti, ed., *Structures and Beyond*. Oxford: Oxford University Press.
- Chierchia, Gennaro. 2006. Broaden your views: implicatures of domain widening and the “logicality” of language. *Linguistic Inquiry* 37(4):535–590.
- Chierchia, Gennaro, Danny Fox, and Benjamin Spector. 2012. Scalar implicature as a grammatical phenomenon. In C. Maienborn, K. von Stechow, and P. Portner, eds., *Semantics: An International Handbook of Natural Language Meaning*, vol. 3, 2297–2332. Berlin: Mouton de Gruyter.
- Cremers, Alexandre and Emmanuel Chemla. to appear. A psycholinguistic study of the different readings for embedded questions. *Journal of Semantics*.
- Crnič, Luka. 2011. *Getting even*. Ph.D. thesis, Massachusetts Institute of Technology.
- Dalrymple, Mary, Makoto Kanazawa, Yookyung Kim, Sam Mchombo, and Stanley Peters. 1998. Reciprocal expressions and the concept of reciprocity. *Linguistics and Philosophy* 21(2):159–210.
- Dayal, Veneeta. 1996. *Locality in WH Quantification: Questions and Relative Clauses in Hindi*. Dordrecht: Kluwer Academic Publishers.
- Égré, Paul and Benjamin Spector. to appear. A uniform semantics for embedded interrogatives: *an* answer, not necessarily *the* answer. *Synthese*.
- von Stechow, Kai. 1999. NPI licensing, Strawson entailment, and context dependency. *Journal of Semantics* 16(2):97–148.
- Fox, Danny. 2007. Free choice disjunction and the theory of scalar implicatures. In U. Sauerland and P. Stateva, eds., *Presupposition and Implicature in Compositional Semantics*, 71–120. New York: Palgrave Macmillan.
- Gajewski, Jon. 2002. On analyticity in natural language. Ms., Massachusetts Institute of Technology.
- Gajewski, Jon. 2005. *Neg-raising: Polarity and presupposition*. Ph.D. thesis, Massachusetts Institute of Technology.
- George, Benjamin. 2011. *Question Embedding and the Semantics of Answers*. Ph.D. thesis, UCLA.
- Gettier, Edmund. 1963. Is justified true belief knowledge? *Analysis* 23(6):121–123.
- Groenendijk, Jeroen and Martin Stokhof. 1984. *Studies on the Semantics of Questions and the Pragmatics of Answers*. Ph.D. thesis, University of Amsterdam.
- Guerzoni, Elena. 2007. Weak exhaustivity and ‘whether’: A pragmatic approach. In *Proceedings*



