

Interpreting Questions under Attitudes

by

Wataru Uegaki

B.A., University of Tokyo (2008)

M.A., University of Tokyo (2010)

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Author

Department of Linguistics and Philosophy

May 18, 2015

Certified by

Irene Heim

Professor of Linguistics

Thesis Supervisor

Accepted by

David Pesetsky

Professor of Linguistics

Department Head

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Abstract

This dissertation concerns three kinds of variability that pose challenges for the compositional semantics of question-embedding sentences: (i) lexical variation among clause-embedding predicates with respect to the *selection of complement types*, (ii) variability in the *exhaustivity* of embedded questions and (iii) variability in the *veridicality* of embedded questions. Based on the proposal that declarative complements of question-embedding predicates are limiting cases of embedded questions, this dissertation presents a compositional-semantic analysis of question-embedding sentences that can correctly predict the three kinds of variability above. According to the proposal, the complement selection is determined solely by the semantic type of the embedding predicate. The variability in exhaustivity and veridicality of embedded questions follows from a unified semantic derivation, namely one involving exhaustification at the matrix level once the lexical semantics of the embedding predicate is taken into account.

Thesis Supervisor: Irene Heim
Title: Professor of Linguistics

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Contents

1	Introduction	15
1.1	Three issues in the semantics of question-embedding	15
1.1.1	Complement selection	18
1.1.2	Exhaustivity	21
1.1.3	Veridicality	22
1.2	Preview of the proposals	24
1.2.1	Two main proposals	24
1.2.2	Capturing the complement selection (Chapter 2)	24
1.2.3	Capturing the exhaustivity (Chapter 3)	25
1.2.4	Capturing the veridicality (Chapter 4)	26
1.2.5	Mention-some and reducibility (Chapter 5)	28
1.3	Basic assumptions	28
1.3.1	The semantic framework	29
1.3.2	Semantics of interrogative complements	34
2	Content nouns and the selectional restrictions of question-embedding predicates	47
2.1	Introduction	47
2.2	The puzzle of ‘content’ DPs	48
2.2.1	Compositionally deriving the entailment	50
2.2.2	Lexically specifying the entailment patterns	51
2.3	Proposal	53
2.3.1	ResPs only take a question complement	54
2.3.2	Solution to the puzzle	55
2.3.3	On exclusively interrogative-embedding verbs	65
2.3.4	Challenges posed by coordination and anaphora	67
2.4	Comparison with alternative approaches	69
2.4.1	Ginzburg (1995)	69
2.4.2	Question-to-proposition reduction theories	73
2.5	Summary	74
3	Analyzing exhaustivity	77
3.1	Introduction	77
3.2	Exhaustivity of question-embedding sentences	78
3.2.1	Three kinds of exhaustivity	78

3.2.2	Which predicate allows which readings	80
3.3	Deriving WE and IE readings	85
3.3.1	WE as a baseline interpretation	86
3.3.2	IE via matrix exhaustification	87
3.3.3	The case of factive predicates	92
3.4	Capturing the distribution of WE and IE	93
3.4.1	X and the monotonicity property of embedding predicates . .	93
3.4.2	Syntactic properties of X	98
3.5	Analyzing SE readings	101
3.5.1	SE is derived from IE via the excluded-middle assumption . .	101
3.5.2	SE readings and neg-raising	103
3.5.3	Capturing the SE data: defeasibility and embeddability . . .	109
3.5.4	Interim summary	114
3.6	Existing analyses	115
3.6.1	Guerzoni (2007)	115
3.6.2	Nicolae (2013)	122
3.7	Summary	124
4	Analyzing veridicality and factivity	125
4.1	‘Decomposing’ responsive predicates	125
4.2	Analyzing factivity	126
4.2.1	Factivity as a limiting case of an existential presupposition . .	127
4.2.2	Solution to the problem with exhaustification above factives .	132
4.3	Empirical generalizations about veridicality and factivity	135
4.3.1	Overview of existing empirical claims	136
4.3.2	Spector and Egré’s (2015) generalization and factivity	139
4.3.3	The ambiguity of communication predicates	141
4.4	Analyzing non-factivity and non-veridicality	142
4.4.1	<i>be certain</i> -type predicates (a.k.a. opinion predicates)	143
4.4.2	<i>tell</i> and other communication predicates	151
4.4.3	<i>agree</i> -type predicates	159
4.4.4	Deriving Spector and Egré’s generalization	169
4.4.5	Presupposition projection in terms of Strong Kleene	175
4.5	Decomposition and lexical semantics	180
4.5.1	Syntactic decomposition	181
4.5.2	Encoding Ans_d in the lexical semantics	182
4.6	Existing analyses of veridicality	182
4.6.1	Spector and Egré (2015)	183
4.6.2	Theiler (2014); Roelofsen et al. (2014)	189
4.7	Summary	195
5	Mention-some and the ‘reducibility’ of responsive predicates	197
5.1	Introduction	197
5.2	Mention-some and non-reducibility	197
5.3	Exhaustification in mention-some readings	201

5.4	Reducibility revisited	205
5.5	Summary	207
6	Conclusions	209
6.1	The resulting picture	209
6.1.1	Complement selection	211
6.1.2	Exhaustivity	211
6.1.3	Veridicality	213
6.2	Future prospects	213
6.2.1	Other kinds of variability: <i>de re/de dicto</i> and mention-some . .	214
6.2.2	Quantificational variability effect (QVE)	214
6.2.3	Integration with the general theories of exhaustification . . .	215
6.2.4	Constraints on the lexical semantics of attitude predicates . .	216

List of Figures

1-1	The proposition-set representation and the partition representation .	37
4-1	The typology of responsive predicates	142
4-2	Summary of the analysis of the typology of responsive predicates . .	174
6-1	Two representative LF structures	210
6-2	Summary of the analysis of the variation in exhaustivity	212
6-3	Summary of the analysis of the veridicality/factivity	213

List of Tables

3.1	Summary of attested readings	85
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Chapter 1

Introduction

1.1 Three issues in the semantics of question-embedding

Interpretations of sentences involving an *embedded question*, as exemplified in (1), have played a central role in the development of the current semantic theories of questions.

- (1) John $\left\{ \begin{array}{l} \text{knows} \\ \text{is surprised} \\ \text{told me} \\ \text{is certain} \\ \text{agrees with Mary} \\ \text{wonders} \end{array} \right\}$ which students came to the party.

Embedded questions have been methodologically important due to the fact that *matrix questions*, as in (2), do not have truth conditions in the usual sense, and thus they are not amenable to the methodology of truth-conditional semantics.

- (2) Which students came to the party?

Faced with this methodological difficulty, theories have used embedded questions, as in (1), as a primary data source in the formal-semantic studies of question meanings (e.g., Karttunen 1977; Groenendijk and Stokhof 1984).

In contrast to the situation with (2), the truth-conditional methodology can be applied to the sentences in (1) since they have truth conditions, just like other declarative sentences. That is, we can assess speaker's judgments as to when the sentences in (1) are true although the same question cannot be asked about (2). We can infer from such judgments on (1) what the semantic interpretation of the interrogative clause *which students came to the party* has to be like, given (i) an independently testable hypothesis about the meaning of embedding predicates such as *know*, and (ii) some general compositional mechanism that combines the meaning of predicates like *know* with their complement. Of course, the semantics of questions gained this way has to be supplemented with the pragmatics of speech acts in order for us to properly understand the discourse functions of (matrix) questions. However, such *pragmatic* aspects of questioning can be assumed to be

independent from the *semantic representation* of questions (Groenendijk and Stokhof 1984). In fact, another way to describe the virtue of employing embedded questions in the study of question meanings is that we can approach their meanings without taking into account the pragmatics of matrix speech acts.

The investigation of the semantics of questions through the lens of embedded questions was initiated by Karttunen (1977) within Montagovian model-theoretic semantics, and carried out further by Groenendijk and Stokhof (1984); Heim (1994); Beck and Rullmann (1999); Lahiri (2002); Guerzoni and Sharvit (2007) and George (2011), among many others. This research program has produced fruitful insights into what the semantic representation of questions has to be like. Some of such important insights are gained from the following three observations:

- (3) **Embedding under declarative-embedding predicates** Interrogative complements can be embedded under some but not all declarative-embedding predicates, such as *know*, *be surprised*, *tell*, *be certain* and *agree*. (e.g., Karttunen 1977)

Variability in exhaustivity Depending on the embedding predicate, sentences involving an interrogative complement vary in whether or not their interpretations refer to an *exhaustive* answer of the question. Specifically, cognitive/epistemic predicates like *know* is compatible with an exhaustive interpretation of their complement while emotive predicates like *surprise* select for a non-exhaustive interpretation. (e.g., Heim 1994; Beck and Rullmann 1999)

Variability in veridicality Depending on the embedding predicate, sentences involving an interrogative complement vary in *veridicality*, i.e., whether or not their interpretations refer to the *true* answer of the question. For example, *know* selects for a veridical interpretation of its complement while *be certain* selects for a non-veridical interpretation. (e.g., Groenendijk and Stokhof 1984; Spector and Egré 2015)

We will see concrete examples of these observations below. What is important at this point is that these observations reveal different semantic aspects of interrogative clauses, and the correct semantic representation of questions in general has to be rich enough to accommodate all of these observations.

The first observation—that interrogative complements can be embedded under declarative-embedding predicates—has led to the hypothesis that a specific proposition (which we might call an ‘answer’) can be retrieved from the semantic interpretation of an interrogative clause. When a declarative-embedding predicate, such as *know*, combines with an interrogative complement, the predicate semantically composes with this ‘answer’ proposition retrieved from the question meaning (Karttunen 1977; Groenendijk and Stokhof 1984; Heim 1994; Dayal 1996). Given the second observation, i.e., the variability in exhaustivity, it is argued that both the set of *exhaustive* answers and the set of *non-exhaustive* answers can be extracted from the interpretations of interrogative clauses (Heim 1994; Beck and Rullmann 1999). Finally, the third observation, i.e., the variability in veridicality, suggests

that both *true* and *false* answers have to be available in the semantic representation of interrogative clauses (Groenendijk and Stokhof 1984; Spector and Egré 2015). Several existing semantic accounts of interrogatives meet these desiderata. For example, the representation of question meanings as *sets of its possible answers*, along the lines of Hamblin (1973) and Karttunen (1977), can provide multiple ways to map question meanings to its propositional answer, which can be either exhaustive or non-exhaustive (as shown by Heim 1994), and either be true or false.

However, the general strategy adopted in the existing studies is to construct the semantics of questions that is rich enough to accommodate the desiderata, and leave open how the semantics can be *constrained* to explain the *variability* existing in the data. That is, even if the proposed semantics can account for the availability of exhaustive and non-exhaustive answers, as well as true and false answers in the semantic representation of questions, it cannot account for why there is variability depending on the embedding predicate, as mentioned in (3). Specifically, the following issues corresponding to the three observations in (3) are unanswered.

- (4) **Complement selection** Why some declarative-embedding attitude predicates (e.g., *know*, *be surprised*, *tell*, *be certain*, *agree*) can embed interrogative complements while other declarative-embedding predicates (e.g., *believe*, *think*) cannot.

Exhaustivity Why cognitive/epistemic predicates like *know* are compatible with an exhaustive interpretation of their complement while emotive predicates like *surprise* select for a non-exhaustive interpretation.

Veridicality Why some predicates (e.g., *know*) select for a veridical interpretation of its complement while other predicates (e.g., *be certain*) select for a non-veridical interpretation.

For example, in an extension of Karttunen’s (1977) semantics by Heim (1994), it is shown how question meanings *can* be mapped to either exhaustive or non-exhaustive answers, but it is left open why some predicates (like *know*) are compatible with exhaustive answers while other predicates (like *surprise*) are not. In this sense, the semantics of questions in the literature have simply ‘generalized to the worst case’, and the issues in (4) have been left open, or considered to be a distinct issue for a separate project.

The goal of this dissertation is to take the existing semantics of embedded questions a step further, and address the three issues in (4) by constraining the compositional semantics in which questions are combined with question-embedding predicates. Just as the investigation of embedded questions has provided insights into the semantics of questions in general, addressing these issues provide further implications for the semantics of questions in general, as well as for the fine-grained lexical semantics of the attitude predicates that embed them.

In this chapter, I will introduce the three issues in some more detail (sections 1.1.1-1.1.3), and give a brief overview of the proposals to be presented in the body of the dissertation (section 1.2). In section 1.3, I will present the basic assumptions that I will make use of in the present dissertation, including those concerning the general

semantic framework as well as those concerning the compositional semantics of interrogative complements.

1.1.1 Complement selection

The first problem that I will address in this dissertation concerns the selectional restrictions of clause-embedding predicates. Except for *wonder*, *ask* and other predicates referred to as INQUISITIVE PREDICATES by Karttunen (1977), the attitude predicates that occur in the construction in (1) can also embed a declarative complement, as shown in (5) below.

$$(5) \text{ John } \left\{ \begin{array}{c} \text{knows} \\ \text{is surprised} \\ \text{told me} \\ \text{is certain} \\ \text{agrees with Mary} \\ \text{*wonders} \end{array} \right\} \text{ that Ann brought whiskey to the party.}$$

The embedding predicates are not ambiguous between the use in (1) and in (5), as suggested by the grammaticality of the following examples with coordinated complements:

$$(6) \text{ John } \left\{ \begin{array}{c} \text{knows} \\ \text{is surprised} \\ \text{told me} \\ \text{is certain} \\ \text{agrees with Mary} \\ \text{*wonders} \end{array} \right\} \begin{array}{l} \text{[which students came] and} \\ \text{[that Ann brought whiskey].} \end{array}$$

I will refer to these predicates that can embed both declarative and interrogative complements as RESPONSIVE PREDICATES, following Lahiri (2002). The behaviors of responsive predicates illustrated above pose a problem for their compositional semantic analysis in view of the common assumption that declarative and interrogative complements denote different kind of semantic objects, i.e., propositions and questions. Given that responsive predicates are not ambiguous between the uses in (1) and (5), it is not clear how they are semantically compatible with propositions as well as questions.

There are at least four approaches to addressing this problem. One approach is to analyze the denotation of responsive predicates as selecting for a proposition, and reduce the compositional semantics of interrogative-embedding sentences as in (1) to that of declarative-embedding sentences as in (5). The second approach involves an opposite reduction. That is, it analyzes the denotation of responsive predicates as selecting for a question, and reduces the compositional semantics of declarative-embedding sentences to that of interrogative-embedding sentences. The third approach is to assume that responsive predicates are actually ambiguous (although their meanings can be systematically related), and explain away the data that goes against the ambiguity, as in (6). The final approach is to deny the

assumption that declarative complements and interrogative complements denote distinct semantic objects. The four approaches are summarized in the following, with respective names for convenience:

(7) **Four approaches to the problem with the selection of responsive predicates**

Question-to-proposition reduction Responsive predicates semantically select for propositions. The compositional semantics of interrogative-embedding sentences is reduced to that of declarative-embedding sentences.

Proposition-to-question reduction Responsive predicates semantically select for questions. The compositional semantics of declarative-embedding sentences is reduced to that of interrogative-embedding sentences.

Ambiguity Responsive predicates are ambiguous.

Semantic uniformity of complements Declarative and interrogative complements denote the same type of semantic object.

As I will discuss below, each of these four approaches have initial challenges.

1.1.1.1 Question-to-proposition reduction

The most common approach in the literature is the question-to-proposition reduction (e.g., Groenendijk and Stokhof 1984; Heim 1994; Ginzburg 1995; Lahiri 2002; Spector and Egré 2015). I include in this category both analyses in which the denotation of an interrogative clause is converted to a proposition by an extra syntactic or semantic operation (Groenendijk and Stokhof 1984; Heim 1994; Ginzburg 1995; Lahiri 2002) as well as analyses in which the basic proposition-taking denotation of a responsive predicate is converted to the question-taking counterpart by a lexical rule (Spector and Egré 2015). As a concrete example, let me briefly summarize the relevant aspect of Groenendijk and Stokhof's (1984) theory. In Groenendijk and Stokhof (1984), questions are semantically represented as propositional concepts (i.e., a function from worlds to propositions). An interrogative complement has propositional concepts as its *intensional* semantic value. Therefore, its *extension* corresponds to a proposition, and the Hintikka (Hintikka 1962) proposition-taking denotation of *know* can be combined with this extension. In other words, the mechanism of extensionalization corresponds to the conversion from questions to propositions in Groenendijk and Stokhof (1984).

A challenge for this approach is that it requires additional explanations for why some attitude predicates, such as *believe*, embed declarative complements but not interrogative complements. If the question denoted by an interrogative complement can be converted to a proposition, the proposition-taking denotation of the *believe*-type predicates should be able to combine with such a proposition. To avoid this prediction, for example, we need syntactic selectional restrictions stating that the *believe*-type predicates do not embed interrogative CPs while *know*-type

predicates do, independently of their semantic selectional restrictions, which would say that both of them select for propositions.

Let's take [Groenendijk and Stokhof's \(1984\)](#) theory as an example again. Without further explanations, the analysis cannot rule out the derivation in which *believe* is combined with the extension of an interrogative complement. Similarly, in an analysis with a lexical rule that turns a proposition-taking predicate into its question-embedding counterpart, as in [Spector and Egré \(2015\)](#), we need further stipulations to prevent the lexical rule from applying to the *believe*-type predicates.

Indeed, syntactic selectional restrictions (the so-called c-SELECTION; [Chomsky 1965](#); [Grimshaw 1979](#)) might be needed anyway independently of semantic selectional restrictions (the so-called s-SELECTION) ([Grimshaw 1979](#)). However, as [Pesetsky \(1991\)](#) argues, c-selection can be reduced to s-selection in various empirical domains of complementation (such as different kinds of infinitive complementation and the complementation by adjectives), and the argument for the autonomous theory of c-selection turns out to be rather weak. In view of this general suspicion against c-selection, it would be preferable if we could do away with purely syntactic stipulations to address the current issue.

1.1.1.2 Proposition-to-question reduction

The proposition-to-question reduction approach has not been explored extensively in the literature. It is mentioned as an analytic possibility (although not endorsed) in [George \(2011\)](#), and advocated by myself in [Uegaki \(to appear\)](#), which is included in this dissertation as chapter 2 with revisions.

I will leave the discussion of this approach to section 1.2, where I will give an overview of the proposals to be made in this dissertation. Let me mention at this point, though, that the approach faces a challenge that is a mirror image of the challenge facing the question-to-proposition reduction. That is, the approach calls for an additional explanation for why some attitude predicates, such as *wonder* and *ask*, only embed interrogatives. This turns out to be a challenge because the approach involves a general mechanism that enables question-taking predicates to embed declaratives.

1.1.1.3 Ambiguity

[Karttunen \(1977\)](#) and [George \(2011\)](#) can be classified as examples of an approach that assumes that responsive predicates are ambiguous between the proposition-taking meaning and the question-taking meaning. In both of these analyses, the two meanings are systematically related (in terms of meaning postulates in [Karttunen 1977](#), and in terms of a theory of the lexicon that 'generates' proposition-taking and question-taking denotations of a predicate in [George 2011](#)), but there are in fact two lexical entries for each responsive predicate. A challenge for this approach is then how to account for the data as in (6), which suggest that responsive predicates are unambiguous between the two uses.

1.1.1.4 Semantic uniformity of complements

An example of the semantic uniformity approach can be found in Theiler (2014), whose analysis is based on Inquisitive Semantics (e.g., Ciardelli et al. 2013). One of the central claims of Inquisitive Semantics is that declarative and interrogative clauses denote the same type of semantic objects: sets of sets of possible worlds. In this approach, the selectional restriction of the responsive predicates is straightforwardly accounted for, and now what is problematic is the selectional restrictions of *both* the *believe*-type predicates and the *wonder*-type predicates. In other words, this approach inherits the challenges from both the question-to-proposition reduction and the proposition-to-question reduction.

To wrap up, the four approaches to the problem of complement selection by responsive predicates all face respective challenges. As will be previewed in section 1.2, the approach I will pursue in this dissertation is the proposition-to-question reduction. It will be argued that this approach is supported by a contrast in the interpretation of the *nominal complements* of attitude predicates while the challenge posed by the *wonder*-type predicates can be addressed once their lexical semantic properties are taken into account.

1.1.2 Exhaustivity

Let us move on to the second issue in the semantics of question-embedding, i.e., exhaustivity. It has been observed in the literature (e.g., Heim 1994; Beck and Rullmann 1999; Theiler 2014) that question-embedding sentences differ in the exhaustivity of their interpretations depending on the embedding predicate. That is to say, roughly, the sentences as in (1) vary in whether their interpretations refer to a complete answer of the embedded question. For example, the interpretation of the sentence with *know* and that with *be surprised* differ in the following way (In chapter 3, I will discuss this empirical claim in more detail):

- (8) [**Situation:** There are three students: Ann, Bill and Chris. Ann and Bill came, but Chris didn't.]
- a. John **knows** which students came.
Interpretation: 'John knows that Ann and Bill came **and Chris didn't**.'
 - b. John **is surprised** which students came.
Interpretation: John is surprised that Ann and Bill came.

The interpretation illustrated in (8a) is called the STRONGLY-EXHAUSTIVE reading while that in (8b) is called the WEAKLY-EXHAUSTIVE reading. As I will argue in chapter 3, this pattern generalizes to other responsive predicates in the same intuitive semantic class: cognitive/epistemic predicates and communication predicates such as *know*, *discover*, *predict* and *tell* allow the strongly-exhaustive interpretation illustrated in (8a) whereas emotive factives such as *surprise*, *happy* and *annoy* select for the weakly-exhaustive interpretation in (8b).¹ The problem is how to capture this

¹There are also apparent counterexamples to the latter claim pointed out by Klinedinst and Rothschild (2011) and Theiler (2014). See chapter 3 for details

generalization. That is, how can the different interpretations of question-embedding sentences be derived from the lexical semantics of responsive predicates?

The issue is further complicated by the possibility of the third kind of interpretation licensed by at least some cognitive and communication predicates, such as *know* and *predict*, in addition to the strongly exhaustive reading. This interpretation is observed by Spector (2005) and Klinedinst and Rothschild (2011) and also experimentally validated by Cremers and Chemla (to appear). The interpretation is intermediate in strength between the strongly exhaustive reading and the weakly exhaustive reading, and is therefore referred to as INTERMEDIATE EXHAUSTIVITY. The paraphrase of the example given below illustrates this interpretation.

- (9) [**Situation:** There are three students: Ann, Bill and Chris. Ann and Bill Came, but Chris didn't.]

Example John predicted which students would come.

Intermediately-exhaustive interpretation: 'John predicted that Ann and Bill would come and *it is not the case that he predicted that Chris would come.*'

In the past literature, the observation that the exhaustivity of embedded questions varies 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, these accounts are not constrained enough to *predict* the variation of exhaustivity in embedded questions (although such attempts are made in Guerzoni 2007 and Nicolae 2013, which I discuss in detail in chapter 3). For example, they cannot explain why emotive predicates like *surprise* do not allow a strongly exhaustive reading. My goal in chapter 3 is to construct a compositional semantics of question-embedding that can predict the variation in exhaustivity, given lexical semantics of embedding predicates.

1.1.3 Veridicality

The third problem concerns the veridical inference in question-embedding sentences. Roughly, I call a question-embedding sentence VERIDICAL if its interpretation refers to the *true* answer of the question. Also, I will refer to the *predicate* embedding the question in such sentences as VERIDICAL WITH RESPECT TO INTERROGATIVE-EMBEDDING. The following examples illustrate the variation in the veridicality of question-embedding predicates: *know* is veridical with respect to interrogative-embedding while *be certain* is not.

- (10) a. John **knows** which students came.
 \Rightarrow For some true answer p to 'Which students came?', John knows p .
 b. John **is certain** which students came.
 \nRightarrow For some true answer p to 'Which students came?', John is certain that p .

At least since [Karttunen \(1977\)](#), it has been traditionally assumed in the literature that veridicality with respect to interrogative-embedding does not completely align with veridicality with respect to *declarative-embedding*. To see this, consider the following examples with *be certain* and *tell*.