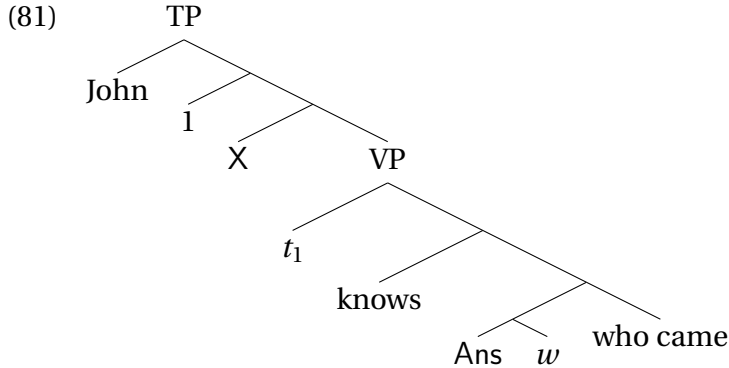
- from *SALT XVII*, 112–129.
- Guerzoni, Elena and Yael Sharvit. 2007. A question of strength: on NPIs in interrogative clauses. *Linguistics and Philosophy* 30(3):361–391.
- Hamblin, Charles L. 1973. Questions in Montague English. *Foundations of Language* 10(1):41–53.
- Heim, Irene. 1992. Presupposition projection and the semantics of attitude verbs. *Journal of Semantics* 9:183–221.
- Heim, Irene. 1994. Interrogative semantics and Karttunen’s semantics for *know*. In *Proceedings of IATL 1*, 128–144.
- Herbstritt, Michele. 2014. *Why can’t we be surprised whether it rains in Amsterdam?: A semantics for factive verbs and embedded questions*. MSc thesis, ILLC, University of Amsterdam.
- Karttunen, Lauri. 1977. Syntax and semantics of questions. *Linguistics and Philosophy* 1(1):3–44.
- Klinedinst, Nathan and Daniel Rothschild. 2011. Exhaustivity in questions with non-factives. *Semantics and Pragmatics* 4(2):1–23.
- Lahiri, Utpal. 2002. *Questions and Answers in Embedded Contexts*. Oxford: Oxford University Press.
- Lassiter, Daniel. 2011. *Measurement and Modality: The Scalar Basis of Modal Semantics*. Ph.D. thesis, New York University.
- Magri, Giorgio. 2009. A theory of individual-level predicates based on blind mandatory scalar implicatures. *Natural Language Semantics* 17(3):245–297.
- Nicolae, Andreea Cristina. 2013. *Any Questions?: Polarity as a Window into the Structure of Questions*. Ph.D. thesis, Harvard University.
- Romoli, Jacopo. 2013. A scalar implicature-based approach to neg-raising. *Linguistics and Philosophy* 36:291–353.
- Rooth, Mats. 1985. *Association with Focus*. Ph.D. thesis, University of Massachusetts, Amherst.
- Rubinstein, Aynat. 2012. *Roots of Modality*. Ph.D. thesis, University of Massachusetts, Amherst.
- Sæbø, Kjell Johan. 2007. A whether forecast. In B. D. ten Cate and H. W. Zeevat, eds., *Logic, Language, and Computation*, vol. 4363 of *Lecture Notes in Computer Science*, 189–199. Springer. ISBN 978-3-540-75143-4.
- Sauerland, Uli. 2004. Scalar implicatures in complex sentences. *Linguistics and Philosophy* 27:367–391.
- Spector, Benjamin. 2005. Exhaustive interpretations: what to say and what not to say. Paper presented at the LSA workshop on Context and Content, Harvard University.
- Spector, Benjamin. 2006. *Aspects de la Pragmatique des Opérateurs Logiques*. Ph.D. thesis, Université Paris Diderot Paris 7.
- Theiler, Nadine. 2014. *A Multitude of Answers: Embedded Questions in Typed Inquisitive Semantics*. MSc thesis, ILLC, University of Amsterdam.
- Villalta, Elisabeth. 2008. Mood and gradability: an investigation of the subjunctive mood in Spanish. *Linguistics and Philosophy* 31:467–522.

## A Dealing with factive predicates

As discussed in section 3.3, 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 3.3. 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):



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

- (82)  $\llbracket \text{know} \rrbracket = \lambda p_{\langle s, t \rangle} \lambda x \lambda w. \text{JDOX}_x^w \subseteq p$   
 $(\text{JDOX}_x^w := \text{the set of worlds compatible with } x\text{'s justifiable belief in } w)$
- (83)  $\llbracket \text{Ans} \rrbracket(w)(Q)$  is defined if  $\exists! p \in Q[p(w) \wedge \forall p' \in Q[p'(w) \rightarrow p \subseteq p']]$ .  
 If defined,  $\llbracket \text{Ans} \rrbracket(w)(Q) = \iota p \in Q[p(w) \wedge \forall p' \in Q[p'(w) \rightarrow p \subseteq p']]$
- (84)  $\llbracket \text{who came} \rrbracket = \{ p \mid \exists X[p = \lambda w. \forall x < X[\text{came}(x, w)]] \}$

The predicate *know* in (82) 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*.