- (11) a. John **is certain** that Ann came.
 \Rightarrow Ann came.
- b. John **told** me that Ann came.
 \Rightarrow Ann came.
- (12) a. John **is certain** which students came.
 \Rightarrow For some true answer p to ‘Which students came?’, John is certain that p .
- b. John **told** me which students came.
 \Rightarrow For some true answer p to ‘Which students came?’, John told me that p .

In (11), we see that both *be certain* and *tell* are non-veridical with respect to declarative-embedding, i.e., they do not entail the truth of their declarative complements. On the other hand, (12) suggests that, whereas *be certain* is non-veridical with respect to interrogative-embedding, *tell* is *veridical* with respect to interrogative-embedding. That is, (12b) licenses the inference that John told me the correct answer to ‘Which students came?’. This behavior is shared by other communication predicates, such as *report*, *show*, *write down* etc.

However, the judgment in (12b) is challenged by [Tsohatzidis \(1993\)](#) and [Spector and Egré \(2015\)](#). They show that the veridical inference is in fact defeasible in interrogative-embedding sentences with communication predicates. The defeasibility can be shown by the following examples:

- (13) a. John told me which students came, but he turned out to be wrong.
- b. Old John told us whom he saw in the fog, but it turned out that he was mistaken (the person he saw was Mr. Smith, not Mr. Brown).
(Tsohatzidis 1993)
- c. Every day, the meteorologists tell the population where it will rain the following day, but they are often wrong. (Spector and Egré 2015)

Uncontroversially veridical predicates, such as *know*, do not exhibit the same defeasibility:

- (14) a. # John knew which students came, but he turned out to be wrong.
- b. # Old John knew whom he saw in the fog, but it turned out that he was mistaken (the person he saw was Mr. Smith, not Mr. Brown).
- c. # Every day, the meteorologists know where it will rain the following day, but they are often wrong.

Based on this observation, [Spector and Egré \(2015\)](#) argue that the class of predicates that are veridical with respect to interrogative-embedding is precisely the class of predicates that are veridical with respect to declarative-embedding. That is,

veridicality with respect to interrogative-embedding and that with respect to declarative-embedding completely align, after all.

These observations about veridicality raise two questions. The first question is how exactly Spector and Egré’s generalization is captured in the compositional semantics of question-embedding. Especially, what is problematic is how to precisely characterize the interpretation of non-veridical predicates. In non-veridical question-embedding sentences as in (12), the interpretation seems to be referring to some non-true answer(s) of the question, but exactly which answers are they? The second question concerns the seeming veridical inference we observe for communication predicates. Even if the veridical inference is defeasible, there is a contrast in the default inference between *tell* with a declarative complement, as in (11b), and *tell* with an interrogative complement, as in (12b). Why is there a default veridical inference when a communication predicate embeds an interrogative complement although there is no parallel inference when the same predicate embeds a declarative complement? These problems are addressed in chapter 4.

1.2 Preview of the proposals

1.2.1 Two main proposals

In the previous section, I discussed three issues in the compositional semantics of question-embedding sentences. In this dissertation, I address the three issues based on the following two main proposals:

1. **Declarative complements as singleton questions** Responsive predicates semantically select for questions, and their declarative complements are analyzed as the limiting (singleton) case of embedded questions.
2. **A unified derivation for exhaustivity** All types of exhaustive interpretations result from the same semantic derivation, one involving so-called matrix exhaustification. The variation in the exhaustive interpretations fall out from this derivation once the lexical semantics of embedding predicates is taken into account.

In the following, I give a preview of how these proposals enable us to address the three issues. The following sections correspond to individual chapters in this dissertation.

1.2.2 Capturing the complement selection (Chapter 2)

Proposal 1—declarative complements as singleton questions—is a particular formulation of the proposition-to-question approach introduced in section 1.1.1. I will propose that responsive predicates select for questions (modeled as sets of propositions) rather than propositions. Declarative complements denote singleton proposition-sets, meaning that embedding of declarative complements is a limiting

case of question-embedding. For example, the declarative complement *that Ann came* of a responsive predicate denotes a singleton set of the proposition that Ann came, as shown in the following:

$$(15) \quad \llbracket \text{that Ann came} \rrbracket^w = \{ \text{'Ann came'} \}$$

At the same time, the responsive predicate *know* has a question-taking semantics that can be paraphrased informally as ‘to know the answer of’. Thus, the meaning of *know* embedding an interrogative complement can be analyzed as in (16a) while *know* embedding a declarative complement can be analyzed as in (16b).

- (16) a. $\llbracket \text{John knows which students came} \rrbracket^w = 1$
 iff John knows the answer to ‘Which students came?’
 b. $\llbracket \text{John knows which students came} \rrbracket^w = 1$
 iff John knows the answer to {Ann came}

Since {that Ann came} is a singleton question whose only answer is ‘Ann came’, (16b) ends up being equivalent to ‘John knows that Ann came’.

In chapter 2, I will put forward an analysis along these lines based on the semantic contrast between responsive predicates and predicates that only embed declaratives (e.g., *believe*), when they take DP complements headed by content nouns, as shown below (Vendler 1972):

- (17) a. John **discovered** the rumor that Mary left.
 \Rightarrow John **discovered** that Mary left.
 b. John **believes** the rumor that Mary left.
 \Rightarrow John **believes** that Mary left.

As long as we assume that responsive predicates take propositions, any plausible predictive account of the entailment in (17b) would incorrectly predict the same entailment to be licensed in (17a). On the other hand, if responsive predicates are question-taking, the contrast in (17) can be captured given an independent claim about the inventory of type-shifters that map entities to propositions and questions. Also, the challenge for the proposition-to-question approach mentioned in section 1.1.1—how to account for the selectional restrictions of the *wonder*-type predicates—can be given a natural semantic solution. The *wonder*-type predicates are those predicates whose lexical semantics is incompatible with singleton questions: they want the question it combines with to be a non-singleton.

1.2.3 Capturing the exhaustivity (Chapter 3)

In chapter 3, I present my solution to the issue of exhaustivity based on Proposal 2, i.e., a unified derivation for exhaustivity. According to this proposal, all varieties of exhaustive interpretations of question-embedding sentences—weak exhaustivity, intermediate exhaustivity and strong exhaustivity—result from the semantic derivation represented in the following kind of LF structure (cf. Klinedinst and Rothschild 2011):

$$(18) \text{ John } [X [\left\{ \begin{array}{c} \text{knows} \\ \text{predicted} \\ \text{was surprised by} \\ \text{told me} \end{array} \right\} [\text{which students came}]]]$$

Here, X represents an operator that ‘exhaustifies’ the interpretation of its scope, in the sense that will be made precise in chapter 3. It should be noted at this point that, although X in (18) is represented as a free-standing syntactic operator (cf. e.g., Chierchia et al. 2012), this operator could also be an obligatory part of the lexical semantics of responsive predicates for the purpose of the current analysis.

What is crucial here is that the exhaustification operation is *obligatory* and it takes scope *above* the embedding predicate. Assuming that the exhaustification operation negates strictly stronger alternatives of its prejacent, it is predicted that the effect of the exhaustification depends on the monotonicity property of the embedding predicate. In particular, the exhaustification would derive intermediate exhaustivity if the embedding predicate has an *upward monotonic* semantics whereas its effect would be vacuous if the embedding predicate is *non-monotonic* (cf. Klinedinst and Rothschild 2011). Furthermore, I will also claim that there is no semantic derivation that directly derives strong exhaustivity, pace the common semantic approaches to strong exhaustivity (e.g., Groenendijk and Stokhof 1984; Heim 1994; Klinedinst and Rothschild 2011). Rather, strong exhaustivity can be indirectly derived from intermediate exhaustivity by the mechanism underlying neg-raising. As I will argue in chapter 3, this theory enables one to correctly predict the range of exhaustive interpretations, based on the lexical semantics of embedding predicates.

1.2.4 Capturing the veridicality (Chapter 4)

In chapter 4, I address the issue of veridicality based on Proposal 1, i.e., that declarative complements of responsive predicates denote singleton questions. To address the problem of veridicality in general, I first consider how veridicality and non-veridicality can be represented in the lexical semantics of responsive predicates. In doing this, I also provide an analysis of factivity stemming from Proposal 1.

According to the analysis presented in chapter 2, the denotation of a responsive predicate takes a question. For example, the denotation of *know* can be paraphrased as ‘to know the answer of’. To make concrete what ‘the answer’ precisely means here, I make use of Dayal’s (1996) answerhood operator, which I notate as Ans_d . Ans_d is a partial function from questions (modeled as sets of propositions) to propositions that presupposes a unique existence of a most informative true member of the question denotation, and returns the most informative true answer. Employing this operator, I argue that the semantics of factive responsive predicates involve two components: Ans_d and (the meaning of) a non-factive proposition-taking predicate. For example, the meaning of *know* is broken down into ‘believe’ and Ans_d . In other words, *know* is a predicate that takes a question as a whole and has the internal semantics of ‘to believe the true most informative answer to’.

In this analysis, the veridicality of *know* is captured by the fact that Ans_d is defined

to return the true answer, both for interrogative and declarative cases. Furthermore, given that declarative complements denote singleton questions (Proposal 1), we can also derive factivity from the *existential presupposition* associated with Ans_d . Ans_d can be thought of as a kind of definite determiner, and it triggers the presupposition that the question it operates on has a true answer. If the embedded question is a singleton denoted by a declarative complement, this presupposition effectively boils down to factivity. For example, the presupposition that ‘Ann came’ contains a true answer is equivalent to the presupposition that Ann came.

The following examples and the paraphrases of their predicted presuppositions/assertions illustrate the above point:

- (19) a. John knows which students came.

Presupposition There is a unique true most informative answer to ‘Which students came?’

Assertion John believes the most informative true answer to ‘Which students came?’

- b. John knows that Ann came.

Presupposition There is a unique most informative true answer to {Ann came}. \Leftrightarrow Ann came.

Assertion John believes the most informative true answer to {Ann came}. \Leftrightarrow John believes that Ann came.

How can this analysis be extended to non-veridical predicates? In chapter 4, I give in-depth analyses of three kinds of non-veridical predicates represented by *be certain*, *tell* and *agree* respectively, and conclude that non-veridical predicates, too, have the internal semantics that can be decomposed into a proposition-taking predicate and an answerhood operator, except that the operator can be evaluated in a world other than the matrix evaluation world. For example, I will argue that *tell* (in its non-veridical reading) means ‘communicate a *possibly* true and most informative answer to’. A possibly true answer of course does not have to be true, and hence non-veridicality of *tell* is captured this way, again both for declarative and interrogative cases. Also, once the projection of the presupposition of Ans_d is taken into account, it turns out that we correctly account for the non-factivity of *tell*.

Hence, Proposal 1 enables us to have a natural account of why Spector and Egré’s generalization holds, i.e., why veridicality with respect to declarative-embedding completely aligns with veridicality with respect to interrogative-embedding: they align because both manifestations of veridicality arise from the same source, i.e., the evaluation of the answerhood operator in the matrix evaluation world.

Regarding the problem of why *tell* has a default veridical inference, I will argue that it can be given a straightforward solution once we assume that *tell* (and other communication predicates) are ambiguous between veridical and non-veridical readings. A pragmatic principle that favors a stronger interpretation of an ambiguous sentence (the Strong Meaning Hypothesis; Dalrymple et al. 1998) predicts that the veridical *tell* is preferred over the non-veridical *tell* in the interrogative case since the former results in the stronger interpretation. The preference does not arise in the

declarative case since the distinction between the veridical *tell* and the non-veridical *tell* collapses in the declarative case. This approach makes a further prediction that the veridical inference in the interrogative case goes away if the predicate is embedded under Downward Entailing contexts since Strong Meaning Hypothesis is a global constraint. I will claim that this prediction is borne out.

In chapter 4, connections between Proposal 1 and Proposal 2 are also discussed. Even though the two proposals are in principle independent, the analysis of veridicality and non-veridicality based on Proposal 1 provides a solution to a problem with the analysis of exhaustivity in chapter 3, which is based on Proposal 2. The analysis of intermediate exhaustivity based on matrix exhaustification is known to face an apparent problem when the embedding predicate is factive (Klinedinst and Rothschild 2011). This problem can be avoided once we adopt the analysis of factivity in terms of the existential presupposition enabled by Proposal 1.

1.2.5 Mention-some and reducibility (Chapter 5)

Thus, the three issues surrounding the semantics of question-embedding that I introduced in section 1.1 are addressed in chapters 2-4. Before concluding the dissertation, I consider the general characteristics of the proposed analysis of question-embedding with respect to the notion of REDUCIBILITY discussed by George (2011).

Roughly, George (2011) calls a responsive predicate REDUCIBLE if the interpretation of its interrogative-embedding use can be paraphrased by the interpretation of its declarative-embedding use. Using examples involving mention-some questions, George points out that some responsive predicates (such as *know*) are non-reducible.

After presenting an extension of the proposed analysis to George's example involving mention-some questions, I show that the current analysis in fact correctly predicts that not all responsive predicates are reducible in George's sense. However, this does not mean that the proposed analysis of question-embedding cannot be characterized by a general feature like reducibility. I will point out in this chapter that the analysis still preserves reducibility in the sense that the interpretation of responsive predicates are reducible if we disregard the effect of factivity contributed by the answerhood operator Ans_d .

1.3 Basic assumptions

In this section, I lay out the basic theoretical assumptions that I will make use of throughout this dissertation. These assumptions are (i) the semantic framework that largely follows Heim and Kratzer (1998), and (ii) the internal composition of interrogative complements following Karttunen (1977) and Beck and Rullmann (1999).

Although I situate the analysis I put forward in this dissertation in a particular theoretical framework of formal semantics, I believe that most of its aspects can be straightforwardly implemented in alternative semantic frameworks. However,

I will not spend much discussion on framework comparisons in the rest of this dissertation, as my main goal is to advance our understanding of a particular empirical aspect of natural language, which has not been theoretically made clear.

1.3.1 The semantic framework

1.3.1.1 The semantic metalanguage and model-theoretic interpretation

As the semantic framework, I will follow Heim and Kratzer (1998) and other current formal semantic literature based on the transformational/minimalist grammars in assuming that semantics operates on the syntactic level of LOGICAL FORM (LF). An LF is a syntactic tree representation of a sentence derived in syntax, independently of semantics.

Semantics is a mapping from LFs to their interpretations. I assume that semantics first translates an LF into a formula in the semantic metalanguage. The metalanguage translation of a sentence unambiguously represents the TRUTH-CONDITIONS of the sentence, i.e., what the world has to be like for the sentence to be true. As the metalanguage, I use a formal language similar to Ty2 (a higher-order type-theoretic language with two sorts of individual types, i.e., e and s and the λ -abstraction; Gallin 1975) sometimes mixed with set-theoretic notations. A metalanguage sentence receives a model-theoretic interpretation in a model consisting of the set of individuals D , the set of worlds W and the interpretation function I that maps constants in the metalanguage to their model-theoretic interpretations. We also use TYPES to categorize metalanguage formulae and their denotations. Here is the inventory of types and their domains:

(20) **Semantic types**

- a. e , t and s are semantic types.
- b. If σ and τ are semantic types, then $\langle \sigma, \tau \rangle$ is a semantic type.
- c. Nothing else is a semantic type.

(21) **Semantic denotation domains**² (D_τ : the set of denotations of type τ)

- a. $D_e := D$
- b. $D_t := \{1, 0\}$
- c. $D_s := W$
- d. For any semantic types σ and τ , $D_{\langle \sigma, \tau \rangle}$ is the set of all functions from D_σ to D_τ

Despite the two-step process of the semantic interpretation, in the actual discussion of the analysis of linguistic phenomena, I will mostly only discuss how linguistic expressions can be translated to metalanguage formulae, assuming that the interpretations of the metalanguage formulae are transparent. Also, I will be rather sloppy in terminology/notation and write the metalanguage translation for an object language expression α at a given world w as $\llbracket \alpha \rrbracket^w$ and call it the DENOTATION

²In chapter 4, I will also consider a trivalent system, in which $D_t := \{1, 0, \#\}$

or EXTENSION of α in w . Similarly, I write the function that maps a world w to α 's denotation at w as $\llbracket \alpha \rrbracket_w$, and call it the INTENSION of α , following the notation in Dowty et al. (1981).

1.3.1.2 Type-driven compositional interpretation

Given a hierarchical tree structure of an LF, semantics recursively interprets the structure in a compositional fashion, using LEXICAL ENTRIES that provide the translations for atomic expressions, or the 'leaves' of the tree, and a limited set of COMPOSITION RULES that determine how the translation of a non-terminal node is derived from the translations of its daughters. Specific examples of compositional rules will be introduced later.

I employ an EXTENSIONAL semantic system, where each lexical item is assigned the extensional semantic value, i.e., what it denotes in a *given possible world*. Thus, lexical entries determine the denotations of lexical items in the following ways:

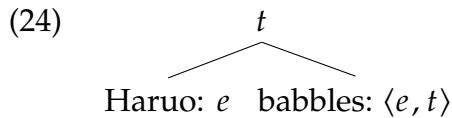
- (22) a. $\llbracket \text{Haruo} \rrbracket^w = \mathbf{h}$
 b. $\llbracket \text{babbles} \rrbracket^w = \lambda x_e. \mathbf{babbles}(x, w)$

The lexical entry in (22a) determines that the translation of the proper name *Haruo* in w is \mathbf{h} , the metalanguage expression denoting the individual Haruo. On the other hand, (22b) determines that the verb *babbles* denotes a function that maps any individual-denoting term x to the metalanguage sentence $\mathbf{babbles}(x, w)$. The subscript e to the variable x in (22b) represents the type of the domain which the variable can range over.

Compositional rules include the following two versions of functional application.

- (23) a. **Functional Application (FA)**
 For all $w \in W$, if the node α has $\{\beta, \gamma\}$ as the set of its daughters and $\llbracket \beta \rrbracket^w \in D_\sigma$ and $\llbracket \gamma \rrbracket^w \in D_{\langle \sigma, \tau \rangle}$, then $\llbracket \alpha \rrbracket^w = \llbracket \gamma \rrbracket^w(\llbracket \beta \rrbracket^w)$
 b. **Intensional Functional Application (IFA)**
 For all $w \in W$, if the node α has $\{\beta, \gamma\}$ as the set of its daughters and $\llbracket \beta \rrbracket^w \in D_\sigma$ and $\llbracket \gamma \rrbracket^w \in D_{\langle \langle s, \sigma \rangle, \tau \rangle}$, then $\llbracket \alpha \rrbracket^w = \llbracket \gamma \rrbracket^w(\lambda w'. \llbracket \beta \rrbracket^{w'})$

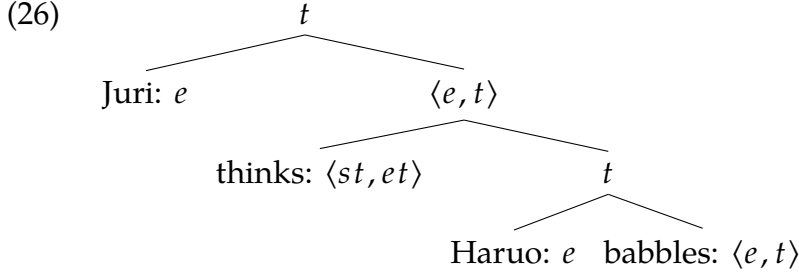
Using Functional Application (FA) defined in (23a), we can derive the truth conditions of the LF in (24) as in (25):



- (25) $\llbracket (24) \rrbracket^w = 1$ iff $\mathbf{babbles}(\mathbf{h}, w)$

Note that syntactic labels for nodes in an LF structure are not necessary for a semantic interpretation. So, I will write syntactic category labels in LFs only when the labels help an illustration. Otherwise, I will either write in the semantic types of the nodes, as in (24), or simply write in the place-holder ' '.

The Intensional Functional Application (IFA) is used to combine an intensional predicate with its complement. For example, the following LF structure is interpreted using the IFA to combine *thinks* and its complement *Haruo babbles*.



Assuming the denotation of *think* in (27), *think* and its complement *Haruo babbles* are composed by IFA, yielding the interpretation in (28).

$$(27) \quad \llbracket \text{thinks} \rrbracket^w = \lambda p_{\langle s, t \rangle} \lambda x. \mathbf{thinks}(x, p, w)$$

$$\begin{aligned}
 (28) \quad \llbracket \text{thinks Haruo babbles} \rrbracket^w &= \lambda x_e. \mathbf{thinks}(x, \lambda w'. \llbracket \text{Haruo babbles} \rrbracket^{w'}, w) \\
 &= \lambda x_e. \mathbf{thinks}(x, \lambda w'. \mathbf{babbles}(\mathbf{h}, w'), w)
 \end{aligned}$$

This function is further combined with the interpretation of the subject *Juri* via FA, and thus the following truth conditions for the whole LF are derived.

$$(29) \quad \llbracket (26) \rrbracket^w = 1 \text{ iff } \mathbf{thinks}(\mathbf{j}, \lambda w'. \mathbf{babbles}(\mathbf{h}, w'), w)$$

1.3.1.3 Interpretation of variables and predicate abstraction

I will assume that pronouns and traces carry INDICES at LF, and are interpreted with respect to an assignment function, which is a function from natural numbers to members of D . An assignment function serves as another parameter of interpretation along with the evaluation world. For example, the interpretation of *she_i* with respect to the assignment function g (and world w) would be the following, for any natural number i :³

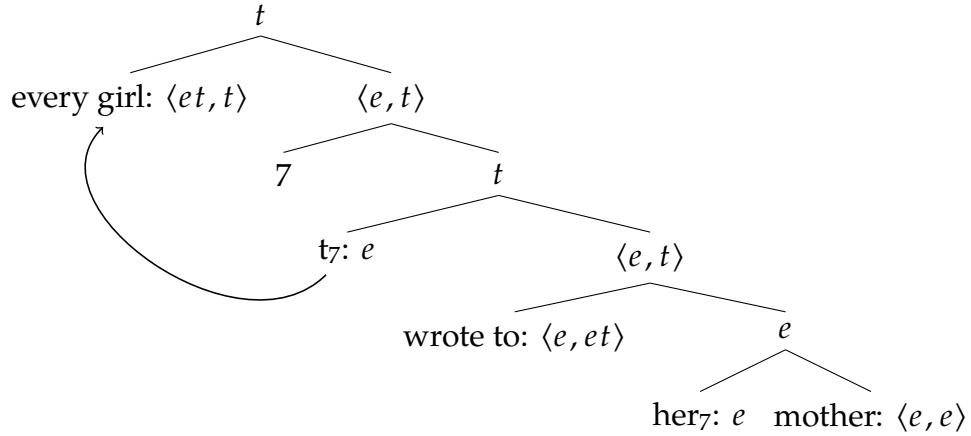
$$(30) \quad \llbracket \text{she}_i \rrbracket^{w, g} = g(i)$$

When the pronoun is FREE, i.e., it is not co-indexed with a c-commanding operator in the syntax, pronouns like (30) pick up its referent according to the contextually available assignment function. On the other hand, when the pronouns is BOUND, i.e. it is co-indexed with a c-commanding operator in the syntax, as in (31), it is assumed that a BINDER INDEX is introduced immediately below the binding operator, as shown in the LF in (32).

$$(31) \quad \text{Every girl}_7 \text{ wrote to her}_7 \text{ mother.}$$

³I disregard the ϕ -features (i.e., the gender and number features) of pronouns here.