- (85)  $\llbracket [\text{Ans } w] \text{ who came} \rrbracket = A \wedge B$

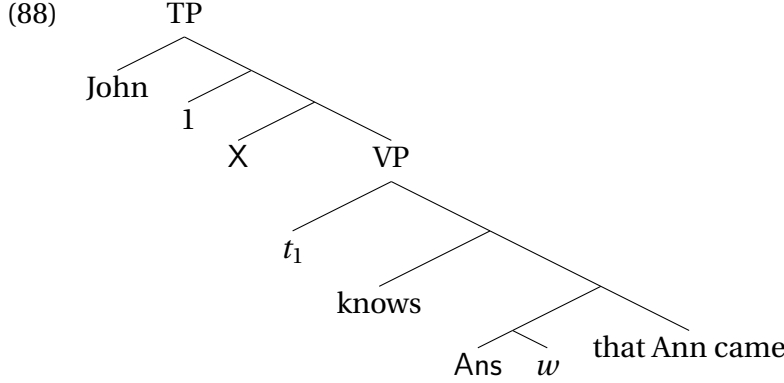
The alternative-semantic value of embedded complements are generated by varying the world variable in the sister position of Ans. This simply creates the set of possible weakly exhaustive answers, as was the case in section 3. Combining this set with the alternative-semantic value of *know* with Point-wise Functional Application, we get the following set of alternatives for the VP in (81).

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

Note that propositions in this set do *not* presuppose factivity crucially because the embedding predicate is simply defined as ‘justifiably believe’. Negation of alternatives from this set that are stronger than the prejacent results in the appropriate IE reading of (81).

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. That is, a declarative clause denotes a singleton proposition-set and occupies the same structural position as an interrogative complement, as illustrated below:

$$(87) \quad \llbracket \text{that Ann came} \rrbracket = \{A\}$$



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 (89) below projects the presupposition that  $A$  is true in  $w$ .

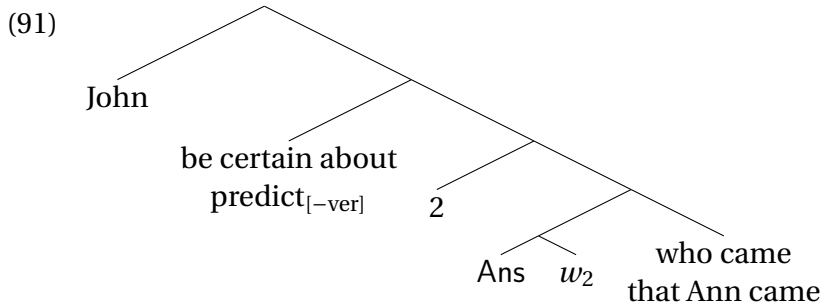
$$\begin{aligned}
 (89) \quad \llbracket \text{know} \llbracket [\text{Ans } w] \llbracket \text{that Ann came} \rrbracket \rrbracket \rrbracket &= \llbracket \text{know} \rrbracket (\llbracket \text{Ans} \rrbracket (w) (\{A\})) \\
 &= \lambda x \lambda w'. \text{JDOX}_x^{w'} \subseteq \llbracket \text{Ans} \rrbracket (w) (\{A\})
 \end{aligned}$$

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:

$$(90) \quad \llbracket \text{predicted}_{[-\text{ver}]} \rrbracket^w = \lambda \mathcal{P}_{\langle s, st \rangle} \lambda x. \exists w' [\text{PRD}_x^w \subseteq \mathcal{P}(w')]$$

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:



Given this formulation, it is correctly predicted that declarative embedding in (91) does not trigger factivity, as *predict that Ann came* has the following semantic value:

$$\begin{aligned}
 (92) \quad \llbracket \text{predict } [2 \llbracket \text{Ans } w_2 \rrbracket \llbracket \text{that Ann came} \rrbracket] \rrbracket &= \llbracket \text{predict} \rrbracket (\lambda w'. \llbracket \text{Ans} \rrbracket (w') (\{A\})) \\
 &= \lambda x \lambda w. \exists w' [\text{PRD}_w^x \subseteq \llbracket \text{Ans} \rrbracket (w') (\{A\})]
 \end{aligned}$$

Assuming that existential quantification projects presuppositions existentially, the presupposition of (92) 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 (92) 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 question-embedding predicates in Groenendijk and Stokhof's (1984) sense. Factive predicates take type  $\langle s, t \rangle$ -argument while non-factive predicates take type  $\langle s, st \rangle$ -argument. 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.