(32)



Following Heim and Kratzer (1998), I assume that a binder index is created at LF by a phrasal movement, and that the movement leaves a type e trace co-indexed with the binder index. In the case of (32), the movement of the quantifier *every girl* leaves a trace indexed as 7, and also creates the binder index 7 immediately below its landing site.⁴

The branching node containing a binder index is interpreted according to the rule of PREDICATE ABSTRACTION, defined as follows:

(33) **Predicate Abstraction (PA)**

For all $w \in W$ and assignment functions $g \in D^{\mathbb{N}}$, if the node α has a binder index i and β as its daughters, then $\llbracket \alpha \rrbracket^{w,g} = \lambda x_e. \llbracket \beta \rrbracket^{w,g[x/i]}$

This rule effectively creates a λ -abstract where the pronouns co-indexed with the binder index are ‘replaced’ with the variable bound by the λ -operator. Traces have the same semantics as pronouns, i.e., they receive interpretations with respect to the assignment function. With this setup, the denotation of the sister constituent of *every girl* in (32) will be the following predicate:

$$\begin{aligned}
 (34) \quad & \llbracket 7 [t_7 \text{ wrote to her}_7 \text{ mother}] \rrbracket^{w,g} \\
 &= \lambda x_e. \llbracket t_7 \text{ wrote to her}_7 \text{ mother} \rrbracket^{w,g[x/7]} \\
 &= \lambda x_e. \mathbf{wroteTo}(x, \mathbf{motherOf}(x, w), w)
 \end{aligned}$$

Given the denotation of *every girl* as in (35), we can derive the truth conditions in (36), which involve the bound interpretation of the pronoun.

$$(35) \quad \llbracket \text{every girl} \rrbracket^w = \lambda P_{\langle e, t \rangle}. \forall x [\mathbf{girl}(x) \rightarrow P(x)]$$

$$(36) \quad \llbracket (32) \rrbracket^w = 1 \text{ iff } \forall x [\mathbf{girl}(x) \rightarrow \mathbf{wroteTo}(x, \mathbf{motherOf}(x, w), w)]$$

1.3.1.4 Presuppositions

Some expressions are PRESUPPOSITIONAL, i.e., their interpretations are defined only if certain conditions are met. For example, under the Frege-Strawson analysis, a definite description refers to the unique entity satisfying the description if there is

⁴See Buring (2004) for a system where the binder index can be freely introduced without movement.

a unique entity that satisfies the description; otherwise the definite description is extensionless. That is, the definite description *the king of France* has the following interpretation.

$$(37) \quad \llbracket \text{the king of France} \rrbracket^w = \begin{cases} \iota x[\mathbf{king}(x, \mathbf{France}, w)] & \text{if } \exists! x[\mathbf{king}(x, \mathbf{France}, w)] \\ \text{undefined} & \text{otherwise} \end{cases}$$

To derive the presuppositionality of definite descriptions, the definite determiner is treated as denoting a PARTIAL FUNCTION of the following form:

$$(38) \quad \llbracket \text{the} \rrbracket^w = \lambda P_{\langle e, t \rangle}. \begin{cases} \iota x[P(x)] & \text{if } \exists! x[P(x)] \\ \text{undefined} & \text{otherwise} \end{cases}$$

I will sometimes use an alternative notation for partial functions as follows following Heim and Kratzer (1998).

$$(39) \quad \llbracket \text{the} \rrbracket^w = \lambda P_{\langle e, t \rangle} : [\exists! x[P(x)]] . \iota x[P(x)]$$

In the latter notation, $\lambda \alpha : [\pi(\alpha)].\varphi$ refers to a partial function which returns a defined value only if $\pi(\alpha)$ holds of the input argument α .

Having introduced presuppositions, we need to specify how presuppositions are inherited in each compositional rule. FA is revised below so that the semantic value of the branching node is defined only if the semantic values of both of the daughter nodes are defined (Heim and Kratzer 1998: 49). (The added condition is underlined.)

(40) **Functional Application (FA; revised)**

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

PA, on the other hand, is revised so that the result is a partial function, as shown in the following (Heim and Kratzer 1998: 106):

(41) **Predicate Abstraction (PA; revised)**

For all $w \in W$ and assignment functions $g \in D^{\mathbb{N}}$, if the node α has a binder index i and β as its daughters, then

$$\llbracket \alpha \rrbracket^{w,g} = \lambda x_e. \begin{cases} \llbracket \beta \rrbracket^{w,g[x/i]} & \text{if } \llbracket \beta \rrbracket^{w,g[x/i]} \text{ is defined} \\ \text{undefined} & \text{otherwise} \end{cases}$$

In order to redefine IFA, we need a notion of *intensions* of sentences that may have presuppositions. An intension of a sentence φ under an assignment function g , $\llbracket \varphi \rrbracket_{\mathcal{C}}^g$ can be defined as follows in a way parallel to the revised definition of PA above.

(42) **Intension**

For all assignment functions $g \in D^{\mathbb{N}}$,

$$\llbracket \varphi \rrbracket_{\mathcal{C}}^g := \lambda w'_s. \begin{cases} \llbracket \varphi \rrbracket^{w',g} & \text{if } \llbracket \varphi \rrbracket^{w',g} \text{ is defined} \\ \text{undefined} & \text{otherwise} \end{cases}$$

IFA is revised as follows using this revised notion of intensions:

(43) **Intensional Functional Application (IFA; revised)**

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

I call a sentence φ a **PRESUPPOSITION FAILURE** in w if $\llbracket \varphi \rrbracket^w$ is undefined. We discuss the issue of presupposition projection out of quantified sentences in chapter 4.

1.3.2 Semantics of interrogative complements

In this section, I will outline the semantics of interrogative clauses based on which I will develop the semantics of question-embedding throughout this dissertation. Specifically, I will review the following two things: (i) the view that interrogative clauses denote **SETS OF PROPOSITIONS**, and (ii) the compositional semantics of interrogative complements along the lines of Karttunen (1977). Of these two, the first assumption is more crucial to the proposals I will make in the following chapters while the second assumption is less so. As long as interrogative complements denote proposition sets of the appropriate form, the internal composition of complements that derive such denotations is of secondary importance. In fact, in the compositional analysis of question-embedding sentences in the following chapters, I will simply omit the internal composition of interrogative clauses and treat them as atomic items denoting appropriate proposition-sets. The reason for reviewing a particular version of the compositional semantics of interrogatives (based on Karttunen 1977) here is to show that it is *possible* to compositionally derive the proposition-set denotation for interrogative complements. In this regard, compositional analyses of interrogative complements other than Karttunen (1977) based on the proposition-set representation, such as those in Hamblin (1973); Hagstrom (1998) and Lahiri (2002) in principle suffice for the current purpose.

1.3.2.1 Question meanings as sets of propositions

As Krifka (2011) notes, there are three prominent model-theoretic analyses of questions where question meanings have the following three kinds of representations, respectively: the **FUNCTIONAL REPRESENTATION**, the **PROPOSITION-SET REPRESENTATION** and the **PARTITION REPRESENTATION**. These three representations are illustrated with the example *Who came?* in the following:

(44) Who came?

- a. **Functional representation:** $\lambda x_e \lambda w_s. \text{came}(x, w)$
- b. **Proposition-set representation:** $\lambda p_{\langle s, t \rangle}. \exists x[p = \lambda w'_s. \text{came}(x, w')]$
- c. **Partition representation:** $\lambda w_s \lambda w'_s. [\lambda x_e. \text{came}(x, w) = \lambda x_e. \text{came}(x, w')]$

Below, illustrate how these semantic objects intuitively represent question meanings, as well as how they satisfy the three desiderata for the semantics of interrogative clauses introduced in section 1.1. The three desiderata are summarized in the following:

(45) **Three desiderata for the semantics of interrogative clauses**

- a. An answer in the form of a proposition can be retrieved from the semantic representation of an interrogative.
- b. Both exhaustive and non-exhaustive answers have to be available in the semantic representation of an interrogative.
- c. Both true and false answers have to be available in the semantic representation of an interrogative.

The functional representation The basic intuition behind the functional representation is that questions represent a proposition with a ‘missing piece’, where the missing piece corresponds to the *wh*-phrase in the case of a *wh*-question. If this missing piece is ‘filled’ one way or the other, the sentence becomes an answer to the question. As such, the functional representation of *who came* is such a function that takes any individual into the corresponding ‘answer’ proposition which states that the individual came. I include in this category the representation of questions as ‘open sentences’, i.e., sentences with a free variable in the place of the *wh*-phrase(s) since the functional representation and open sentences are in one-to-one correspondence: An open sentence can be mapped to the corresponding functional representation by a λ -abstraction of the free variables while a functional representation can be mapped to the corresponding open sentence by applying the function to an arbitrary free variable. In the modern semantic theories, the open sentence/function approach is advocated by Hintikka (1976), Berman (1991) and more recently by Jacobson (2013) in the formal semantic literature.

How does the functional representation fare with the three desiderata in (45)? Here, I will discuss how the first and third desiderata are met in this approach. The desideratum concerning exhaustivity of answers will be discussed later, after I present the relationship between the three representations. In the functional approach, the propositional answers are something that are derived by applying the functional representation to members of its domain. The members of the domain of the functional representation correspond to TERM ANSWERS, such as the answer *Ann* in response to *Who came?*. In other words, the approach takes term answers as the basic form of answers, and propositional answers are derived by applying the functional question denotation to the term answers.

Both true and false answers can be derived in this way since the function can be applied to any entity in the domain whether or not the resulting proposition is true. For example, the function in (44a) can be applied to any individual to return the propositional answer that that individual came, regardless of whether the answer is true.

The proposition-set representation The proposition-set approach follows the idea that the semantic value of a question represents the set of their possible answers. Thus, in the case of *who came*, the proposition-set representation is the set of propositions of the form *x came*, where *x* is any individual. Thus, if Ann and Bill are the only individuals, the proposition-set representation of *Who came?* would look

like {'Ann came', 'Bill came'}.⁵ This kind of representation is defended by Hamblin (1973) and Karttunen (1977) although they differ in the compositional semantics of interrogatives.⁶ Also, the proposition-set representation is assumed in a number of semantic studies of embedded-questions including Dayal (1996); Beck and Rullmann (1999); Lahiri (2002); George (2011) and Spector and Egré (2015). A refined version of the approach has been advocated as INQUISITIVE SEMANTICS by Ciardelli et al. (2013), where one of the primary refinements being the downward-closure of proposition sets. It is easy to see how the approach satisfies the first and third desiderata in (45). The members of the proposition-set themselves represent the propositional answers, and they include both true and false ones. Again, I will discuss the issue of exhaustivity later.

The partition representation Finally, the partition representation follows the idea (dating back to Hamblin 1958) that questions partition the whole logical space into mutually exclusive possibilities. The function in (44c) maps worlds to particular 'cells' (of type $\langle s, t \rangle$) in the partition, each of which completely determines who came and who didn't come. Equivalently, (44c) is an equivalence relation that relates two worlds if and only if the set of individuals who came in the two worlds are the same. Thus, given an arbitrary world, (44c) returns the *strongly exhaustive* answer of the question in that world. The difference between the proposition-set representation and the partition representation is depicted in Figure 1-1. The partition approach is put forth by Hamblin (1958) and developed in a greater detail by Groenendijk and Stokhof (1984).

Again, it is easy to see that the partition representation satisfy the first and the third desiderata in (45). Each of the cells, which can be derived by applying the function as in (44c) to an arbitrary world, corresponds to an exhaustive answer of the question, which could be true or false.

Relationship between representations Of the three representations, the functional representation is the most informative and the partition representation is the least informative while the proposition-set representation has an intermediate strength of informativeness (Krifka 2011). In other words, we can construct a function that maps a functional representation to the corresponding proposition-set representation, but not vice versa. Similarly, we can construct a function that maps a proposition-set representation to the corresponding partition representation, but not vice versa. Overall, the following mapping relations hold among the three

⁵Later, I will refine this treatment, and include the proposition 'Ann and Bill came' after presenting the compositional semantics of interrogatives along the lines of Karttunen (1977).

⁶Another difference between Hamblin (1973) and Karttunen (1977) is that Hamblin (1973) includes true as well as false answers in the set while Karttunen (1977) only includes true answers. Furthermore, the treatment of the answer corresponding to *No one came* for *Who came?* differs. If in fact no one came, Karttunen's question denotation for *who came* would be the proposition that no one came. What I will call the proposition-set representation does not share these properties with Karttunen's denotation. That is, the proposition-set includes false answers and does not include a proposition corresponding to *No one came*.

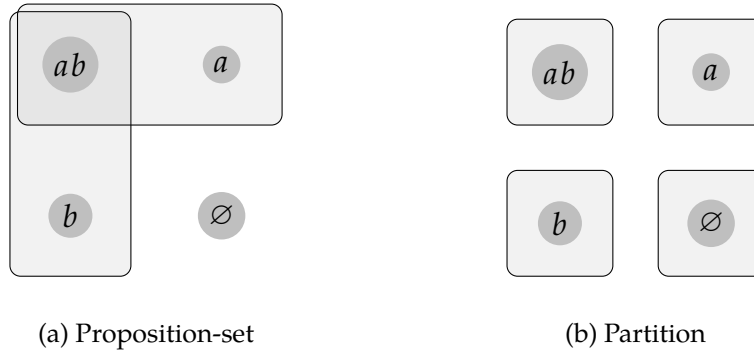


Figure 1-1: The proposition-set representation and the partition representation.

The figures depict the representations for the question *Who came?*, assuming that there are only two individuals *a* and *b*. The small circles represent specific worlds, where both *a* and *b* came (*ab*), only *b* came (*a*), only *a* came (*b*), and neither came (\emptyset). The lined rectangles indicate the propositions in a proposition-set or the specific cells of a partition.

representations.

(46) Functional representation \nleftrightarrow Proposition-set \nleftrightarrow Partition

Let me illustrate this in more detail. The mapping from functional representations to proposition-set representations is given in (47):

(47) If F is a functional representation of a question,
then $\{F(x) \mid x \in \text{dom}(F)\}$ is its proposition-set representation.
(Krifka 2011: 1760)

On the other hand, it is impossible to derive a functional representation from a proposition-set representation. In other words, there cannot be an inverse function of (47). This is so since there can be different functional representations that map to the same proposition-set representation. For example, the two functions in (48a) correspond to the same proposition-set in (48b).

- (48) a. **Functional representation:**
- $\lambda x \in \{\mathbf{a}, \mathbf{b}\} \lambda w. \text{came}(x)$
 - $\lambda p \in \{\lambda w. \text{came}(\mathbf{a}), \lambda w. \text{came}(\mathbf{b})\} \lambda w. p(w)$
- b. **Proposition-set representation:** $\{\lambda w. \text{came}(\mathbf{a}, w), \lambda w. \text{came}(\mathbf{b}, w)\}$

The two functional representations in (48a) are collapsed into the single proposition-set representation roughly because of the following fact: the functional representation transparently preserves which ‘part’ of an answer corresponds to the *wh*-phrase and which part doesn’t. For example, the two functions in (48a) transparently represent the following two interrogative sentences.

- (49) a. Who among Ann and Bill came?
b. Which happened: Ann came and Bill came?

This kind of distinction is lost in the proposition-set representation because it does not provide information about which ‘part’ of an answer corresponds to the *wh*-phrase.

Next, let us move on to the relationship between the proposition-set representation and the partition representation. Proposition-set representations can be mapped to partition representations in the way given in (50).

- (50) If Q is a proposition-set representation of a question,
then $\lambda w \lambda w'. \forall p \in Q [p(w) = p(w')]$ is its partition representation.

In contrast, we cannot determine a proposition-set representation given a partition representation. Multiple proposition-sets may correspond to a single partition, as in the following case.

- (51) a. **Proposition-set representation:**
- $\{A, B\}$
 - $\{\neg A, \neg B\}$
- b. **Partition representation:** $\lambda w \lambda w'. [A(w) = A(w') \wedge B(w) = B(w')]$

Here, we have distinct sets of propositions, one being a set of ‘positive’ propositions while the other being a set of ‘negative’ propositions. However, the partition corresponding to these sets turns to be the same one in (51b), i.e., the partition that compartmentalizes the logical space into four cells: one where both A and B holds, one where only A holds, one where B holds, and one where neither A nor B holds (see Figure 1-1(b)).

Empirical arguments for choosing a representation Now that we have grasped the theoretical differences between the three semantic representations, let us ask if there is empirical arguments for favoring one representation over the other. This is where the second desideratum in (45)—the need for both exhaustive and non-exhaustive answers in question meanings—becomes relevant. Below, I summarize Heim’s (1994) argument against taking partitions to be the *only* representation of questions, based on the observation concerning the interpretation of interrogatives under *surprise*.

Recall that the empirical motivation for the second desideratum in (45) is the difference in the interpretations of interrogative complements embedded under predicates like *know* on the one hand and predicates like *surprise* on the other hand. In the current context, what is relevant is the interpretation of interrogatives under *surprise*, as exemplified in the following (Heim 1994; Beck and Rullmann 1999):⁷

- (52) [**Situation:** John expected all of Ann, Bill and Chris to come. It turned out that Ann and Bill came and Chris didn’t.]
John was surprised by who came. (**Judgment:** False)

⁷I will discuss this data point in more detail in chapter 3. There, I will also discuss the counterexamples to the claim discussed in Klindinst and Rothschild (2011) and Theiler (2014).

The fact that (52) sounds false given this situation suggests that the complement of (52) receives the interpretation of the *weakly exhaustive* answer ‘Ann and Bill came’ rather than the *strongly exhaustive* answer ‘Ann and Bill came *and* Chris didn’t’. We can conclude from this observation that weakly exhaustive answers have to be available in the semantic representation of the interrogative complement *who came*.

Since each cell in a partition represents complete resolutions of the question, only *strongly exhaustive* answers are available in the partition representation of questions. This means that the partition representation does not satisfy the second desideratum in (45), and thus cannot account for the data in (52). Furthermore, the partition representation cannot be converted to other representations since it is the least informative representation.

On the other hand, both functional and proposition-set representations satisfy the desideratum. The non-exhaustive answers required to account for the data in (52) are available in the set of propositions themselves in the proposition-set representation. Also, the functional representation can be converted to such a proposition-set representation using the mapping in (47). Note that the need for strongly exhaustive answers (in addition to weakly exhaustive answers) is not a problem for these representations since they can be converted to the partition representation using the mappings in (50).

Hence, there is an empirical argument to favor the functional and the proposition-set representation of question meanings over the partition representation. In contrast, there does not seem to be an empirical argument to favor either functional or proposition-set representation over the other, at least if we focus on embedded questions.^{8,9} Thus, following the general methodological strategy of choosing the weakest possible semantic representation that can capture the relevant empirical facts, I will employ the proposition-set representation for question meanings in the analysis of embedded questions in the rest of this dissertation.

1.3.2.2 The internal composition of interrogative complements

An LF-based revision of Karttunen (1977) As the compositional semantics of interrogative complements that derives the proposition-set question denotation, I will adopt an LF-based rendition of Karttunen’s (1977) Montague-semantic analysis based on von Stechow (1996) and Heim (2012). According to this analysis, *wh*-questions have LF structures as in (53), which involves what Karttunen (1977) calls

⁸Berman’s (1991) analysis of quantificational variability crucially relies on the functional representation, but it was reformulated using proposition-set representations by Lahiri (2002).

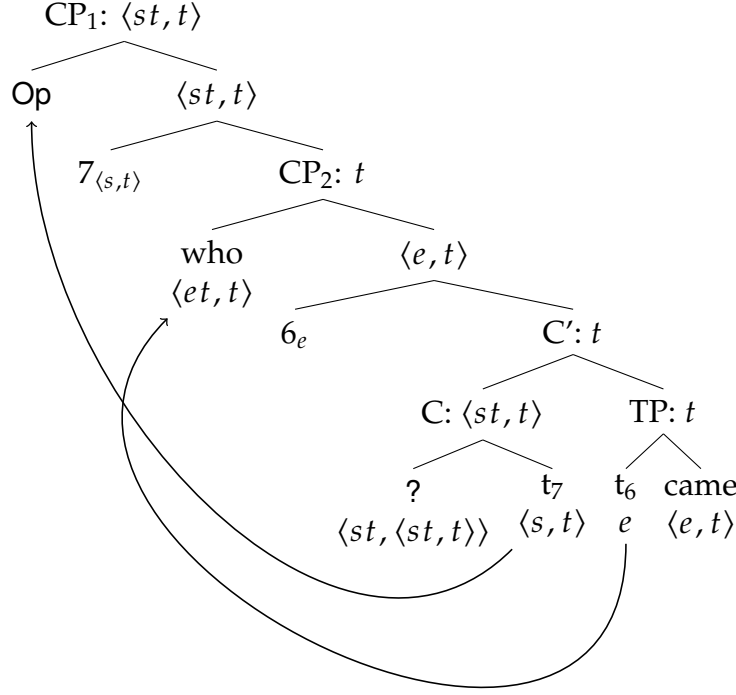
⁹Krifka (2011) argues that the behavior of answer particles in response to polar questions and alternative questions as exemplified below can only be captured in the functional representation.

- (i) A: Did Bill leave?
B: Yes. / He did (leave).
- (ii) A: Did Bill leave, or not?
B: *Yes. / He did (leave).

However, it is not clear if similar arguments can be made with respect to the semantics of embedded questions.

the proto-question operator ? in the C position and the movement of the *wh*-item from the in-situ position to the specifier of CP.

(53) Who came?



Following von Stechow (1996), I define the denotation of the proto-question operator ? as the identity relation between propositions, as in the following.

$$(54) \quad \llbracket ? \rrbracket^w = \lambda p_{\langle s, t \rangle} [\lambda q_{\langle s, t \rangle} . p = q]$$

The *wh*-phrases have the same denotations as existential quantifiers. For example, *who* has the following denotation:

$$(55) \quad \llbracket \text{who} \rrbracket^w = \lambda P_{\langle e, t \rangle} . \exists x [\text{person}(x, w) \wedge P(x)]$$

The denotations of *wh*-phrases will be refined later to accommodate their number features.

The structure also involves a movement of a semantically vacuous null operator Op from the sister position of ?, which adjoins to the CP and leaves a propositional-type trace. This movement effectively derives the same result as what is done by the ‘WH-Quantification Rule’ in Karttunen (1977).

The crucial steps in the compositional derivation are given below:

$$(56) \quad \llbracket [C \ ? \ t_7] \rrbracket^{w, g} = \lambda q_{\langle s, t \rangle} . [g(7) = q] \quad (\text{via FA})$$

$$(57) \quad \llbracket [C \ C \ TP] \rrbracket^{w, g} \Leftrightarrow [g(7) = [\lambda w' . \text{came}(g(6), w')]] \quad (\text{via IFA})$$

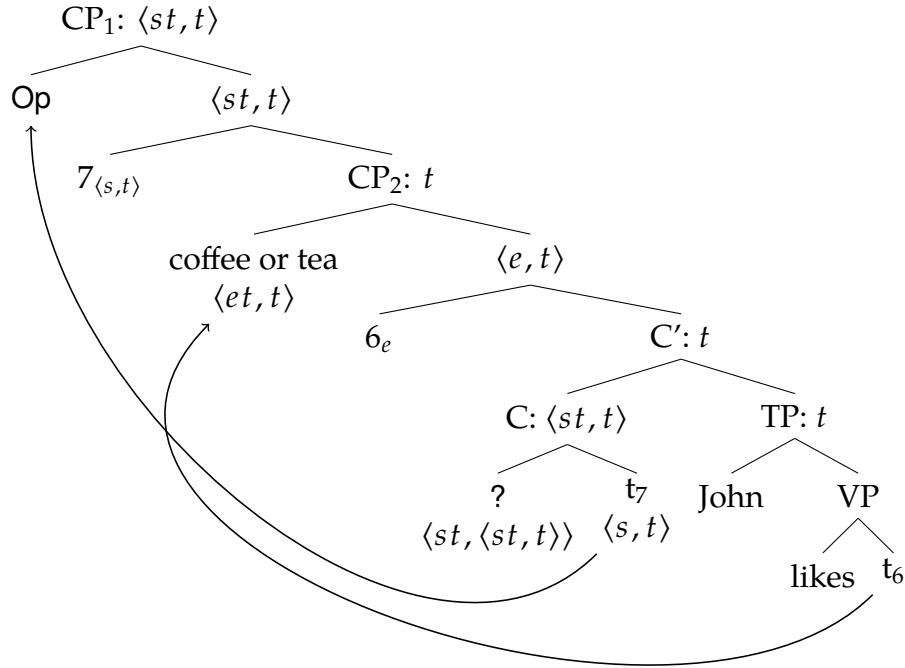
$$(58) \quad \begin{aligned} & \llbracket [_{CP_2} \text{ who } [6 \ C']] \rrbracket^{w, g} \\ & \Leftrightarrow [\lambda P_{\langle e, t \rangle} . \exists x [\text{person}(x, w) \wedge P(x)] (\lambda x . [g(7) = [\lambda w' . \text{came}(x, w')]])] \\ & \Leftrightarrow \exists x [\text{person}(x, w) \wedge [g(7) = \lambda w' . \text{came}(x, w')]] \quad (\text{via FA}) \end{aligned}$$

$$(59) \quad \llbracket [CP_1 \ 7 \ CP_2] \rrbracket^{w,g} \\ = \lambda p_{\langle s,t \rangle}. \exists x [\mathbf{person}(x, w) \wedge [p = \lambda w'. \mathbf{came}(x, w')]] \quad (\text{via PA})^{10}$$

The resulting interpretation of the LF in (59) is the desired proposition-set denotation of the question *who came*, i.e., the set of propositions of the form ‘*x came*’, where *x* is any person.

Let us now turn to questions other than *wh*-questions. I assume that alternative questions involve a covert LF movement of the disjunctive phrase above ?, as in the LF in (60).

(60) Does John like [coffee]_F or [tea]_F?



With the denotation of *coffee or tea* of type $\langle et, t \rangle$, as in (61), we can derive the denotation of an alternative questions in a way parallel to *wh*-questions.

$$(61) \quad \llbracket \text{coffee or tea} \rrbracket^w = \lambda P_{\langle e,t \rangle}. P(\mathbf{coffee}) \vee P(\mathbf{tea})$$

$$(62) \quad \llbracket (60) \rrbracket^w = \lambda p_{\langle s,t \rangle}. [p = \lambda w'. \mathbf{like}(j, \mathbf{coffee}, w') \vee p = \lambda w'. \mathbf{like}(j, \mathbf{tea}, w')]$$

The resulting interpretation of (60) is the set of two propositions ‘John likes coffee’ and ‘John likes tea’, which intuitively correspond to the set of possible answers of the

¹⁰To allow abstraction of non-entity denoting variables, I redefine assignment functions as functions from natural numbers to denotations of any type (members of $\bigcup_{\tau \in \text{TYPE}} D_\tau$). Also, I assume that binder indices are marked with the type of the associated trace, and that the rule of Predicate Abstraction is generalized as follows:

(i) **Predicate Abstraction (PA; generalized)**

For all $w \in W$ and assignment functions $g \in [\mathbb{N} \mapsto \bigcup_{\tau \in \text{TYPE}} D_\tau]$, if the node α has a binder index i_σ and β as its daughters, then

$$\llbracket \alpha \rrbracket^{w,g} = \lambda \chi_{\sigma}. \begin{cases} \llbracket \beta \rrbracket^{w,g[\chi/i]} & \text{if } \llbracket \beta \rrbracket^{w,g[\chi/i]} \text{ is defined} \\ \text{undefined} & \text{otherwise} \end{cases}$$

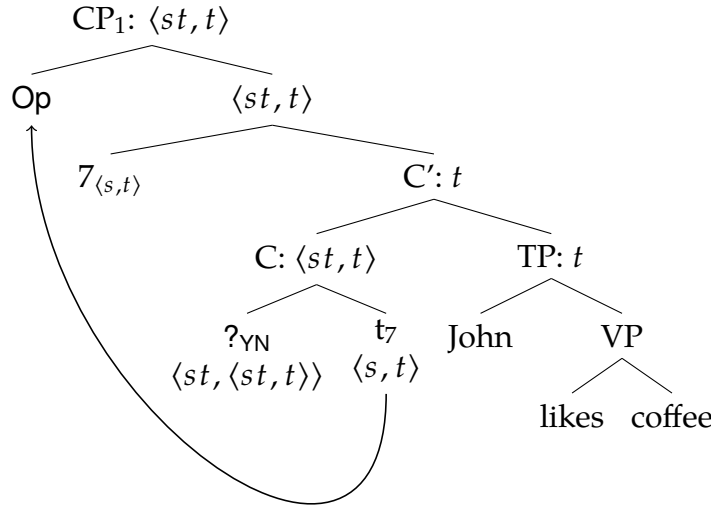
alternative question. It should be noted, however, that this treatment leaves open a number of issues surrounding the syntax and semantics of alternative questions. These issues include the treatment of the exclusive inference (that John likes only one of coffee or tea in the case of (60); Karttunen 1977, Biezma and Rawlins 2012), INTERVENTION EFFECT (Beck and Kim 2006), the effect of the focus-marking (Han and Romero 2004; Pruitt and Roelofsen 2011). As a proper treatment of the syntax and semantics of alternative questions is beyond the scope of the current dissertation, I will simply leave the readers to refer the work cited above for further details on these issues. It suffices for the purpose of the current dissertation as long as there exist a compositional semantics for alternative questions that derives the desired proposition-set denotation.

Finally, I will treat Yes/No-questions as involving a special Proto-question operator $?_{YN}$, which is defined as follows:

$$(63) \quad \llbracket ?_{YN} \rrbracket^w = \lambda p_{\langle s, t \rangle} \lambda q_{\langle s, t \rangle} . [p = q \vee p = \neg q]$$

This operator encodes what is done by the ‘Yes/No-Question Rule’ in Karttunen (1977). The LF for Yes/No questions do not involve a moving *wh*-phrase, as illustrated in the following structure:

(64) Does John like coffee?



The resulting denotation of the Yes/No question in (64), given in (65), corresponds to the set of two propositions ‘John likes coffee’ and ‘John doesn’t like coffee’.

$$(65) \quad \llbracket (64) \rrbracket^w = \lambda p . [p = \lambda w' . \text{like}(\mathbf{j}, \text{coffee}, w') \vee p = \lambda w' . \neg \text{like}(\mathbf{j}, \text{coffee}, w')]$$

Number feature of *wh*-phrases The number feature of *wh*-phrases affects the range of possible answers to the question. For example, the questions in (66) and (67) differ in whether they allow an answer with a plural subject:

- (66) A: Which **student** came?
 B: { Ann came / # Ann and Bill came }.

- (67) A: Which **students** came?
 B: { Ann came / Ann and Bill came }.

In the [Karttunen](#)-style compositional semantics of *wh*-questions, this effect of the number feature of *wh*-phrases can be analyzed in terms of the domain of the existential quantifier denoted by the *wh*-phrases. That is, singular *wh*-phrases denote existential quantifiers ranging over singular individuals while plural *wh*-phrases denote existential quantifiers ranging over singular or plural individuals. Compositionally, this is done by making *which* an existential quantifier ranging over both atomic individuals and pluralities, and analyzing (i) the extensions of singular NPs as sets of atomic individuals and (ii) the extensions of plural NPs as sets of atomic as well as plural individuals. That plural nouns include singular as well as plural individuals in their extensions is defended by authors such as [Krifka \(2004\)](#); [Sauerland et al. \(2005\)](#); [Zweig \(2009\)](#).

Formally, we have the following denotations for *which*, *student* and *students*, assuming that **a**, **b** and **c** are the only students in *w*. (*X* is a variable ranging over atoms and pluralities of individuals.)

$$(68) \llbracket \text{which} \rrbracket^w = \lambda P_{\langle e,t \rangle} \lambda Q_{\langle e,t \rangle} . \exists X [P(X) \wedge Q(X)]$$

$$(69) \text{ a. } \llbracket \text{student} \rrbracket^w = \{\mathbf{a}, \mathbf{b}, \mathbf{c}\}$$

$$\text{ b. } \llbracket \text{students} \rrbracket^w = \left\{ \begin{array}{c} \mathbf{a}, \mathbf{b}, \mathbf{c}, \\ \mathbf{a} \oplus \mathbf{b}, \mathbf{b} \oplus \mathbf{c}, \mathbf{c} \oplus \mathbf{a}, \\ \mathbf{a} \oplus \mathbf{b} \oplus \mathbf{c} \end{array} \right\}$$

Given the above ingredients, the Karttunen-style compositional semantics for *wh*-questions introduced above derives the following denotations for (66A) and (67A):

$$(70) \llbracket \text{Which student came?} \rrbracket^w \\
= \lambda p . \exists X [\llbracket \text{student} \rrbracket^w(X) \wedge p = \lambda w' . \mathbf{came}(X, w')] \\
= \{\lambda w . \mathbf{came}(\mathbf{a}, w), \lambda w . \mathbf{came}(\mathbf{b}, w), \lambda w . \mathbf{came}(\mathbf{c}, w)\}$$

$$(71) \llbracket \text{Which students came?} \rrbracket^w = \\
= \lambda p . \exists X [\llbracket \text{students} \rrbracket^w(X) \wedge p = \lambda w' . \mathbf{came}^*(X, w')] \\
= \left\{ \begin{array}{c} \lambda w . \mathbf{came}(\mathbf{a}, w), \lambda w . \mathbf{came}(\mathbf{b}, w), \lambda w . \mathbf{came}(\mathbf{c}, w), \\ \lambda w . \mathbf{came}^*(\mathbf{a} \oplus \mathbf{b}, w), \lambda w . \mathbf{came}^*(\mathbf{b} \oplus \mathbf{c}, w), \lambda w . \mathbf{came}^*(\mathbf{c} \oplus \mathbf{a}, w), \\ \lambda w . \mathbf{came}^*(\mathbf{a} \oplus \mathbf{b} \oplus \mathbf{c}, w) \end{array} \right\}$$

(\star : the distributive operator, i.e. $P^\star := \lambda X . \forall x [x \leq X \wedge \mathbf{Atom}(x) \rightarrow P(x)]$)
[\(Link 1983\)](#)

The question denotations in (70) and (71) capture the contrast shown in (66-67). Propositions corresponding to the answers with a plural subject are not included in the set of propositions in (70) while they are included in (71). Accordingly, I also revise the semantics of *who* presented above. In introducing the compositional system, I treated *who* as an existential quantifier ranging over singular individuals for the sake of simplicity. However, the fact that both answers below are felicitous suggests that *who* patterns just like *which students* in terms of the manifestation of the number feature in their semantics.

- (72) A: Who came?
 B: { Ann came / Ann and Bill came }

Thus, I revise the denotation of *who* as an existential over singular or plural individuals, as follows (I assume **people** to be the predicate true of singular human individuals as well as human pluralities):

$$(73) \llbracket \text{who} \rrbracket^w = \lambda P_{\langle e, t \rangle}. \exists X[\text{people}(X, w) \wedge P^*(X)]$$

De re/de dicto ambiguity in interrogative complements The final aspect of the semantics of questions that I will assume in the current dissertation concerns the *de re/de dicto* ambiguity in interrogatives. Basically, I will set aside the issue of the *de re/de dicto* ambiguity in this dissertation, and simply follow Beck and Rullmann's (1999) reconstruction-based analysis of *de dicto* readings.

Groenendijk and Stokhof (1984) observe that sentences such as (74) are ambiguous between two readings, which they refer to as *DE RE* and *DE DICTO* readings. Assuming that Ann is the only student who came, the two readings correspond to the paraphrases given in (74a) and (74b).

- (74) John knows which student came.
 a. 'John knows that Ann came (and no one else did)' (*de re*)
 b. 'John knows that Ann is the only student who came' (*de dicto*)

Under the *de re* reading, John may not know that Ann is a student. Just knowing that only Ann—the actual student who came—came suffices for (74) to be true under this reading, regardless of whether he knows whether she is a student. On the other hand, under the *de dicto* reading, John knows that Ann is a student, and that she is the student who came.

If we look back at the denotation of *wh*-questions derived by our compositional semantics, as in (75), we see that only the *de re* interpretation is predicted:

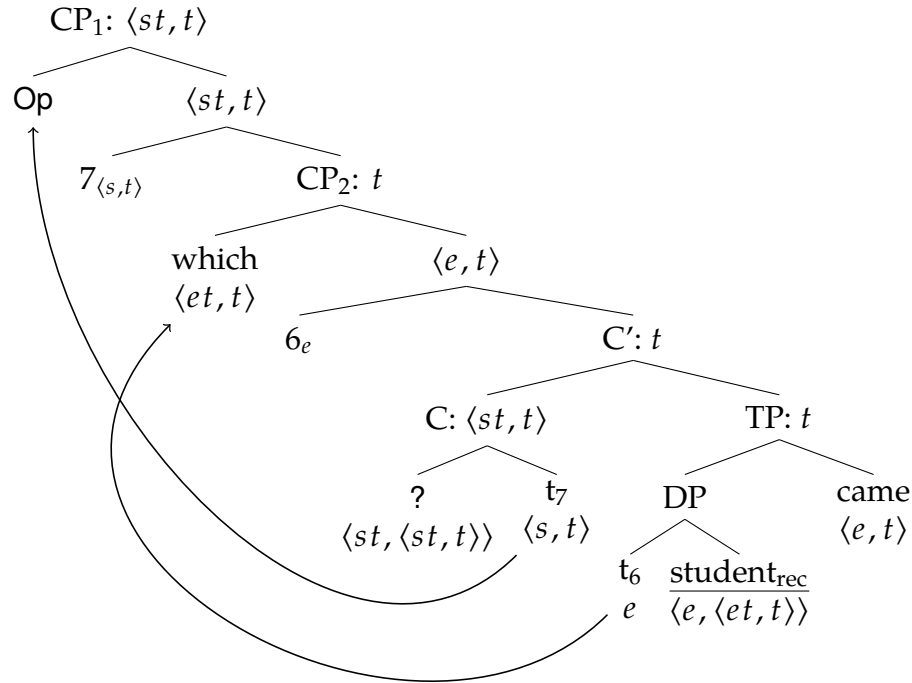
$$(75) \lambda p_{\langle s, t \rangle}. \exists x[\text{student}(x, w) \wedge [p = \lambda w'. \text{came}(x, w')]]$$

This is so since the propositions in the set in (75) are those of the form $\lambda w'. \text{came}(x, w')$ or '*x came*', which by itself does not convey the information that *x* is a student. The predicate **student** in (75) simply restricts the set of propositions, but does not contribute to the content of the propositions. Thus, saying that John knows the true proposition in this set (such as '*Ann came*') amounts to the *de re* reading of (74).

Groenendijk and Stokhof (1984) and subsequently Heim (1994) encode *de dicto* readings into the mechanism that derives the *strongly exhaustive* reading of interrogatives. This treatment captures the alleged empirical fact that strong exhaustivity necessarily involves *de dicto* readings. However, this empirical fact is disputed. Specifically, Beck and Rullmann (1999) argue that strong exhaustivity and the *de re/de dicto* ambiguity are empirically independent, employing an example using the verb *agree*. Sharvit (2002), on the other hand, argues against Beck and Rullmann (1999) and conclude that strong exhaustivity in fact necessarily involves *de dicto* readings. She provides support for the claim using examples involving the verb *surprise*.

In this dissertation, I will not make any commitment as to whether exhaustivity and the *de re/de dicto* are empirically related. Nor do I make any original theoretical proposal as to how *de dicto* readings are derived. To derive the *de dicto* readings, I will simply follow Beck and Rullmann's (1999) analysis in assuming that *de dicto* readings arise from the reconstruction of the NP part of *which*-phrases. The reason for choosing this analysis is that it is flexible enough to accommodate a wide variety of possible empirical generalizations about *de dicto* readings. An example of such an LF is given below:¹¹

(76) Which student came? (with reconstruction of *student*)



The idea here is to make the NP-part of the *which* phrase scope below the ?-operator, so that ? would bind the world parameter of the NP. That is, the LF would derive the following set as its denotation.

$$(77) \quad \llbracket (76) \rrbracket^w = \lambda p_{\langle st, t \rangle}. \exists x [p = \lambda w'. \mathbf{student}(x, w') \wedge \mathbf{came}(x, w')]$$

Since each proposition in this set is of the form $\lambda w'. \mathbf{student}(x, w') \wedge \mathbf{came}(x, w')$, or 'x is a student and x came', it would lead to the desired *de dicto* reading. Technically, in order for the composition to go through, we need the following denotation for the reconstructed NP:¹²

¹¹The analysis is technically distinct from that of Beck and Rullmann's (1999) since they employ a system with explicit world pronouns which can be freely indexed modulo syntactic constraints on co-indexation.

¹²When the *wh*-phrase is in the object position, I assume that it first undergoes a short movement and adjoins to the TP before moving to the specifier of CP. The reconstruction of the NP then targets this intermediate landing site adjoining to the TP.

$$(78) \quad \llbracket \text{student}_{\text{rec}} \rrbracket^w = \lambda x_e \lambda P_{\langle e, t \rangle} . \mathbf{student}(x, w) \wedge P(x)$$

As Beck and Rullmann (1999) argue, the analysis by itself does not predict any relationship between the *de re/de dicto* ambiguity and strong exhaustivity since reconstruction and the mechanism that derives strong exhaustivity (including the one I will propose in Chapter 3) are independent from each other. In this sense, it can in principle be subject to different constraints on *de dicto* readings if such constraints turn out to be empirically necessary.

Chapter 2

Content nouns and the selectional restrictions of question-embedding predicates

2.1 Introduction

This chapter deals with the issue concerning the complement selection of responsive predicates, i.e., the following issue repeated from chapter 1:

- (1) **The issue of complement selection** Why some declarative-embedding attitude predicates (the RESPONSIVE PREDICATES, e.g., *know*, *be surprised*, *tell*, *be certain*, *agree*) can embed interrogative complements while other declarative-embedding predicates (e.g., *believe*, *think*) cannot.

As discussed in the previous chapter, the standard answer to this question states that the basic denotation of responsive predicates selects for a proposition, i.e., the meaning of declarative clauses, and assumes some form of reduction from the meaning of embedded interrogatives to propositions (e.g., Karttunen 1977; Groenendijk and Stokhof 1984). However, such an account wrongly predicts that a *believe*-type predicate would be able to embed an interrogative complement if it were not for further stipulations.¹ For example, in Groenendijk and Stokhof's (1984) theory, the intension of an interrogative clause is a propositional concept (i.e., a function from worlds to propositions). Thus, the extension of an interrogative clause is a proposition (corresponding to the true exhaustive answer to the question) which can be combined with the proposition-taking denotation of a responsive predicate. However, if the semantic type of *believe* is the same as *know* in that it selects for a proposition, we expect that *believe* would embed an interrogative complement in a derivation in which its denotation is combined with the extension of the complement, just as in the case of *know*, unless further stipulations are made.

¹An exception is Ginzburg (1995), who has a reduction in terms of coercion, but avoids this problem by positing an ontological distinction between the objects *believe* and *know* select for. See Section 2.4.1 for a review of Ginzburg's position in the context of the current dissertation.

In this chapter, I propose an alternative approach to the issue that avoids this problem, arguing that the basic denotation of responsive predicates select for a *question*, rather than a *proposition*. According to this view, responsive predicates select for a *set of propositions*, which corresponds type-wise to an interrogative complement, even when *know* takes a declarative complement. On the other hand, I will argue that the *believe*-type predicates are simply proposition-taking predicates just as in the standard analysis. In other words, I will argue that there is a difference between *know* and *believe* in their semantic types, contrary to the standard view that they are both proposition-taking.

The argument will be based on a contrast in entailment patterns between responsive predicates and the *believe*-type predicates when they embed a DP with a clausal complement, such as *the rumor that S*. I will argue that the proper analysis of this phenomenon crucially requires that *know* and other responsive predicates operate on a set of propositions, in contrast to the *believe*-type predicates which simply take a proposition. Below are the crucial claims I will make in the argument:

- There is a contrast in entailment patterns between *John believes the rumor that p* and *John knows the rumor that p*, which generalizes to other exclusively declarative-embedding predicates and responsive predicates. (Section 2.2)
- If we follow the standard view in assuming that both *believe* and *know* are proposition-taking, we face a problem in accounting for the above contrast. More specifically, we either over-generate the entailment-pattern in the case of *know*-type predicates (Section 2.2.1) or are forced to stipulate lexical entries that do not provide an explanation of the observation (Section 2.2.2).
- To account for the observation, I propose that *know*-type predicates only take a question while *believe*-type predicates take a proposition (Section 2.3.1). Given this, the contrast in the entailment between the two kinds of predicates is accounted for in terms of the difference in available type-shifters resolving the type-mismatch between the attitude predicate and the object DP. More specifically, what I will call the content-retrieval type-shift can be applied to *believe*-type predicates, but not to *know*-type predicates (Section 2.3.2).

Also, in Section 2.4, I compare the current proposal with two existing analyses of responsive predicates, i.e., Ginzburg's (1995) analysis and the analysis in which question-embedding is reduced to proposition-embedding (Karttunen 1977; Groenendijk and Stokhof 1984; Lahiri 2002), and offer arguments that prefer the current proposal over these alternatives.

2.2 The puzzle of 'content' DPs

The central puzzle dealt with in the present chapter is the contrast between *believe* and *know* as exemplified in (2): the two verbs have different entailment patterns when they are combined with a DP with a propositional complement, such as *the rumor that Mary left* (Vendler 1972; Ginzburg 1995; King 2002; Moltmann 2013).

- (2) a. John **believes** the rumor that Mary left. \Rightarrow John **believes** that Mary left.
 b. John **knows** the rumor that Mary left. \nRightarrow John **knows** that Mary left.

In (2), it is shown that *believe* can, but *know* cannot, license the entailment from x Vs the rumor that p to x Vs that p . As I will argue in detail below, in the standard assumption that *know* has a proposition-taking denotation, an additional stipulation will be needed to block whatever the mechanism that licenses the entailment of *believe* in the case of *know*.²

Generally, the contrast is between attitude verbs that only embed a declarative *that*-clause, and those that can embed either a declarative or an interrogative clause, as shown in (3). I refer to the former class of predicates as EXCLUSIVELY PROPOSITION-TAKING PREDICATES (henceforth ProPs) and to the latter class of predicates as RESPONSIVE PREDICATES (from Lahiri 2002; henceforth ResPs). Note that factivity cross-cuts this distinction as verbs like *report*, *predict* and *tell* are non-factive ResPs while verbs like *resent* and *regret* are factive ProPs.³

- (3) a. John $\left\{ \begin{array}{c} \text{believes} \\ \text{accepted} \\ \text{trusted} \\ \text{denied} \\ \text{(dis)proved} \\ \text{validated} \end{array} \right\}$ the rumor that Mary left.
 \Rightarrow John $\left\{ \begin{array}{c} \text{believes} \\ \text{accepted} \\ \text{trusted} \\ \text{denied} \\ \text{(dis)proved} \\ \text{validated} \end{array} \right\}$ that Mary left.
 b. John $\left\{ \begin{array}{c} \text{knows} \\ \text{discovered} \\ \text{reported} \\ \text{predicted} \end{array} \right\}$ the rumor that Mary left.
 \nRightarrow John $\left\{ \begin{array}{c} \text{knows} \\ \text{discovered} \\ \text{reported} \\ \text{predicted} \end{array} \right\}$ that Mary left.

²I will discuss the fact that sentences equivalent to (2b) using *wissen* is unacceptable in German (and the corresponding facts in other languages that lexically distinguish the acquaintance ‘know’ and the knowledge ‘know’) in Section 2.3.2.2.

³A possible counterexample to the generalization is *tell*. Although *tell* is a ResP, it seems that there is a reading of (i) that entails that John told me that Mary left.

(i) John told me the rumor that Mary left.

In this chapter, I tentatively assume that *tell* is ambiguous between the ResP version, which can embed an interrogative, and the ProP version, which cannot embed an interrogative but licenses the entailment in question. I would like to leave further investigation of the behavior of *tell* for future research.

The contrast can be intuitively described in the following way: ProPs like *believe* can establish the relevant attitude relation between the attitude holder and the ‘content’ of the DP in the object position, but there is no parallel reading of ResPs that establishes the entailment. The puzzle is why there is such a contrast between the two types of predicates. More roughly, the question is why *know* cannot do what *believe* can do.⁴

To see the problem more clearly, let us consider concrete compositional semantics for the sentences in (3). Below, I describe two kinds of plausible compositional semantics, one deriving the entailment with ProPs (e.g., *believe*) straightforwardly in the compositional system, and the other deriving the contrast in entailment by virtue of the lexical denotation of attitude predicates. I will argue that the contrast above cannot be given an explanatory account with either account, as long as we assume that ResPs like *know* take propositions.

2.2.1 Compositionally deriving the entailment

First, let us assume the following propositional denotation for *rumor* in (4a), with which we can derive the correct entailment with *believe* based on its standard denotation in (4b).

- (4) a. $\llbracket \text{rumor} \rrbracket^w = \lambda q_{\langle s, t \rangle} \lambda p_{\langle s, t \rangle} . \text{rumor}(p, w) \wedge p = q$
 b. $\llbracket \text{believe} \rrbracket^w = \lambda p_{\langle s, t \rangle} \lambda x_e . \text{DOX}_x^w \subseteq p$ (Hintikka 1962)
 ($\text{DOX}_x^w :=$ the set of worlds compatible with x ’s beliefs in w)
- (5) $\llbracket \text{John believes the rumor that Mary left} \rrbracket^w = 1$
 iff $\text{DOX}_j^w \subseteq \iota p [\text{rumor}(p, w) \wedge p = \{w' \mid \text{left}(\mathbf{m})(w')\}]$

Here, *believe* has its standard Hintikkan denotation that takes a propositional argument. The denotation of *rumor* takes a complement proposition and returns a predicate of propositions that is true of a proposition satisfying the description **rumor** and is identical to the complement proposition. As a result of the standard functional application, *John believes the rumor that Mary left* is true iff John believes the unique proposition that is a rumor and identical to the proposition that Mary left. This is true only when John believes that Mary left. Thus, giving the standard denotations to ProPs and a propositional denotation to content DPs, as in (4), captures the correct entailment pattern for ProPs.

However, the problem arises when we replace the denotation of *believe* in (5) with the proposition-taking denotation of *know*. We would incorrectly predict exactly

⁴One might wonder whether the ‘anti-factive’ meaning/implication associated with *rumor* has to do with the non-entailment in the case of *know*. Specifically, one might suggest that the factivity of *know* is incompatible with the ‘anti-factivity’ of *rumor*, and thus x knows the rumor can only be interpreted as an acquaintance, which is why the entailment does not hold. However, this hypothesis does not account for the fact that the entailment does not hold for non-factive verbs such as *report* and *predict* either. Also, this hypothesis incorrectly predicts that if the noun is neutral in factivity, as *story* or *hypothesis*, the entailment would go through. However, this is not the case:

(i) John knows the {story/hypothesis} that Mary left. \nRightarrow John knows that Mary left.

See Section 2.4.1 for cases where the noun is factive, as *fact* or *truth*, and an account of them.

the same entailment as in the case of *believe*. Below, it is shown that given the simplified proposition-taking meaning for *know* in (6) (i.e., *believe* + factivity),⁵ we would predict the truth conditions of *John knows the rumor that Mary left* in (7), which is true only when John believes that Mary left, and that it is true that Mary left (due to the factivity presupposition, underlined in (7)). This entails that John knows that Mary left, contrary to the fact.

$$(6) \quad \llbracket \text{know} \rrbracket^w = \lambda p_{\langle s, t \rangle} \begin{cases} \lambda x. \text{DOX}_x^w \subseteq p & \text{if } p(w) \\ \text{undefined} & \text{otherwise} \end{cases}$$

$$(7) \quad \llbracket \text{John knows the rumor that Mary left} \rrbracket^w = 1 \\ \text{iff } \text{DOX}_j^w \subseteq \iota p[\text{rumor}(p, w) \wedge p = \{w' \mid \text{left}(\mathbf{m})(w')\}] \wedge \underline{\text{left}(\mathbf{m})(w)}$$

In fact, the argument here does not hinge on the exact implementation of the meaning of content nouns assumed here. As long as there is a general compositional mechanism deriving the relevant entailment for any proposition-taking predicates, we would predict the same mechanism to hold for both ProPs and ResPs given the standard assumption that both kinds of verbs have proposition-taking denotations.⁶

2.2.2 Lexically specifying the entailment patterns

The way the problem is stated above assumes a simplistic denotation for *the rumor* so that the entailment of *believe* goes through with its standard denotation while the lack of entailment of *know* is problematic. Another plausible way to analyze the contrast is to capture it by the lexical denotations of the relevant attitude predicates. The accounts by King (2002) and Moltmann (2013) are both along these lines although there are technical differences. In this line of approach, it is easier to start the discussion with the non-entailment fact with ResPs. The non-entailment fact straightforwardly comes out if we assume that a content DP denotes a non-propositional object and that *know* is ambiguous between the proposition-taking variant for ‘knowledge’ and the non-proposition taking variant for ‘acquaintance’, the distinction (roughly) corresponding to that between *wissen* and *kennen* in German. The denotation for the former variant of *know* is given in (6) and the latter in (8),

⁵Of course, this denotation of *know* is oversimplified. After Gettier (1963), there is vast philosophical discussion on the proper conditions for knowledge that goes beyond the traditional picture that knowledge consists of justified true belief. However, this problem is orthogonal to the issue discussed in this chapter, which arises in a more sophisticated analysis of *know* as long as the analysis assumes that it takes a propositional complement.

⁶I categorize the treatment of content nouns by Kratzer (2006) and Moulton (2008) as a variant of the approach considered here, as their compositional system is constructed in such a way that the entailment fact with *believe* is predicted straightforwardly. In their system, a content DP like *the rumor* denotes an abstract object called a ‘content’ from which its propositional information can be retrieved. Their denotation for *believe* is such that it takes a content argument and the subject believes whatever the propositional information of this content. It is clear that this system correctly predicts the entailment fact with *believe*, but it over-generates the entailment if we simply extend their denotation for *believe* to *know*. Hence, their treatment faces the same problem as the approach considered here. It should be emphasized, however, that the analysis of ResPs is outside the scope of Kratzer and Moulton, and so this is not a problem with their analysis of content nouns *per se*.

where α is a variable over a specific kind of non-propositional (type a) objects, whose instance a content DP denotes.

$$(8) \quad \llbracket \text{know}_A \rrbracket^w = \lambda \alpha_a \lambda x_e. \mathbf{acquainted}(x)(\alpha)(w)$$

Under this system, since a content DP like *the rumor* is compatible only with the ‘acquaintance’ *know* in (8), and ‘being acquainted’ with a certain object does not entail propositional knowledge of its content, the non-entailment fact comes out naturally. Here, I stay away from detailed model-theoretic characterization of objects of type a and the relation **acquainted** in order to make the argument general. The only assumption needed to derive the non-entailment is that x ’s being acquainted with α with propositional content p does not entail x ’s knowing that p . This is a fairly uncontroversial assumption: one can be acquainted with a rumor, story etc. without believing its propositional content. For example, one can be acquainted with a rumor about oneself, by just being told by someone that such a rumor is going around, while disbelieving the content of the rumor.⁷

Now, the problem is how to account for the entailment fact with *believe*. A possible way out is to stipulate the lexical semantics of *believe* in a way so that it can access the propositional content of the abstract object it combines with, as shown in (9). In (9), *believe* establishes the believing-relation between the subject and the propositional content retrieved from its first argument by the function \mathcal{F}_{cont} .

$$(9) \quad \llbracket \text{believe}_{cont} \rrbracket^w = \lambda \alpha_a \lambda x_e. \llbracket \text{believe} \rrbracket^w (\mathcal{F}_{cont}(w)(\alpha))(x)$$

where $\mathcal{F}_{cont} \in D_{\langle s, \langle a, st \rangle \rangle}$ and $\mathcal{F}_{cont}(w)(x) :=$ the propositional content of x in w

Indeed, this might be a descriptively adequate analysis of the contrast in (3). However, simply stipulating lexical entries like these does not *explain* why the (im)possibility of embedding an interrogative complement correlates with the contrast, i.e., why ProPs license the relevant entailment while ResPs don’t. One of the problems with this account is that it does not answer why *believe* is not like *know* in being ambiguous between the standard proposition-taking version and the other version as in (10) below (i.e., the ‘acquaintance’ version of *believe*), which does not involve \mathcal{F}_{cont} .

$$(10) \quad \llbracket *believe_A \rrbracket^w = \lambda \alpha_a \lambda x_e. \mathbf{R}(x)(\alpha)(w)$$

where \mathbf{R} is a relation such that $\mathbf{R}(x)(\alpha)(w) \not\models \mathbf{DOX}_x^w \subseteq \mathcal{F}_{cont}(w)(\alpha)$

Having (10) as the denotation of *believe* that combines with a content DP incorrectly predicts that *believe* would lack the entailment.

One way to solve this problem is to state a general lexical rule that turns a proposition-embedding verb like *believe* into its content-retrieving version, as in (9). This lexical rule can be stated as follows:

$$(11) \quad \text{For any predicate } R \text{ such that } \llbracket R \rrbracket^w \in D_{\langle st, et \rangle}, \text{ there is a predicate } R_{cont} \text{ with the same phonological form such that } \llbracket R_{cont} \rrbracket^w = \lambda x_e. \llbracket R \rrbracket^w (\mathcal{F}_{cont}(w)(x))$$

⁷ Another possibly distinct reading of *know* + DP is a Concealed Question (henceforth CQ) reading, but it is clear that it does not have the relevant entailment, either. This is because knowing an answer to the CQ ‘What is α ?’ does not entail the knowledge of α ’s content however we formalize CQ readings.

This general lexical rule gives us the correct prediction that all ProPs license the relevant entailment. However, the problem is that it over-generates the same entailment with all ResPs, as long as we assume that ResPs take propositions just like ProPs. That is, the rule in (11) predicts that the following denotation for *know* is available, which incorrectly predicts the entailment for *know*.

$$(12) \quad \llbracket *know_{cont} \rrbracket^w = \lambda \alpha_a \lambda x_e. \llbracket know \rrbracket^w (\mathcal{F}_{cont}(w)(\alpha))(x)$$

Thus, the approach that just uses lexical specifications lacks a principled explanation of the correlation between the ability to embed interrogatives and the relevant entailment pattern. If the approach is supplemented with a general lexical rule to capture one direction of the correlation, i.e., that ProPs always license the entailment, we over-generate the entailment with ResPs as well, under the standard assumption that ResPs are proposition-taking. Indeed, one could imagine that the lexical rule in (11) is sensitive not just to *types*, but to the *specific semantic features* of the predicates they can apply to. However, the question is what such general semantic features would be that distinguish ProPs and ResPs. (Recall that factivity cross-cuts the distinction.)

In sum, the contrast in (3) is problematic whether we assume a compositional semantics that predicts the entailment fact of *believe* straightforwardly, or we lexically specify the entailment patterns in the denotation of the relevant predicates. Generally speaking, the problem with the former approach is that the combination of assumptions (i) and (ii) below over-generates the relevant entailment for ResPs.

- (i) ResPs select for the same kind of object that ProPs select for (such as a proposition).
- (ii) A general mechanism (e.g., propositional denotation of content DPs, the lexical rule in (11)) derives the entailment fact of ProPs with its standard denotation.

On the other hand, the problem with the latter approach is that, either we end up lexically stipulating the entailment pattern for each predicate, or we would be forced to assume (ii) above in the form of a lexical rule. In the former case, we lack an explanation for the generalization, and in the latter case, we again over-generate the entailment for ResPs, given assumption (i).

The proposal I will put forth in this chapter agrees with assumption (ii), but it further constrains the semantics of attitude predicates so that the crucial contrast between ResPs and ProPs can be explained in terms of their ability to embed an interrogative complement. The basic proposal is fairly simple: it denies assumption (i).

2.3 Proposal

The central proposal is that ResPs do not take a proposition, but only take a proposition-set as their complement. In this section, after presenting the basic compositional semantics of the proposed analysis, I illustrate how this proposal

leads to the solution to the puzzle of content DPs described in the previous section. In the last subsection, I will discuss the general constraint on the lexical semantics of attitude verbs arising from the proposal, especially in relation to exclusively interrogative-embedding verbs, such as *ask* and *wonder*.

2.3.1 ResPs only take a question complement

As stated briefly above, I propose that ResPs only select for a question, but not for a proposition. For instance, below is the *only* denotation for *know* in this chapter, which will be used both for its declarative-embedding and for its interrogative-embedding use.

$$(13) \quad \llbracket \text{know} \rrbracket^w = \lambda Q_{\langle st, t \rangle} \cdot \begin{cases} \lambda x_e. \mathbf{DOX}_x^w \subseteq \text{Ans}(w)(Q) & \text{if } \exists p \in Q[p(w)] \\ \text{undefined} & \text{otherwise} \end{cases}$$

According to this denotation, *know* presupposes that the question (or a set of propositions) it combines with contains at least one true proposition. Its truth-conditional contribution is that the subject x believes the ‘answer’ of the question, determined by the *Ans*-function defined as follows:

$$(14) \quad \text{Ans}(w_s)(Q_{\langle st, t \rangle}) := \lambda w'. \forall p \in Q[p(w) \rightarrow p(w')]$$

Given the proposition-set denotation for interrogative complements introduced in chapter 1, this analysis derives the weakly exhaustive reading for sentences with *know* embedding an interrogative complement.⁸ For example, the truth conditions of *John knows who came* would be the following (assuming that someone came in w):

$$(15) \quad \llbracket \text{John knows who came} \rrbracket^w = 1 \\ \text{iff } \mathbf{DOX}_j^w \subseteq \{ w' \mid \forall p \in \llbracket \text{who came} \rrbracket^w [p(w) \rightarrow p(w')] \}$$

The truth conditions state that John believes all the true members of the proposition-set denotation of *who came*. This is equivalent to saying that John believes that everyone who came came, i.e., the weakly-exhaustive interpretation. Note that the central claim here concerns the *semantic type* of responsive predicates, i.e., that they select for a type $\langle st, t \rangle$ object. We will refine the *lexical semantic content* of responsive predicates in the coming chapters. In particular, I will discuss the treatment of exhaustivity, including the treatment of strong exhaustivity in chapter 3. Also, in chapter 4, I will explore ways to extend the analysis to non-veridical predicates such as *be certain* and *agree*.

When *know* as defined above takes a declarative complement, the type-shifter in (16) turns the proposition denoted by the embedded clause into the singleton set containing it. Combining this singleton set with (13), we derive the correct truth conditions of a sentence in which *know* embeds a declarative clause, as shown in (17). The underlined conjunct is projected from the presupposition of *know*.

⁸The *Ans*-operator in (14) is similar to Heim’s (1994) **Answer1**. The difference is that the latter assumes that a question-denotation is a function from worlds to proposition-sets (following Karttunen 1977 original analysis), and that the world argument of **Answer1** binds the world argument of the question.

- (16) $\llbracket \text{Id} \rrbracket^w = \lambda p_{\langle s, t \rangle} [\lambda q_{\langle s, t \rangle} . q = p]^9$
- (17) $\llbracket \text{John knows [Id [that Mary left]]] \rrbracket^w = 1$
iff $\text{DOX}_j^w \subseteq \text{Ans}(w)(\lambda q . q = \{ w' \mid \text{left}(\mathbf{m})(w') \}) \wedge \underline{\text{left}(\mathbf{m})(w)}$
iff $\text{DOX}_j^w \subseteq \{ w' \mid \text{left}(\mathbf{m})(w') \} \wedge \underline{\text{left}(\mathbf{m})(w)}$

As for ProPs, they have the standard proposition-taking denotations, as the following one for *believe*, repeated from the previous section.

(4b) $\llbracket \text{believe} \rrbracket^w = \lambda p_{\langle s, t \rangle} \lambda x_e . \text{DOX}_x^w \subseteq p$

This denotation takes a proposition as its first argument. Thus, it is compatible with a declarative complement with a propositional denotation without the *Id* type-shift. An interrogative complement is incompatible with this kind of predicate due to type mismatch: An interrogative complement denotes a set of propositions, but (4b) selects for a proposition.

2.3.2 Solution to the puzzle

In this section, I illustrate how the proposal above can provide a solution to the puzzle of content DPs. The analysis assumes a non-propositional denotation for content DPs, and basically follows the lexical specification approach considered in the previous section, but avoids the problem of stipulation and over-generation pointed out there. The proposal that ResPs only take a question complement offers an explanation for the difference in the entailment patterns between ResPs and ProPs.

The gist of the proposal is the following. When a ProP or ResP is combined with an entity-denoting content DP, a type-mismatch arises. However, a ProP can be related to the propositional content of the DP via a type-shifting operation. As a result of this, the entailment under discussion holds for ProPs. On the other hand, the same mechanism involving entity-to-proposition conversion is not applicable to ResPs. Since ResPs select for questions, the resulting proposition of such a conversion is not a suitable argument for ResPs. Instead, a ResP combines with a DP through one of two ways. One is through converting the DP into its corresponding Concealed Question (CQ), as in *John discovered the answer* under the interpretation ‘John discovered what the answer is’. The other is through the predicate’s separate entity-relating acquaintance-like denotation, as in *John discovered the rumor on the Internet*. Note here that some predicates allow only one of the two interpretations for independent reasons. For example, *John knows the rumor that p* resists a CQ reading for pragmatic reasons which I will discuss below. I will argue that neither of these two readings licenses the relevant entailment if the reading is possible at all. This captures the fact that ResPs do not exhibit the same entailment pattern as ProPs. In other words, the difference in entailment between ResPs and ProPs comes

⁹The name *Id* is inspired by Partee (1986), where the type-shifter *IDENT* is defined as a type-shifter that turns an individual into (the characteristic function of) its singleton set, as follows:

(i) $\llbracket \text{IDENT} \rrbracket^w(x) = \lambda y_e . [y = x]$

out as the result of the type-shift forced by the selectional property of each type of verbs. Below, I will discuss how the meanings of ProP + DP and ResP + DP are derived in the proposed system, after which I show how the analysis solves the puzzle of content DPs.

2.3.2.1 ProP + content DP

First of all, I claim that content DPs such as *the rumor that Mary left* denotes an individual of type e as shown in (18).

$$(18) \quad \llbracket \text{the rumor that Mary left} \rrbracket^w \\ = \iota x [\mathbf{rumor}(x)(w) \wedge \mathcal{F}_{cont}(w)(x) = \{w' \mid \mathbf{left}(\mathbf{m})(w')\}]$$

Since a ProP like *believe* wants a proposition as its complement, as in (4b), (18) cannot be combined with it directly. However, the type-shifting operation in (19) is available, which denotes the following function:

$$(19) \quad \llbracket \text{Cont} \rrbracket^w(x) = \lambda w'. \begin{cases} w' \in \mathcal{F}_{cont}(w)(x) & \text{if } \mathcal{F}_{cont}(w)(x) = \mathcal{F}_{cont}(w')(x) \\ \text{undefined} & \text{otherwise} \end{cases}$$

In words, when applied to x , this function returns a proposition that states that x 's actual content is true, with the presupposition that x 's actual content is the content of x . For example, when applied to (18), it returns the following partial proposition:

$$(20) \quad \llbracket \text{Cont} [\text{the rumor that Mary left}] \rrbracket^w = \lambda w'. \\ \begin{cases} \mathbf{left}(\mathbf{m})(w') & \text{if } \mathcal{F}_{cont}(w')(\llbracket \text{the rumor that Mary left} \rrbracket^w) = \{w'' \mid \mathbf{left}(\mathbf{m})(w'')\} \\ \text{undefined} & \text{otherwise} \end{cases}$$

The (partial) proposition derived this way can be combined with *believe*. Regardless of how the presupposition of (20) is projected, the resulting proposition entails (21).

$$(21) \quad \mathbf{DOX}_j^w \subseteq \{w' \mid \mathbf{left}(\mathbf{m})(w')\}$$

Hence, the entailment fact of ProPs+DP can be correctly captured.

One might wonder why the denotation of the Cont type-shifter in (19) has to be so complex. That is, why the following simpler denotation does not suffice.

$$(22) \quad \llbracket \text{Cont} \rrbracket^w(x) = \mathcal{F}_{cont}(w)(x)$$

Indeed, this version of Cont would capture the entailment fact, but it would make an incorrect prediction about the precise interpretation of *believe*+DP sentences. The interpretation of *believe*+DP cannot be described simply in terms of belief of the content of the object denoted by the DP. Let me illustrate this using the following example:

$$(23) \quad \text{John believes the rumor Bill has been circulating.}$$

Suppose the content of the rumor Bill has been circulating is that Mary left the town. Suppose further that John believes that Mary left the town, but he is not sure what the content of the rumor Bill has been circulating is. He has seen Bill whispering

something to people, but doesn't know what he was whispering, nor has he heard the rumor from Bill. In this situation, the sentence in (23) is not intuitively true.

This intuitive judgment is not captured by the definition of *Cont* in (22), as the sentence would be predicted to be true as long as John believes that Mary left the town. On the other hand, the definition of *Cont* in (19) predicts that (23) is a presupposition failure. Here is why. Let me first write the denotation of the object DP *the rumor Bill has been circulating* as **r**, as in (24a), for simplicity. The actual content of this object is the proposition that Mary left, as shown in (24b).

- (24) a. $\llbracket \text{the rumor Bill has been circulating} \rrbracket^w = \mathbf{r}$
 b. $\mathcal{F}_{\text{cont}}(w)(\mathbf{r}) = \lambda w'. \mathbf{left}(\mathbf{m})(w')$

Then, the result of applying *Cont* to this DP would be the following, according to the definition in (19).

- (25) $\llbracket \text{Cont [the rumor Bill has been circulating]} \rrbracket^w$
 $= \lambda w'. \begin{cases} w' \in \mathcal{F}_{\text{cont}}(w)(\mathbf{r}) & \text{if } \mathcal{F}_{\text{cont}}(w)(\mathbf{r}) = \mathcal{F}_{\text{cont}}(w')(\mathbf{r}) \\ \text{undefined} & \text{otherwise} \end{cases}$
 $= \lambda w'. \begin{cases} \mathbf{left}(\mathbf{m})(w') & \text{if } \lambda w''. \mathbf{left}(\mathbf{m})(w'') = \mathcal{F}_{\text{cont}}(w')(\mathbf{r}) \\ \text{undefined} & \text{otherwise} \end{cases}$

Following the standard assumption that the presupposition of the complement of *believe* projects to the belief state of the subject (e.g., Karttunen 1974), (23) would have the presupposition that John believes the presupposition of (25).

- (26) $\llbracket \text{John believes Cont [the rumor Bill has been circulating]} \rrbracket^w$ is defined
 iff $\mathbf{DOX}_j^w \subseteq \{w' \mid \lambda w''. \mathbf{left}(\mathbf{m}, w'') = \mathcal{F}_{\text{cont}}(w')(\mathbf{r})\}$

This presupposition is not satisfied in the scenario given above since John does not know that the content of **r**, i.e., the rumor that Mary has been circulating, is the proposition that Mary left. I submit that this is an empirically adequate treatment of the 'un-trueness' of (23) in the given situation. The condition in the presupposition of *Cont* cannot be encoded in the assertion since the negation of (23), i.e., (27) is also intuitively untrue in the situation introduced above.

- (27) John does not believe the rumor Bill has been circulating.

The presuppositional treatment in (19) predicts that (27) is a presupposition failure just like (23) is. This is in line with the intuitive judgment of (27). Hence, I will use (19) rather than the simpler (22) as the definition of *Cont*.

As King (2002) discusses, something like the type-shifter *Cont* is needed outside the domain of attitude verbs. Data like (28a) suggest that adjectives such as *true* and *false* denote predicates of propositions of type $\langle st, t \rangle$. Given this, we need *Cont* to account for (28b), in which *true/false* is predicated of the propositional content of the rumor. That is, *true/false* is predicated of the denotation of *Cont* [*the rumor*].

- (28) a. That Mary left is true/false.
 b. The rumor is true/false.

Similar arguments can be made using examples like the following involving the predicates *compatible* and *contradict*.

- (29) a. That John saw Mary {is compatible with / contradicts} what she said.
 b. The rumor {is compatible with / contradicts} what she said.

2.3.2.2 ResP + content DP

In the previous section, I discussed how ProP + DP licenses the relevant entailment by virtue of the content-retrieval type-shifter applied to the DP. In this section, we turn to ResP + DP. I will argue that ResP + DP is interpreted with the Concealed Question (CQ) reading of the DP. Also, depending on the predicate, it can combine with a DP under a distinct entity-relating reading, such as the acquaintance reading of *know*. In the following, I will argue that none of them guarantees the relevant entailment. It should be stressed at this point that it suffices for the purpose of this chapter—to explain the contrast in entailment between ResPs and ProPs—to show that the compositional semantics does not guarantee that ResP + DP licenses the relevant entailment. Thus, although there are some cases where CQ or an acquaintance/entity-relating reading is not possible for a particular ResP + DP combination, investigating the constraints that govern the distributions of these readings is beyond the scope of this dissertation. As long as the possible readings of ResP + DP are shown *not* to license the relevant entailment, we can account for the contrast between ResPs and ProPs.

Concealed questions Let us consider a case where a ResP combines with a content DP. Similarly to the case of ProP + DP, the proposed denotation of a ResP, which is question-taking, cannot be combined with (18), repeated below.

$$(18) \llbracket \text{the rumor that Mary left} \rrbracket^w = \iota x [\text{rumor}(x)(w) \wedge \mathcal{F}_{cont}(x) = \{w' \mid \text{left}(\mathbf{m})(w')\}]$$

Therefore, again, some extra operation is needed to make the composition go through, but this time the operation has to involve a conversion from an individual into a question, rather than into a proposition (I discuss below the possibility of nesting Cont and Id). I argue that this operation can be carried out by Cq, a type-shifter which turns an individual into its corresponding Concealed Question (CQ).

Due to this operation, for example, the truth conditions of *John knows Cq [the president of the US]* will be, roughly, that John knows which person the president of the US is. Concretely, I adopt Aloni's (2008) analysis of CQs,¹⁰ slightly modifying it to fit the current compositional setup.

In Aloni's (2008) analysis, *John knows the winning card* in its CQ reading roughly means 'John knows that x is the winning card', where x is an individual concept in a contextually salient CONCEPTUAL COVER (Aloni 2001), a set of individual concepts

¹⁰In Aloni and Roelofsen (2011), a number of problems with Aloni (2008) are addressed, and a modification is proposed. However, since the simpler analysis of Aloni (2008) suffices for my purpose, I adopt Aloni's version here.

with the constraint that each individual in the set is mapped from each world by exactly one cover.¹¹ Examples of a cover are the sets A and B in the following, the former identifies a card by position while the latter by suit.

- (30) a. $A = \{\text{the card on the left, the card on the right}\}$
b. $B = \{\text{the Ace of Spades, the Ace of Hearts}\}$

The CQ reading of *John knows the winning card* differs depending on which cover is contextually given. If the position cover, A, is salient, the sentence means that John can identify the winning card based on its position. On the other hand, if the suit cover, B, is salient, the sentence means that John can identify the winning card based on its suit.

A CQ reading of the DP *the winning card* is then analyzed in terms of the type-shifter Cq as follows, using the notion of conceptual covers.

- (31) $\llbracket \text{Cq} \rrbracket^C = \lambda x_e. \{ p \mid \exists w[p = \lambda w'. \forall c' \in R_C[c'(w') = x \leftrightarrow c'(w) = x]] \}$
where R_C is a conceptual cover given by context C

In prose, the CQ corresponding to the individual denoted by *the winning card*, for example, is the partition of worlds in which each cell consists of worlds that agree on which concept identifies the winning card. The conceptual cover, i.e., the domain of individual concepts quantified in (31), is contextually determined. Therefore, the interpretation of (31) differs according to which of the two covers in (30) is salient in the context.

For example, applying Cq to the DP *the winning card*, the predicted truth conditions of the sentence *John knows Cq [the winning card]* will be (32). (Here, we let the extension of *the winning card* be **wc**.)

- (32) $\llbracket \text{John knows Cq [the winning card]} \rrbracket^{w,C} = 1$
iff $\text{DOX}_j^w \subseteq \text{Ans}(w, \{ p \mid \exists w[p = \lambda w'. \forall c \in R_C[c(w') = \mathbf{wc} \leftrightarrow c(w) = \mathbf{wc}]] \})$
iff $\text{DOX}_j^w \subseteq \{ w' \mid \forall c \in R_C[c(w') = \mathbf{wc} \leftrightarrow c(w) = \mathbf{wc}] \}$

For illustration, suppose that the contextually salient cover is the one in (30a), and further suppose that the winning card is the card on the left. Then, the truth conditions of *John knows Cq [the winning card]* predicted by (32) is that John correctly believes that the card on the left is the winning card. When we replace *the winning card* in (32) with a content DP like *the rumor that p*, the resulting truth conditions would not entail that John knows that Mary left. This is so because we can construct John's belief state so that a particular concept (e.g., the rumor that Sue told, the rumor that he read on the Internet) identifies the rumor that *p*, but he does not believe that *p*.

Digression: Pragmatic constraint on CQ Above, I discussed the general treatment of CQs and what the predicted CQ reading of ResP + DP would look like. One might wonder at this point whether examples like *John knows the rumor that p* actually

¹¹Formally, a conceptual cover CC is a set of functions $W \mapsto D$ such that $\forall w \in W[\forall d \in D[\exists! c \in CC[c(w) = d]]]$

have CQ readings. In fact, many speakers find it difficult to accept these sentences under CQ readings. The fact is clearer if we move to languages that have a lexical distinction between the ‘knowledge’ *know* and the ‘acquaintance’ *know*. German *wissen* and French *savoir* are unacceptable when they are combined with a content DP such as ‘the rumor’, as shown in (33).

- (33) Ich kenne/#weiß das Gerücht, dass Maria weggegangen ist. (German)
 I know_{Acq}/know_K the rumor that Maria left is.

If the CQ type shifter Cq is available in general, why are these verbs unacceptable with ‘the rumor’ whereas it can be used with other CQ-denoting DPs? I argue that this is due to an independent problem concerning pragmatic conditions on whether a DP can denote a CQ. Specifically, I argue that this is due to the constraint on CQs that the identifying concept has to be more salient than the description of the DP whose identity is in question (Aloni and Roelofsen 2011; Frana 2010). To see this, observe the following contrast.

- (34) a. John knows Obama. (#CQ)
 b. John knows the president of the United States. (✓CQ)

Here, out of the blue, (34a) is odd as a CQ where it means, for example, that John can identify Obama by his political role. On the other hand, (34b) can be naturally understood as a CQ, where it means that John can name the president of the US. This contrast can be explained by the relative salience of names and political roles: Since names are more salient concept than political roles, it is more natural to identify the latter using the former.

What is going on in the CQ reading of *John knows the rumor that p* (and its German counterpart in (33)) can be understood in terms of the same pragmatic constraint. In the following pair, (35a) is odd as a CQ, but (35b) can be a felicitous CQ which, for example, means that John can identify the content of the rumor that Mary told.¹²

- (35) a. John knows the rumor that Mary left. (#CQ)
 b. John knows the rumor which Mary told. (✓CQ)

I argue that these data are due to the fact that the content of a rumor is a more salient identifying concept than its source. Thus, identifying a rumor’s source using its content, as in (35b) is natural, but the other way around, as in (35a) is not. In other words, sentences like (35a) is infelicitous as a CQ, just like (34a) is, since it is difficult to find an identifying concept for a rumor more salient than its propositional content.

Acquaintance Next, we turn to the acquaintance reading and, more generally, entity-relating meanings of ResPs. As in the analysis entertained in Section 2.2.2, I simply treat English *know* as ambiguous between the knowledge version and the acquaintance version, where the latter has the following denotation as a simple transitive verb with type-*e* arguments.

¹²I thank an anonymous reviewer for *Journal of Semantics* for pointing out this contrast.

$$(36) \quad \llbracket \text{know}_A \rrbracket^w = \lambda y_e \lambda x_e. \mathbf{acquainted}(x)(y)(w)$$

Languages like German and French lexicalize this distinction. Thus, *kennen* and *connaître* have the same denotation as (36) while *wissen* and *savoir* have the denotation of the ‘knowledge’ *know*, repeated below.

$$(13) \quad \llbracket \text{know} \rrbracket^w = \lambda Q_{\langle st, t \rangle}. \begin{cases} \lambda x_e. \mathbf{DOX}_x^w \subseteq \text{Ans}(w)(Q) & \text{if } \exists p \in Q[p(w)] \\ \text{undefined} & \text{otherwise} \end{cases}$$

As we discussed in Section 2.2.2, we assume that the relation **acquainted** is defined so that **acquainted**(*x*)(*y*)(*w*) does not entail that *y* knows, or believes, the content of *x* (if *x* has a content at all). This is an uncontroversial assumption given the natural understanding of the notion of acquaintance. With this, we can account for the fact that *John knows_A the rumor that Mary left* does not entail *John knows_K that Mary left*: simply being acquainted with the rumor that *p* does not entail knowing/believing that *p*.

ResPs other than *know* also have entity-relating denotations. For example, *discover* and *report* have non-CQ readings as in the paraphrases given below.

(37) John discovered the rumor (on the Internet) that Mary left.
 ‘John came across a text (on the Internet) saying that Mary left’

(38) John reported the rumor that Mary left.
 ‘John reported that it is being rumored that Mary left.’

I will not attempt to analyze these entity-relating meanings in terms of the verbs’ meanings as a ResP,¹³ and simply capture them using lexical entries separate from their entries as ResPs, as given in the following:

- (39) a. $\llbracket \text{discover}_{\text{entity}} \rrbracket = \lambda x_e \lambda y_e. \mathbf{discoverEntity}(y)(x)(w)$
 b. $\llbracket \text{report}_{\text{entity}} \rrbracket = \lambda x_e \lambda y_e. \mathbf{reportEntity}(y)(x)(w)$

The lack of the relevant entailment is again accounted for by the natural assumptions about the relations involved in these readings: discovering an object whose content is *p* doesn’t entail discovering that *p*; reporting a communicative event whose content is *p* doesn’t entail communicating that *p*.¹⁴

It should be noted that I do not have a proof that entity-relating denotations of ResPs *never* license the relevant entailment since I do not provide a general theory of entity-relating denotations of ResPs.¹⁵ Still, it is important to stress that the current account avoids the incorrect prediction that the entailment should be *generally* possible across ResPs, unlike the account considered in Section 2.2.1. Also, the current account is more advantageous than the theory considered in Section 2.2.2 in successfully predicting that ProPs generally license the entailment. In Section

¹³I will discuss a specific semantic relation between the knowledge *know* and the acquaintance *know* in Section 2.4.1, in relation to the behavior of *know* when they take factive DPs like *the fact*.

¹⁴I am assuming here that events are a subtype of entities in the ontology, and that the DP *the rumor* can denote a linguistic object whose content is a rumor or a communicative activity that involves rumoring.

¹⁵In fact, what is happening with *tell the rumor* discussed in footnote 3 might be a case in which the entity-relating denotation of *tell* happens to be one that licenses the entailment.

2.3.2.4, I discuss the advantage of the current approach over an account based on lexical stipulations in more detail.

2.3.2.3 Problem with nesting *Id* and *Cont*

Summarizing the solution discussed above, the contrast in the entailment patterns between ResPs and ProPs can be explained based on their basic selectional properties, once we adopt the current proposal, i.e., ProPs only select for propositions while ResPs only select for questions. When attitude verbs are combined with a content DP, there has to be a type-shifting operation by which the individual denoted by the DP is coerced into the type of object that the attitude verbs select for. When the verb is a ProP, the type-shifter *Cont* can convert an individual into its propositional content. This treatment gives us the correct entailment pattern of *x ProP the NP that p*. On the other hand, when the verb is a ResP, the same type-shifter is not applicable since the propositional content retrieved from an individual cannot be combined with a ResP, which selects for a question rather than a proposition. There are two ways in which a ResP can select for an individual, i.e., through CQ or through a separate entity-relating denotation. CQ readings do not allow the entailment from *x ResP the NP that p* to *x ResP that p*. An entity-relating readings does not automatically guarantee the relevant entailment for ResPs, either. This accounts for the empirical pattern we observed in Section 2.2.

Nevertheless, there is one issue in the current account which I have not discussed yet. The issue concerns the nested applications of the type-shifters *Cont* and *Id*, as in the following:

(40) John knows [*Id* [*Cont* [the rumor that Mary left]]].

The nested type-shifting in (40) predicts that the sentence is true iff (Mary actually left and) John's epistemic state entails the content of the rumor that Mary left, which entails that John knows Mary left. This is a reading that we wanted to rule out. Below, I will offer a way to avoid this problem in terms of a general principle governing type-shifting.

The application of *Cont* and *Id* in (40) can be ruled out if sequential application of multiple type-shifters is blocked when the resulting type can be achieved by an application of a single type-shifter. Application of *Id* + *Cont* in (40) maps entities to proposition-sets, but the same result can be obtained by simply applying the CQ-type shifter, *Cq*. I argue that a principle on type-shift blocks the former (more complex) kind of type-shift if the latter (simpler) kind of type-shift is possible. The principle can be stated in the following way.

(41) Economy Principle on type-shifting operations

A structure involving successive applications of multiple type-shifters α and β to the form φ i.e., $[\beta [\alpha \varphi]]$, is ruled out if there is a basic type-shifter γ such that the semantic type of $[\gamma \varphi]$ is the same as that of $[\beta [\alpha \varphi]]$.

This principle is conceptually similar to Chierchia's (1998) 'Type-shifting as a Last

Resort'¹⁶ in that it blocks a structure involving type-shifting operations in the presence of another structure involving less type-shifting operations. However, the Economy Principle in (41) is different from 'Type-shifting as a Last Resort' in that it is blind to the actual meaning of the resulting type-shift, and applies just based on the comparison of *types* between the two structures. This is necessary for our purpose because $\llbracket \text{Id} [\text{Cont } X] \rrbracket$ is distinct from $\llbracket \text{Cq } X \rrbracket$, but we still want the latter to block the former. This feature of the Economy Principle can be understood as a consequence of the fact that type-shift is a *repair strategy of type-mismatches*. Given a type-mismatch, the semantic computation compares all combination of type-shifters that can resolve the mismatch regardless of the resultant meaning, and chooses a simpler candidate. In this conception of type-shift, $\text{Id} + \text{Cont}$ and Cq are compared by the semantic computation as possible candidates to resolve the type-mismatch between *know* and a DP, and the latter is chosen because it involves less type-shifting operators. Of course, this analysis still leaves open why there is no type-shifter that does what $\text{Id} + \text{Cont}$ does in one step, i.e., the hypothetical type-shifter in (42) below:

$$(42) \quad \llbracket \text{Id-Cont} \rrbracket^w = \lambda x \in D_e. \{ \mathcal{F}_{\text{cont}}(x) \}$$

This question will be discussed in the next section in connection to the comparison of the current analysis with an account based on lexical stipulations.¹⁷

2.3.2.4 How is this better than lexical stipulations?

Finally, let me address a question concerning the stipulation I have in my account, and how the proposal can be argued to be superior to an alternative account in which the existence and absence of the relevant entailment is simply lexically encoded in each attitude predicate.

In the account laid out above, I propose an inventory of type-shifters that relate entities, propositions and proposition-sets. Namely, there are following three type-shifters.¹⁸

¹⁶'Type-shifting as a Last Resort' (Chierchia 1998) is formulated as follows: For any type-shifting operator τ and any expression X : $*\tau(X)$ if there is an expression E such that for any X in its domain, $E(X) = \tau(X)$.

¹⁷Another solution to the problem suggested to me by Floris Roelofsen (p.c.) is to assume a semantics of declarative clauses in which they denote singleton proposition-sets from the outset. This can be implemented in Alternative Semantics (Kratzer and Shimoyama 2002) or Inquisitive Semantics (Ciardelli et al. 2013) with a declarative operator that 'collapses' the alternatives in a declarative complement into a singleton set. Kratzer and Shimoyama's (2002) \exists -operator can be thought of as such an operator:

$$(i) \quad \llbracket \exists \alpha \rrbracket^{w,g} = \{ \lambda w'. \exists p [p \in \llbracket \alpha \rrbracket^{w,g} \wedge p(w') = 1] \}$$

In this formulation, we can get rid of Id because ResPs can simply combine with declarative clauses. Instead, we need a type-shifter that maps singleton proposition-sets to its sole member in order to treat the declarative embedding of ProPs . (This is in fact Partee's (1986) ι (iota) type-shifter.) This formulation still preserves the account of the contrast between ProPs and ResPs in terms of their basic type-distinction. At the same time, it avoids the problem with $\text{Id} + \text{Cont}$ by doing away with the Id type-shifter.

¹⁸ ι instead of Id if we choose the solution given in footnote 17 to the problem discussed in the previous section.

- (43) a. $\llbracket \text{Id} \rrbracket^w = \lambda p_{\langle s, t \rangle} . \lambda q_{\langle s, t \rangle} . [p = q]$ (proposition-to-singleton)
 b. $\llbracket \text{Cont} \rrbracket^w = \lambda w' . \begin{cases} w' \in \mathcal{F}_{\text{cont}}(w)(x) & \text{if } \mathcal{F}_{\text{cont}}(w)(x) = \mathcal{F}_{\text{cont}}(w')(x) \\ \text{undefined} & \text{otherwise} \end{cases}$ (entity-to-content)
 c. $\llbracket \text{Cq} \rrbracket^w = \lambda x_e . \{ p \mid \exists w [p = \lambda w' . \forall c' \in \mathcal{R}_C [c'(w') = x \leftrightarrow c'(w) = x]] \}$
 where \mathcal{R}_C is a conceptual cover given by context C (entity-to-CQ)

One thing that is crucial in the account is that the following type-shifter is not available:

$$(44) \quad \llbracket \text{Id-Cont} \rrbracket \\ = \lambda x_e \lambda p_{\langle s, t \rangle} . \left[p = \begin{cases} \lambda w' . w' \in \mathcal{F}_{\text{cont}}(w)(x) & \text{if } \mathcal{F}_{\text{cont}}(w)(x) = \mathcal{F}_{\text{cont}}(w')(x) \\ \text{undefined} & \text{otherwise} \end{cases} \right]$$

If this type-shifter were available, using it to resolve the type-mismatch between a ResP and a DP would make an incorrect prediction that *John knows the rumor that p* entails that *John knows that p*, just as in a case where the two type-shifters Id and Cont are nested.

It would be more desirable if I could offer an independent argument for the unavailability of (44), but I will not venture such an explanation in this chapter. Rather, I submit the inventory in (43) as part of my theoretical claim about how entities, propositions, and proposition-sets are mapped into each other in the grammar.¹⁹ Indeed, this involves stipulation, but the stipulation, together with the proposal regarding the semantic types of ProPs and ResPs, enables us to make *predictions* about possible interpretations of ProP/ResP+DP constructions. Specifically, it captures the fact that all ProP+DP combinations license the relevant entailment while ResP+DP combinations don't license the entailment modulo entity-relating readings.

This predictive power is what makes the current proposal more desirable than an account in which the denotation of each attitude predicate is lexically specified as to whether it gives rise to the relevant entailment, as discussed in Section 2.2.2. Simply stipulating the entailment pattern for each predicate is descriptively adequate, but it does not *predict* that any ProP will license the entailment. Also, it is superior to the sophisticated version of the lexical specification account that uses a general lexical rule, as in (11) repeated from Section 2.2.2, to capture this fact.

- (11) For any predicate R such that $\llbracket R \rrbracket^w \in D_{\langle st, et \rangle}$, there is a predicate R_{cont} with the same phonological form such that $\llbracket R_{\text{cont}} \rrbracket^w = \lambda x_e . \llbracket R \rrbracket^w (\mathcal{F}_{\text{cont}}(w)(x))$

¹⁹A similar kind of stipulation is made in other works on type-shifting as well (e.g., Partee 1986; Chierchia 1998). For example, Partee (1986) defines the type-shifter IDENT as in (i), which maps entities to predicates, but she does not include another possible type-shifter IDENT*, given in (ii), in the inventory of type-shifters that maps entities to generalized quantifiers.

- (i) $\text{IDENT}(x) = \lambda y \in D_e . [y = x]$
 (ii) $\text{IDENT}^*(x) = \lambda P \in D_{\langle e, t \rangle} \lambda x_e . [y = x]$

Note that IDENT* is similar to (44) in that it returns a singleton set of what would result from another type-shifter.

This is so because the sophisticated lexical specification account incorrectly predicts that ResPs generally license the relevant entailment whereas the current account crucially avoids this prediction. One way to save the lexical rule account, of course, is to adopt the semantic-type distinction between ProPs and ResPs in my proposal. In this account, the lexical rule is defined to apply only to proposition-taking predicates, and since ResPs are question-taking, the lexical rule simply does not apply to them. However, now this is an account that is equivalent to the my proposal with just a technical difference: what is being done by Cont in my account is now carried out by (11).

2.3.3 On exclusively interrogative-embedding verbs

The semantic typology of (finite-)clause-embedding attitude predicates that emerges from the current proposal is the following: if a predicate can embed both a declarative and an interrogative clause, it is semantically (only) question-taking. On the other hand, if a predicate only embeds a declarative clause, it is semantically proposition-taking. A predicate in the former class can embed a declarative complement as well as an interrogative complement with the help of Id in (16).

An immediate question that one would raise against the current proposal is what to do with exclusively interrogative-embedding verbs like *ask* and *wonder* (i.e., INQUISITIVE VERBS in Karttunen’s 1977 classification). If these verbs have a question-taking denotation, we would wrongly predict that they can embed a declarative complement just like *know* does, with the help of Id, unless an independent explanation is given for their selectional restriction.

I argue that this problem can be avoided since exclusively interrogative-embedding verbs are characterized by what I will refer to as the NON-TRIVIALITY PRESUPPOSITION, which requires the proposition set in the complement to be a non-singleton. The presupposition is stated below.

(45) Non-triviality presupposition of inquisitive verbs

$\llbracket \text{wonder/ask/inquire} \rrbracket^w(Q)(x)$ is defined only if the following proposition is compatible with x ’s beliefs: $\lambda w. \exists p \in Q[p(w)] \wedge \exists p \in Q[\neg p(w)]$

Intuitively, inquisitive verbs presuppose that it is compatible with the subject’s beliefs that the question is non-trivial, in the sense that there are true answers as well as false answers to the question.

The presupposition in (45) cannot be satisfied if Q is a singleton given that a single proposition cannot be both true and false in a particular world. The net result is that the singleton set of a proposition—which results from applying Id to a declarative complement—cannot be combined with an inquisitive verb like *ask* or *wonder*, as it will necessarily result in a presupposition failure.

Not only is it intuitively the case that inquisitive verbs have the non-triviality presupposition, but the presupposition can be derived from the semantic analysis of these predicates once we assume that these predicates share the meaning core that can be paraphrased as ‘want to know’, as suggested by Karttunen (1977) and Guerzoni and Sharvit (2007). Below, I show how the non-triviality presupposition is

derived in the meaning of *want to know*, once we make the following two assumptions about the semantics of *want*: (i) x *wants* p presupposes that x does not believe p , and (ii) presuppositions triggered by the complement of *want* is projected into the belief state of the subject of *want*, e.g., *John wants Mary to stop smoking* presupposes that John believes that Mary used to smoke. These presuppositions are relatively uncontroversial aspects of the meaning of *want* maintained in analyses such as Heim (1992), von Stechow (1999) and those in the subsequent literature. They can be formally stated as follows:

- (46) $\llbracket \text{want} \rrbracket^w(p)(x)$ is defined only if
- (i) $\text{DOX}_x^w \not\subseteq p$, and (x does not believe p)
 - (ii) $\text{DOX}_x^w \subseteq \{w' \mid p(w') \in \{0, 1\}\}$ (x believes the presupposition of p)

In the case of x *wants to know that* p , these two presuppositions together turn out to be contradictory. This is so because the first presupposition requires that x does not believe that x knows p , but the second presupposition, i.e., the projection of the presupposition of the complement, requires that x believes p due to the factivity of x *knows that* p .²⁰

What this shows is that the sentence x *wants to know that* p always faces a presupposition failure. Thus, in order for x *wants to know* Q to be defined, Q has to be a non-singleton. We have now seen that the non-triviality presupposition falls out from the semantics of *want to know*. Hence, assuming that *wonder* and *ask* share the same meaning core as *want to know*, we can derive the non-triviality presupposition from their semantics.

To sum up, exclusively interrogative-embedding verbs, such as *wonder* and *ask*, do not constitute counterexamples to the current proposal.²¹ This is because

²⁰Formally, this can be proved as follows. By assumption, we have the following two presuppositions:

- (i) $\text{DOX}_x^w \not\subseteq \{w' \mid p(w') \wedge \text{DOX}_x^{w'} \subseteq p\}$ (x does not believe that x knows p)
- (ii) $\text{DOX}_x^w \subseteq p$ (x believes p)

From (ii) and positive introspection, we derive the following:

- (iii) $\text{DOX}_x^w \subseteq \{w' \mid \text{DOX}_x^{w'} \subseteq p\}$ (x believes that x believes p)

Conjoining (ii) and (iii), we derive the following:

- (iv) $\text{DOX}_x^w \subseteq \{w' \mid p(w') \wedge \text{DOX}_x^{w'} \subseteq p\}$ (x believes that [p and x believes p])

This contradicts (i). This proof assumes that *know* is analyzed as *believe* + factivity, but an analogous proof can be constructed as long as we assume the principle of POSITIVE CERTAINTY, i.e., ' x believes p ' entails ' x believes that x knows p ' (see e.g., van der Hoek 1993) in the place of positive introspection.

²¹Another problem concerning *wonder* is that they do not embed CQs. If the Cq type-shifter turns an entity into a question, and if *wonder* selects for a question, why can't it combine with a DP under a CQ reading? This is a problem for any theory that treats the semantics of CQs on a par with *wh*-complements (see Nathan 2006 for discussion). Capturing the distribution of CQs is a long-standing issue (see e.g., Nathan 2006; Frana 2010; Aloni and Roelofsen 2011), and is certainly beyond the scope of this dissertation. Here, I follow Pesetsky's (1991) syntactic treatment and assume that *wonder* cannot embed a CQ due to its Case requirement, specifically, that it requires its object to

they have a characteristic presupposition requiring the question-denotation of the complement to be ‘non-trivial’, which explains their impossibility to combine with a singleton proposition-set.

2.3.4 Challenges posed by coordination and anaphora

In this section, I will address several challenges against the current proposal having to do with coordination and anaphora. The common feature behind the challenges is that, although the current proposal makes a distinction in semantic types between ResPs and ProPs, there seem to be examples where the complements of the two types of predicates are syntactically treated on a par. Below are such examples:

- (47) John reported and Bill believes that Mary left. (Right-Node Raising)
- (48) John believes what Bill reported. (Free relative)
- (49) John reported who came. Mary believes it. (Anaphora)

In (47), the declarative complement *that Mary came* is ‘shared’ by the conjuncts involving *report* and *believe* in a Right-Node Raising (RNR). The worry is that, if *report* and *believe* select for different types of complements, it is not clear at first glance how their complements can be shared. In (48), the complement of *believe* has to match in semantic types with the free relative *what Bill reported*. In the common semantic analysis of free relatives, they are treated as a kind of definite descriptions with the same semantic type as its gap position (e.g., [Jacobson 1995](#)). Prima facie, this poses a puzzle for the current analysis since *what Bill reported* would have the question-type whereas *believe* selects for a proposition. Finally, in (49), the pronoun *it* in the complement of *believe* seems to be referring to a propositional discourse referent provided by the complement of *report* in the first sentence. However, since *report* directly takes a question argument, there is no constituent in the first sentence that can provide a propositional discourse referent.

Of these three data points, the first two turn out to be unproblematic if we consider the compositional details of the analysis. The current analysis posits the type-shifter *Id*, which shifts the propositional denotation of a declarative complement

be Caseless. Since Case Filter rules out DPs without a Case, this assumption captures the fact that *wonder* cannot embed a DP complement. In contrast, *ask* does not have the same Case requirement. Thus, it does take a CQ complement, as in *John asked the time*.

However, as [Nathan \(2006\)](#) points out, this cannot be the whole story since *wonder* does take a limited number of DP complements, as shown below.

- (i) a. Kim wondered **something**.
- b. Kim wondered who left, and Sandy wondered {**that** as well/**the same thing**}.

I have to leave this problem open, and simply point out the connection of these data to another open question, namely the selectional restriction of *think*. Although the verb *think* is a ProP, it does not embed content DPs, except the kind of DPs exemplified in (i) above (see [Moltmann 2013](#) for a semantic proposal for discussion concerning *something* in these examples):

- (ii) John thought {*the rumor/**something**/**that**/**the same thing**}.

into a singleton question. Thus, the LF representation of the RNR example in (47) would be (50a) or (50b), depending on whether the shared constituent (or the pivot in the terminology in the RNR literature) is analyzed as outside or inside the coordinated structure (see Sabbagh 2014 and references therein for the details of the common analyses of RNR that largely conform to either the structure in (50a) or that in (50b)).

- (50) a. [John reported [Id _____]] and [Bill believes _____] **that Mary left**.
 b. [John reported [Id _____]] and [Bill believes **that Mary left**].

The crucial point here is that the gap in the first conjunct is not in the complement position of *report*, but rather in the sister of *Id*. Given this kind of structure, a well-formed RNR structure can be derived with the shared constituent being the proposition-denoting declarative complement.

The problem with free relatives (e.g., (48)) can be solved along similar lines. The gap in the free relative *what Bill knows* is in the sister position of *Id* embedded under *report*, as in the following structure.

- (51) [John believes [what Bill reported [Id _____]]].

Thus, the free relative *what Bill reported* can be straightforwardly analyzed as denoting a proposition, instead of a question, under the definite analysis of free relatives. This proposition serves as the internal argument of *believe*.

Regarding the third problem concerning the anaphora in (49) repeated below, I argue that it can be analyzed as a kind of E-type anaphora, as in example (52) made famous by Evans (1977, 1980):

- (49) John reported who came. Mary believes it.
 (52) Just one congressman admires Kennedy. He is very junior.

I analyze E-type pronouns as a disguised definite description, following Cooper (1979) and Heim and Kratzer (1998). Under this analysis, E-type pronouns have the following kind of LF representation, where R is a contextually salient relation and *pro* is a silent pronoun that may or may not be bound.

- (53) the $[R_i \text{ } pro_j]$

For example, in the case of (52), R_i is resolved to the relation holding between a congressman and individuals he admires (i.e., $\lambda x \lambda y. \mathbf{admire}(y, x, w) \wedge \mathbf{congressman}(y, w)$), and pro_j refers back to Kennedy. As a result, the pronoun has the interpretation equivalent to the definite description *the congressman who admires Kennedy*.

The same thing happens in (49) except that the pronoun in the structure in (53) refers to the question in the preceding linguistic context and R refers to a contextually salient relation of type $\langle \langle st, t \rangle, \langle st, t \rangle \rangle$. That is, *it* in (49) is analyzed as having the E-type structure in (53), with R and *pro* referring to the following objects:

- (54) a. $\llbracket R_i \rrbracket^{w,g} = \lambda Q_{\langle st, t \rangle} \lambda p_{\langle st, t \rangle}. [\exists w' [p = \mathbf{Ans}(w')(Q)] \wedge \mathbf{communicate}(j, p, w)]$

$$\text{b. } \llbracket \text{pro}_j \rrbracket^{w,g} = \llbracket \text{who came} \rrbracket^w$$

As a result, the E-type pronouns is predicted to have the following interpretation.

$$(55) \quad \llbracket \text{the } [R_i \text{ pro}_j] \rrbracket^{w,g} \\ = \iota p [\exists w' [p = \text{Ans}(w')(\llbracket \text{who came} \rrbracket^w)] \wedge \text{communicate}(j, p, w)]$$

In words, this proposition is the answer to *who came* that is communicated by John. I submit that this is the correct interpretation of the pronoun *it* in (49). In chapter 4, I will propose a concrete lexical semantics of communication predicates like *report* that in fact makes the kind of relation in (54a) salient.

To wrap up, the current analysis already provides analyses of the potentially challenging examples involving coordination and anaphora. The coordination data can be analyzed if we take into account the presence of *Id* in the structure, and the potentially problematic anaphora can be analyzed as an E-type anaphora involving a question-type pronoun.

2.4 Comparison with alternative approaches

2.4.1 Ginzburg (1995)

Ginzburg (1995) accounts for the contrast in the entailment patterns between ResPs and ProPs by arguing that ProPs select for a proposition but factive ResPs select for a ‘fact’, a different object from a proposition in his ontology (originally due to Russell 1918/1919). According to him, a declarative complement of *know* denotes a fact while the question-denotation of an interrogative complement can be turned into a fact that *resolves* the question by the mechanism of semantic coercion. Factive predicates like *know* are combined with the fact resulting from this coercion.

Specifically, assuming that a content DP like *the rumor* denotes a proposition, Ginzburg argues that a sentence of the form *x knows the rumor* only has a CQ (or an acquaintance) reading. On the other hand, a declarative complement of *know* can denote a fact, which combines with *know*. Hence the entailment does not go through. In contrast, ProPs such as *believe* select for a proposition. Since *the rumor* denotes a proposition which is identical to the denotation of its complement, the entailment from *x believes the rumor that p* to *x believes that p* is straightforward.

He supports his claim about ResPs by the observation that the entailment of the form in (3) does hold when the nominal is factive, such as *fact* or *truth*, as shown below.

$$(56) \quad \text{John knows the \{fact/truth\} that Mary left.} \Rightarrow \text{John knows that Mary left.}$$

Factive DPs such as *the fact* or *the truth* denote facts. Therefore, it is predicted that a fact-selecting verb such as *know* can license the entailment when they take a factive DP object, just as in the case where a proposition-selecting verb such as *believe* takes a proposition-denoting DP object.

However, Ginzburg’s analysis thus sketched has several problems. First of all, his account of the lack of the entailment applies only to *factive* responsive ResPs, but

not to *non-factive* ResPs, such as *report* or *predict*. Ginzburg argues that non-factive ResPs select for a proposition, and thus predicts that the problematic entailment goes through when they take a content DP like *the rumor*. However, as Lahiri (2002: 290–291) notes, this prediction is not borne out, as shown below.²²

- (57) John {**reported/predicted**} the rumor/hypothesis that Mary left.
 \Rightarrow John {**reported/predicted**} that Mary left.

Also, there is a problem of overgeneration due to the coercion mechanisms he posits. In accounting for the declarative-embedding of factive ResPs, Ginzburg actually assumes a mechanism of coercion that converts a proposition denoted by a declarative clause into a fact that *proves* the proposition, in addition to the coercion from questions to facts. But, once we had this coercion mechanism, it is not clear how it does not apply to content DPs like *the rumor*, and licenses the problematic entailment. That is, if *know* is combined with the result of applying the proposition-to-fact coercion to *the rumor*, *John knows the rumor that p* would mean ‘John knows a fact proving the rumor that *p*’, which in turn means that John knows that *p*. This is exactly the entailment that we want to prevent from arising, but it is not clear how it is blocked in Ginzburg’s system.²³ Ginzburg mentions this problem (pp.597–598). However, he only suggests that an alternative CQ reading is available in these sentences, and does not discuss why the problematic reading that I sketched above is blocked.²⁴

Furthermore, other things being equal, a general process of coercion from questions to facts predicts that a verb must be able to embed a question if a verb can embed a fact (i.e., it is factive). However, there are counterexamples to this prediction: verbs such as *regret* and *resent* are factive, but they do not embed an interrogative, as the following example shows.

- (58) John regrets {that he cannot accept the invitation/*who can accept the invitation}.

Ginzburg needs independent stipulations to account for the behavior of these verbs.

Lastly, the fact that the entailment goes through for ResPs when the nominal is factive, as shown in (56), does not favor Ginzburg’s analysis over my analysis. This is because the data can be captured in the current analysis as a result of the acquaintance reading, assuming a specific analysis of the acquaintance relation.

²²The non-factive ResP *tell* does not behave exactly in the same way as *report* or *predict*. See fn. 3. This behavior of *tell* is not a problem for Ginzburg unlike *report*. However, the current account might need to assume that *tell* is ambiguous between a proposition-taking and a question-taking version to account for it.

²³A similar problem arises in example (i).

(i) John **knows** the question of who left. \Rightarrow John **knows** who left.

Given that the DP *the question...* denotes a question just as an interrogative complement does, as Ginzburg assumes, the coercion from a question to a fact resolving the question should license the entailment, contrary to the data. It follows from ‘John knows a fact that resolves the question of who left’ that ‘John knows who left’.

²⁴On the other hand, in the proposed system, there are multiple answers to why the nesting of *Id* and *Cont* is ruled out, as discussed in 2.3.2.3.

That the relevant construction involves an acquaintance reading rather than a CQ reading is evidenced by the fact that the acquaintance predicates like *kennen* or *wissen um* ‘know about’, but not *wissen*, can be combined with the German equivalent of *the fact*:²⁵

- (59) a. Hans kennt die Tatsache, dass *p*. (entails ‘John knows that *p*’)
 John know_A the fact that *p*
 b. Hans weiß um die Tatsache, dass *p*. (entails ‘John knows that *p*’)
 John know_A about the fact that *p*
 c. #Hans weiß die Tatsache, dass *p*.
 John know_K the fact that *p*

Roughly, my derivation of the entailment relies on two assumptions: (i) being acquainted with *x* entails (among other things) knowing that *x* exists; (ii) the content-bearing object denoted by the DP *the fact that p* exists only if *p* is a fact. Combining (i) and (ii) together, we derive the fact that *John knows_A the fact that p* entails ‘John knows that *p* is true’. Below, I explain this derivation in more detail.

The first (arguably reasonable) assumption is that one is acquainted with an object only if the object exists and she believes that the object exists. This can be stated as follows:

- (60) **acquainted**(*y*)(*x*)(*w*) only if **exist**(*y*)(*w*) \wedge **DOX**_{*x*}^{*w*} \subseteq { *w'* | **exist**(*y*)(*w'*) }

That is, *x* can be acquainted with *y* only if *y* actually exists and *x* knows that *y* exists. The second assumption is that the DP *the fact that p* is *necessarily* extensionless if *p* is not a fact. This is not a trivial assumption, and needs some elaboration. What underlies here is an ontological assumption about the properties of content-bearing objects. I assume that the properties of a content-bearing object are *essential*, i.e., are world-independent across worlds in which the object exists.²⁶ That is, it cannot be the case that a content-bearing object is a rumor in one world, but not in another world. In other words, an object predicated of as a rumor in one world cannot be identified with another object predicated of as a non-rumor in another world even if their contents are the same. In worlds where the content is not rumored, the object simply does not exist.²⁷ This is also true of objects that are predicated of as

²⁵I thank an anonymous reviewer of Journal of Semantics for bringing up this fact.

²⁶ This assumption can be formally stated as follows:

$$\forall x \in D[x \in \text{dom}(\mathcal{F}_{\text{cont}}) \rightarrow \forall P \in D_{\langle e, st \rangle}[\exists w[P(x)(w)] \rightarrow \forall w'[P(x)(w') \vee \neg \text{exist}(x)(w')]]]$$

²⁷The ontological assumption is motivated by the truth-conditions of acquaintance sentences in general, independently of the considerations of factive content nouns. The starting point is that acquaintance readings are extensional, i.e., the DP in the object position of the acquaintance *know* cannot be interpreted *de dicto*. This is evidenced by the oddness of the example in (i). On the other hand, a *de re* reading of the object DP of the acquaintance *know* is exemplified by (ii).

- (i) #John knows the president, but it is not Obama.
 Paraphrase (Intended): John is acquainted with someone who he mistakenly believes to be the president.
 (ii) John knows the president, but he does not know that he is the president.

facts. In worlds where p is false, the object denoted by *the fact that p* does not exist (see [Moltmann \(2013: 132–134\)](#) for a similar assumption about the characteristics of ATTITUDINAL OBJECTS, an ontological category for the objects of attitudes in her semantics).

Given these two assumptions, we can derive the entailment in (56), i.e., the entailment from *John knows the fact that p* to *John knows that p* . First, the first conjunct of (60) tells us that p is true (since, otherwise, the object DP would be extensionless) —(a). Furthermore, given the second assumption, p is true in all worlds in which the object denoted by the DP exists. This is because, in those worlds, the object is a fact and its content is p , due to the essentialness of the properties of content-bearing objects. Finally, the second conjunct of (60) tells us that John believes the existence of the object denoted by the DP, which means that he believes that p is true —(b). By (a) and (b), we conclude that John knows that p in w .²⁸ Hence, the data in (56) can be accounted for in the current proposal with assumptions about the semantics of factive nominals and the ontology of contentful objects. Also, this proof can be extended to other combinations of factive ResPs and factive nominals such as *discover the truth that p* .

Thus, I argue that the current proposal has advantages over [Ginzburg's \(1995\)](#) account. Furthermore, it is worthwhile to note that the current proposal succeeds in capturing the data in an ontology that is more conservative than Ginzburg's, who assumes quite a rich ontology including 'facts' and 'questions' as primitives distinct from 'propositions'.

Paraphrase: John is acquainted with Obama, but he does not know that Obama is the president.

On the other hand, what is interesting about the content nouns and contentful objects is that the example in (iii), which is parallel to (ii), sounds odd.

(iii) #John knows the rumor that Mary left, but he does not know that it is rumored that Mary left.

The oddness of (iii) is accounted for given the assumption about the properties of content-bearing objects described above. If an object is a rumor in some world, it is a rumor in every world in which it exists. In (iii), since the object with which John is acquainted has the property of being a rumor in the actual world, it is a rumor also in the worlds compatible with John's beliefs (The object exists in all worlds compatible with John's beliefs because he is acquainted with it). Thus, if one is acquainted with a content-bearing object which is a rumor, he knows of the object as a rumor. This is why the sentence in (iii) sounds odd: it is a contradiction that John knows the rumor, and doesn't know that the rumor is not a rumor.

²⁸The proof here assumes a simplified view that a true belief constitutes knowledge, which is known to be too simplistic ([Gettier 1963](#)). However, the explanation described here can be carried over to a more sophisticated analysis of *know* which involves conditions for capturing the so-called Gettier cases, in addition to the traditional 'truth', 'belief' and 'justification' conditions. What is needed is that the truth of the content holds across the worlds compatible with the beliefs⁺ of the attitude holder, where beliefs⁺ are constrained by the additional conditions that are needed to account for the Gettier cases.

2.4.2 Question-to-proposition reduction theories

In this section, I compare the current analysis with a more standard approach to ResPs where their question-taking meanings are reduced to their proposition-taking meanings (Karttunen 1977; Groenendijk and Stokhof 1984; Lahiri 2002, among others). An interesting property of the current proposition-to-question reduction analysis is that it involves the opposite reduction from the standard approach. In the standard approach, the proposition-embedding meaning of a ResP is basic, from which question-embedding is derived in some way or other. On the other hand, in the current analysis, the question-embedding meaning of a ResP is basic, from which the embedding of declaratives is derived. In this section, I make two further kinds of arguments for favoring the current analysis.

2.4.2.1 The selectional restrictions of attitude predicates

The two analyses differ in the variety of embedding possibilities they allow for a clause-embedding attitude predicate. Specifically, as stated in Section 2.3.3, the current theory predicts that there would in principle be no verb that exclusively embeds an interrogative, unless independent explanations are made. On the other hand, the standard question-to-proposition reduction theory predicts that there would be no exclusively proposition-taking predicates unless further explanations are made. This is because, for any proposition-taking denotation, there must in principle be a corresponding question-taking denotation if the reduction from question-embedding to proposition-embedding is general. Take, for example, Groenendijk and Stokhof's (1984) theory. In their analysis, the extension of an interrogative clause is a proposition, and thus it can be combined with a responsive predicate such as *know*, which selects for a proposition. However, unless there is an additional stipulation, it is predicted that *believe* can embed an interrogative clause in the same way.²⁹

At first glance, both of these predictions seem to be problematic, as can be seen in the actual embedding patterns of attitude predicates summarized below.

(61) The typology of the selection restrictions of attitude predicates

	embed declaratives	not embed declaratives
embed interrogatives	<i>know, be certain, tell</i> etc.	<i>ask, wonder</i> etc.
not embed interrogatives	<i>believe, think</i> etc.	—

²⁹One piece of evidence for the reduction of question-embedding to proposition-embedding in terms of extensionalization that Groenendijk and Stokhof (1984) discuss is the alleged fact that the responsive predicate *tell* becomes veridical when it embeds an interrogative complement although it is not factive when it embeds a declarative complement. However, this claim is questioned by Spector and Egré (2015), who argue that *tell* in question-embedding can in fact be non-veridical, based on the following example.

- (i) Every day, the meteorologists tell the population where it will rain the following day, but they are often wrong.

We will discuss more on the veridicality of embedded questions in chapter 4.

The exclusively interrogative-embedding verbs such as *ask* and *wonder* are *prima facie* problematic for the current analysis, and so are the exclusively declarative-embedding verbs such as *believe* and *think* for the standard question-to-proposition reduction analysis. However, as argued in Section 2.3.3, there is an independent semantic explanation for why verbs such as *ask* or *wonder* cannot embed a declarative: they presuppose that the proposition-set they combine with is a non-singleton.

On the other hand, it is difficult to account for the existence of exclusively declarative-embedding verbs on independent semantic grounds. That is, the set of verbs that exclusively embed declaratives does not seem to be characterized by any independent lexical semantic property. One argument comes from the lexical semantic similarity between *believe* and *be certain*. Assuming that there is no independently testable lexical semantic difference between *believe* and *be certain*, it is hard to explain from their meanings why *believe* does not embed an interrogative complement while *be certain* does.³⁰ Note, on the other hand, that the existence of exclusively declarative-embedding predicates (and the fact that they cannot be independently characterized) is not problematic for the proposed analysis. This is because the proposed constraint on the lexical denotation allows an attitude verb to have a proposition-taking denotation, and there is no general operation by which a question-taking denotation is created out of this proposition-taking denotation.

Hence, there is an asymmetry between the current proposal and the standard analysis. In both accounts, semantic types do not explain the selectional restriction of one of the three classes of predicates in the table in (61). In the current proposal, types don't explain the selectional restriction of exclusively question-taking predicates while, in the standard analysis, types don't explain exclusively proposition-taking predicates. What I argued in this section is that it is easy to semantically account for the former case, but not the latter. Exclusively question-taking verbs form a semantically natural class in having the non-triviality presupposition, so that their behavior can be explained away within the proposed theory. On the other hand, exclusively proposition-taking verbs are difficult to characterize semantically.

2.5 Summary

In this chapter, I have argued for the semantics of question-embedding in which the denotation of a question-embedding Responsive Predicate (ResP), such as *know*, always selects for a question. This contrasts with the standard treatments (e.g., Karttunen 1977; Groenendijk and Stokhof 1984; Lahiri 2002), where ResPs select for a proposition. According to the proposal, the basic denotation of these predicates takes a set of propositions, which corresponds to the proposition-set denotation of an interrogative complement. Thus, they straightforwardly combine with the proposition-set denotation of an interrogative complement, deriving appropriate

³⁰Indeed, the situation is ultimately problematic from learnability and cross-linguistic point of view. Thus, hopefully, future research will uncover some principled ways to predict which declarative-embedding predicates take interrogative complements. It remains to be seen how these future discoveries will affect the present debate.

truth conditions of question-embedding sentences. When the predicates embed a declarative complement, a type-shifter converts the embedded proposition into the singleton set containing that proposition. The singleton question derived this way is combined with a ResP, yielding the correct truth conditions of declarative-embedding sentences. Thus, the current proposal reduces proposition-embedding to question-embedding, as opposed to the standard treatment in which question-embedding is reduced to proposition-embedding.

Equipped with independently motivated type-shifting operations, the proposal provides a novel account of the contrast in entailment between ResPs and ProPs when they take a content DP. The account has empirical and conceptual advantage over [Ginzburg's \(1995\)](#) existing analysis. Also, the proposed reduction from declarative-embedding to interrogative-embedding enables a straightforward semantic account of the selectional restrictions of attitude predicates, which is difficult in the more standard question-to-proposition reduction theories. Although exclusively interrogative-embedding predicates, such as *ask* and *wonder*, pose a *prima facie* problem for the current analysis, their behavior can be explained in terms of their characteristic presupposition that requires their complements to be non-trivial questions.

Chapter 3

Analyzing exhaustivity

3.1 Introduction

In this chapter, we turn to the issue of exhaustivity of embedded questions introduced briefly in chapter 1. As will be shown in detail below, predicates vary with respect to the strength of exhaustivity involved in the interpretation of their interrogative complements. Among question-embedding predicates, cognitive attitude predicates such as *know* and communication predicates such as *tell* license a so-called STRONGLY-EXHAUSTIVE (SE) reading (Groenendijk and Stokhof 1984) whereas EMOTIVE FACTIVES (EFs) like *be happy*, *be pleased*, *be surprised* and *be annoyed* select for a WEAKLY EXHAUSTIVE (WE) reading, 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 3.6. 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).

In this chapter, 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 chapter.)

- (i) IE is derived by obligatory matrix exhaustification (Klinedinst and Rothschild 2011). (§3.3)
- (ii) The effect of the exhaustification depends on the monotonicity property of the embedding predicate (§3.4). In particular,
 - IE is derived if the embedding predicate is upward monotonic.

- Vacuous if the embedding predicate is non-monotonic.
- (iii) Emotive predicates are non-monotonic. (§3.4)
 - (iv) There is no exhaustification in the embedded clause (pace [Klinedinst and Rothschild](#)) (§3.5).
 - (v) SE readings are derived from IE, via the mechanism of neg-raising. (§3.5)

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

3.2 Exhaustivity of question-embedding sentences

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

3.2.1 Three kinds of exhaustivity

Let me first illustrate the three kinds of exhaustivity with examples. Suppose the sentence *John reported who came* was uttered in a 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 question denotation) of the interrogative complement to be true. Under the IE reading, (1) is true iff John reported all the true answers to be true while, for each of the false answers, he didn't report it to be true. Under the SE reading, (1) is true iff John reported all true answers to be true and false answers to be false. Here, the difference between the IE and SE readings is that of the scope of

the negation. In IE, the negation in the paraphrase is above the embedding predicate ‘report’ while in SE, the negation is below ‘report’. Also, it is important to note at this point that I will restrict the discussion throughout this chapter 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 (see section 1.3.2.2 for the general overview on the *de re/de dicto* ambiguity in questions).

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

To formally characterize the readings I just exemplified, we first assume proposition-set denotations for interrogative complements introduced in section 1.3.2. A proposition-set denotation of an interrogative complement is the set of propositions corresponding to the possible ‘positive’ answers. For example, the denotation of *who came* is the set of propositions of the form ‘*x came*’ as in the following:

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

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

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

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

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

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

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

IE readings of question-embedding sentences involve the requirement that the subject does not have the relevant attitude toward false answers (which I will refer to as the ‘No-false-attitude’ condition. In the case of (1), the condition states that John didn’t report that Chris came). The reading can be stated as a conjunction of a WE reading and the no-false-attitude condition in the following way.

- (7) **Intermediately-exhaustive (IE) reading** of $x \text{ Vs } Q$ is true in w iff¹
- $$\llbracket V \rrbracket^w (\lambda w' \forall p \in Q[p(w) \rightarrow p(w')])(x) \wedge \forall p \in Q[p(w) = 0 \rightarrow \neg \llbracket V \rrbracket^w(p)(x)]$$
- (to be revised)

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

3.2.2 Which predicate allows which readings

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

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

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

3.2.2.1 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*.²

Furthermore, there is evidence that cognitive predicates and communication predicates are compatible with IE readings as well (Spector 2005, 2006; Klinedinst and Rothschild 2011; Cremers and Chemla to appear). This can be seen by the fact that (9) is intuitively true given the situation in (9a) but false given (9b).³

- (9) John knows/reported which students came.
(**Judgment:** True under (9a); False under (9b))
- a. **Situation A:** Ann and Bill came, but Chris didn't. John {believes/reported} that Ann and Bill came, but he is {unopinionated about/didn't report anything about} whether Chris came.
 - b. **Situation B:** Ann and Bill came, but Chris didn't. John believes/reported that Ann, Bill and Chris came.

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

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

²In section 3.5.2.2, we will discuss the fact that some communication predicates, especially under their 'literal' reading, seem to resist SE readings, as discussed by Heim (1994); Beck and Rullmann (1999) and Theiler (2014).

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

- (10) a. ‘John knows $A \wedge B$, but does not *know* C .’
 b. ‘John knows $A \wedge B$, but does not *believe* C .’

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

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

- (11) **Intermediately-exhaustive (IE) reading** of x 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 later. Hereafter, I will use (11) as the descriptive characterization of IE readings.

3.2.2.2 Emotive factives

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

- (12) [**Situation:** Among Ann, Bill and Chris, John expected that everyone would come. In fact, Ann and Bill came but Chris didn’t.]
 a. It surprised John which students came. (Judgment: False)
 b. It surprised John which students didn’t come. (Judgment: True)

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

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

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

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

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

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

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

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

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

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

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

- (16) It didn't surprise John which students didn't come. (Judgment: False)
 a. WE: 'John was not surprised that $\neg C$ '. (False in (12))
 b. IE: The negation of (14) (True in (12))
- (17) John isn't happy about what was on the menu. (Judgment: False)
 a. WE: 'John is not happy that $A \wedge B$ '. (False in (13))
 b. IE: The negation of (15) (True in (13))

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

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

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

The last sentence above would be false under its WE reading because the WE answer of the embedded question 'Bob runs the race in under six minutes' is unsurprising to Emily. Theiler (2014) provides a more detailed discussion about when emotive predicates allow an SE reading. According to her, there are two readings of emotive predicates: LITERAL and DEDUCTIVE, and it is only when the emotive predicates are interpreted with a deductive reading that they allow an SE reading. Roughly, the difference between the literal reading and the deductive reading corresponds to the difference between an immediate emotive reaction against a perception and an emotive state that one reaches after an inference. For example, the literal reading of *be surprised by p* can be paraphrased as 'be immediately surprised by the direct perception of *p*' and the deductive reading as 'reaches the conclusion that *p* is surprising'.

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

- (19) In effect, it surprised John which students came.
 (20) In effect, John was happy about which students didn't come.

Also, it can be argued that the *since*-clause in Klinedinst and Rothschild's example (18) forces the deductive reading since it suggests that an inference is involved in Emily's surprise. On the other hand, there is no definite way to force a literal reading, but Theiler suggests that an example that ensures that the relevant emotion

is a result of a direct perception tends to be interpreted as ‘literal’. For example, the following rendition of the last sentence of [Klinedinst and Rothschild](#) example in (18) sounds less natural as a consistent continuation of the earlier context.

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

I will assume that [Theiler’s \(2014\)](#) description of the SE judgment of emotive factives is correct: emotive factives are ambiguous between the literal reading and the deductive reading, and the SE judgment obtains only with deductive readings. In the following, when I simply use the term ‘emotive factives’, it refers to emotive factives with the literal readings, i.e., the ones that conform to the ‘traditional’ judgment discussed above. I will discuss how the SE judgment in the deductive reading comes about in section 3.5.2.4.

3.2.2.3 Summary of the empirical generalization

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

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

Table 3.1: Summary of attested readings

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

3.3 Deriving WE and IE readings

In this section, I lay out my basic analysis of WE and IE readings, based on [Klinedinst and Rothschild’s \(2011\)](#) analysis. SE readings will be discussed in section 3.5. 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.

3.3.1 WE as a baseline interpretation

My strategy for analyzing the three readings of embedded questions is to assume that WE readings are the basic interpretation of interrogative complements, and derive the stronger readings, i.e., IE and SE readings, by applying further operations to the baseline interpretation. Following Heim (1994); Dayal (1996); Beck and Rullmann (1999), I assume that WE readings of interrogative complements are derived by applying the answerhood operator *Ans* to the question denotation. Here, *Ans* returns the conjunction of all the true members of the input question denotation.^{4,5}

$$(22) \quad \llbracket \text{Ans} \rrbracket^w = \lambda Q_{\langle s, t \rangle} \lambda w'. \forall p \in Q [p(w) \rightarrow p(w')]$$

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

Under the standard assumption that responsive predicates have proposition-taking denotations (which I argued against in chapter 2), the WE answers derived as in (23) can be directly combined with the proposition-taking denotation of responsive predicates, such as *know* and *predict* in (24). Such derivations derive WE readings, as shown in (25).

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

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

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

In the view defended in the previous chapter, responsive predicates have question-taking denotations, contrary to what is assumed in the above illustration. In the next chapter, I will present a way to reconcile the compositional system using *Ans* with the view that responsive predicates take questions by hypothesizing that responsive predicates in general are ‘decomposed’ into a proposition-taking core predicate and *Ans*. For example, I will propose that *know* is decomposed into ‘believe’ and *Ans*. Thus, although *know* as a whole selects for a question, it internally contains the meaning of *Ans*.

Importantly, the analysis of exhaustivity that I will present in the current chapter is in principle independent from my claim in the previous chapter that responsive predicates take questions. Therefore, I will leave detailed discussion of the decompositional analysis to the next chapter, and present the analysis in the current chapter assuming the standard proposition-taking denotations for responsive predicates. Note, however, that this is simply for expository purposes and the proposal in the present chapter is compatible with the proposal in the previous chapter, as I will illustrate in the next chapter.

⁴The intension of this operator is equivalent to the function *Ans* in the previous chapter.

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

3.3.2 IE via matrix exhaustification

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

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

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

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

In this section, I illustrate how the IE reading is derived from the LF in (26), given a particular assumption about the alternatives of an interrogative complement. I further propose an implementation of X as a quantifier that binds into the world-argument of *Ans*, and argue that this analysis does away with a technical problem associated with the first analysis. A more general comparison between X and the exhaustivity operator employed in the literature on the grammaticalized theory of exhaustive inferences is given in 3.4.2.2.

3.3.2.1 X as an alternative-sensitive operator

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

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

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

[Klinedinst and Rothschild \(2011\)](#) further stipulate that the alternative-semantic value of an interrogative complement is the set of its *possible* WE answers.⁷ For

⁶[Klinedinst and Rothschild](#) themselves call the operator EXH, following the literature on grammatical theory of scalar implicature (e.g., [Chierchia et al. 2012](#); [Fox 2007](#)). However, the operator I will posit in the analysis crucially differs from EXH in this literature in that the former negates *strictly stronger* alternatives while the latter negates *non-weaker* alternatives. Also, it will be discussed in section 3.4.2 that the syntactic properties of the two operators differ.

⁷I call this a stipulation because this assumption does not follow from the general theory of

instance, the alternative-semantic value of *Ans +which students will come* looks like the following:

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

Effectively, the alternative-semantic value of *Ans +complement* ends up being equivalent to the alternative-semantic value of the complement itself. Before discussing how this value is compositionally derived, let us see how we can derive IE readings given the ordinary semantic value and the alternative-semantic value of the complement in (29) and (30).

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

$$(31) \quad \begin{array}{ll} \text{a. } \llbracket \text{predict} \rrbracket^{\text{Alt}} = \{ \lambda p_{\langle s, t \rangle} \lambda x \lambda w. \text{predict}(x, p, w) \} \\ \text{b. } \llbracket \text{John} \rrbracket^{\text{Alt}} = \{ j \} \end{array}$$

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

$$(32) \quad \llbracket \text{John predicts [Ans [which students will come]]} \rrbracket^{\text{Alt}} \\ = \left\{ \lambda w. \text{predict}(j, p, w) \mid p \in \left\{ \begin{array}{c} A, B, C \\ A \wedge B, B \wedge C, C \wedge A \\ A \wedge B \wedge C \end{array} \right\} \right\}$$

(33) Composition rules for alternative-semantic values

Let γ be a node whose daughters are $\{\alpha, \beta\}$. Then, $\llbracket \gamma \rrbracket^{\text{Alt}} =$

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

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

alternatives or focus. For example, there is no focused item in an interrogative complement whose focus-semantic value compositionally derives the set of WE answers. Klinedinst and Rothschild (2011) state the following regarding this issue:

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

$$(34) \quad \llbracket (26) \rrbracket^w = 1 \text{ iff } \mathbf{predict}(j, A \wedge B, w) \wedge \neg \mathbf{predict}(j, A \wedge B \wedge C, w)$$

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

$$(35) \quad \llbracket (26) \rrbracket^w = 1 \text{ iff } \mathbf{predict}(j, A \wedge B, w) \wedge \neg \mathbf{predict}(j, C, w)$$

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

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

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

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

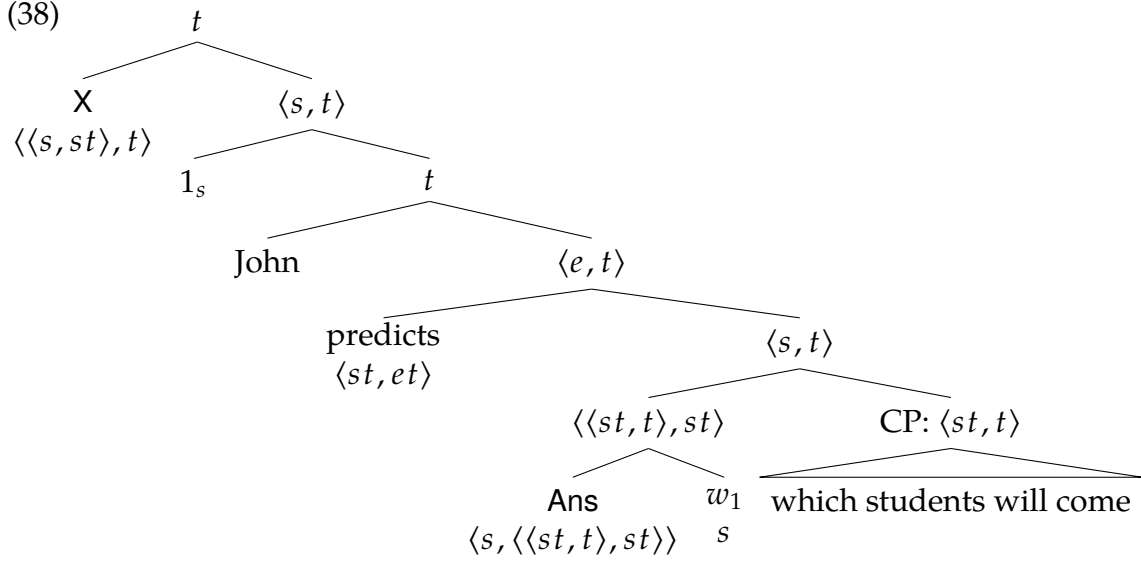
$$(37) \quad \llbracket \text{which students will come} \rrbracket^{\text{Alt}} = \{A, B, C, A \wedge B, B \wedge C, C \wedge A, A \wedge B \wedge C\}$$

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

3.3.2.2 X as a quantifier binding the world argument of Ans

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

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



(39) $\llbracket \text{Ans} \rrbracket^w = \lambda w' \lambda Q \lambda w'' . \forall p \in Q[p(w') \rightarrow p(w'')]$

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

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

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

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

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

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

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

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

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

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

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

Hence, the quantificational analysis of X correctly derives the IE reading. In section 3.4.2, I discuss more about the syntactic properties of X , where I will argue that X is obligatorily base-generated in the argument position of Ans and moves to the appropriate scope position.

Is there any reason to prefer the quantificational analysis over the alternative-based analysis? In section 3.4.2, I will argue that the quantification analysis is preferable on the basis of the fact that X does not associate with alternative-inducing expressions other than Ans . Here, I point out another, technical problem with the alternative-based account. Above, X as an alternative-sensitive operator is defined as follows:

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

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

$$(26) \quad [X [\text{John predicts Ans} [\text{which students will come}]]].$$

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

$$(45) \quad \begin{array}{ll} \text{a. } \llbracket \text{John predicts Ans} [\text{which students will come}] \rrbracket \\ \quad = \lambda w. \text{predict}(\mathbf{j}, \llbracket \text{Ans} \rrbracket^w(\{A, B, C, A \wedge B, B \wedge C, C \wedge A, A \wedge B \wedge C\}), w) \\ \text{b. } \llbracket \text{John predicts} [\text{Ans} [\text{which students will come}]] \rrbracket^{\text{Alt}} \\ \quad = \left\{ \lambda w. \text{predict}(\mathbf{j}, p, w) \mid p \in \left\{ \begin{array}{l} A, B, C \\ A \wedge B, B \wedge C, C \wedge A \\ A \wedge B \wedge C \end{array} \right\} \right\} \end{array}$$

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

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

$$(46) \quad \lambda w'. \text{predict}(j, \llbracket \text{Ans} \rrbracket^w(\{A, B, C, A \wedge B, B \wedge C, C \wedge A, A \wedge B \wedge C\}), w')$$

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

In the illustration in section 3.3.2.1, I implicitly assumed that (46) is the prejacent, but this technically does not follow from the analysis itself.⁹ Hence, I conclude that the quantificational analysis of *X* is preferred over the alternative-based analysis for the above technical reason, and I will hereafter adopt the quantificational analysis of *X* in the following sections. However, I will also borrow the terms ‘prejacent’ and ‘alternatives’ from the alternative-based analysis to refer to the kind of proposition/proposition-set in (41a) and (41b).

3.3.3 The case of factive predicates

As we briefly discussed in section 3.2.2.1, IE readings of factive predicates involve a non-factive counterpart of the relevant attitude expressed by the embedding predicate. Klinedinst and Rothschild’s (2011) analysis does not obviously capture this fact since the *X*-operator is defined to simply negate the alternative values of its prejacent, which already involves the presuppositions triggered by the embedding predicate. For example, the predicted truth conditions (in *w*) of the IE reading of *John knows which students came* will be the following:

$$(47) \quad \llbracket X [\text{John knows which students came}] \rrbracket^w = 1 \\ \text{iff } \llbracket \text{know} \rrbracket^w(A \wedge B)(j) \wedge \neg \llbracket \text{know} \rrbracket^w(A \wedge B \wedge C)(j)$$

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 the next chapter, I will give a semantics of factive predicates which systematically derives the fact that the members of the alternatives do involve factivity, and hence does not encounter the above problem, extending the view advocated in the previous chapter that responsive predicates are semantically question-taking. I will leave details of the analysis to the next chapter, but the basic idea of the solution is the following: a factive predicate is decomposed into its *non-factive component* and an answerhood-operator inspired by Dayal (1996), and the presupposition triggered

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

by the latter derives factivity only when the complement is a singleton question.¹⁰ Given this setup, the prejacent and alternatives for *John knows which students came* would be something like the following:

- (48) John believes $[[\text{Ans } w] \text{ which students came}]$
- a. **Prejacent:** $\lambda w'. \llbracket \text{John believes } [[\text{Ans } w] \text{ which students came}] \rrbracket^{w'}$
 - b. **Alternatives:**

$$\left\{ \lambda w'. \llbracket \text{John believes } [[\text{Ans } w''] \text{ which students came}] \rrbracket^{w'} \mid w'' \in W \right\}$$

$$= \left\{ \lambda w'. \mathbf{DOX}_j^{w'} \subseteq p \mid p \in \left\{ \begin{array}{c} A, B, C \\ A \wedge B, B \wedge C, C \wedge A \\ A \wedge B \wedge C \end{array} \right\} \right\}$$

Since each proposition in (48b) does not involve factivity, we can derive the correct IE reading for *know*, as follows:

- (49) $\llbracket X [\text{John knows which students came}] \rrbracket^w = 1$ iff
 $\mathbf{DOX}_j^w \subseteq A \wedge \mathbf{DOX}_j^w \not\subseteq [A \wedge B \wedge C]$

This suffices for our purpose in the current chapter.

3.4 Capturing the distribution of WE and IE

3.4.1 X and the monotonicity property of embedding predicates

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. In particular, if the embedding predicate has the property satisfied by α in the following, the application of X is vacuous.

- (50) For any p, p' such that $p \neq p'$, $\llbracket \alpha \rrbracket(p) \not\models \llbracket \alpha \rrbracket(p')$ and $\llbracket \alpha \rrbracket(p') \not\models \llbracket \alpha \rrbracket(p)$

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

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

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

In the world w where Ann came, but Bill didn't, the truth conditions of (51) will be the following:

- (52) $\llbracket (51) \rrbracket^w \Leftrightarrow \llbracket \alpha \rrbracket^w(A) \wedge \forall p \in \{\llbracket \alpha \rrbracket(A), \llbracket \alpha \rrbracket(B), \llbracket \alpha \rrbracket(A \wedge B)\} [p \subset \llbracket \alpha \rrbracket(A) \rightarrow \neg p(w)]$

¹⁰Klinedinst and Rothschild (2011: 17) briefly mentions a possibility of accounting for IE of factives in terms of lexical decomposition.

What is crucial here is that, if the embedding predicate α has the property in (50), no 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, $\llbracket \alpha \rrbracket(A)$. Thus, the second conjunct of (52) will be tautological, meaning that the application of X is vacuous in such a case. Also, if α is a factive predicate, what matters is the non-factive counterpart of α given the decompositional picture suggested in the previous section where the alternatives and prejacent are constructed with the non-factive propositions. That is, if the non-factive counterpart of α has the property in (50), the application of X is vacuous.

I argue that this is exactly what happens with emotive factives with the literal reading (I will discuss the deductive reading of emotive factives in the next section).¹¹ Following the terminology of the literature (e.g., Lassiter 2011; Anand and Hacquard 2013), I will call the relevant property of these predicates NON-MONOTONICITY although what is intended here is not merely the negation of (upward or downward) monotonicity, but the stronger property in (50).¹²

At least under their literal reading, non-factive counterparts of emotive factives are non-monotonic in this stronger sense. For instance, assuming that the non-factive counterpart of *be happy that p* can be paraphrased by ‘would be happy if p' ’, its non-monotonicity can be seen by the invalidity of the inferences as follows:

- (53) John would be happy if Ann and Bill come.
 \nRightarrow John would be happy if Bill comes.
- (54) John would be happy if Ann comes.
 \nRightarrow John would be happy if Ann and Bill come.

In (53), we see that *would be happy if p* is not upward monotonic. The counterexample to the inference can be constructed with a case where John wants Bill *not* to come, but wants Ann to come, and the extent to which he wants Ann to come is greater than the extent to which he wants Bill not to come. In this situation, the antecedent of (53) is true since he would be happy if Ann comes regardless of whether Bill comes, but the consequent of (53) is false since John wants Bill *not* to come. In (54), we see that *be happy* is not downward monotonic. The counterexample of the entailment can be constructed with a scenario where John wants Ann to come, but wants Bill not to come. This time, the extent to which he wants Bill not to come is greater than the extent to which he wants Ann to come. Thus, the antecedent of (54) is true, but the consequent is false. The lack of entailment relations between *would be happy if p* and *would be happy if p'* also holds for any logically independent pair p and p' .

Parallel facts holds for *be surprised* as well:

¹¹Footnote 47 of Spector and Egré (2015) briefly discusses the prediction of Klinedinst and Rothschild’s (2011) analysis when applied to *surprise*, which they take to be non-monotonic. The current analysis generalizes this observation to emotive factives in general, including those with ‘positive’ meanings such as *be happy*, and connects it to the general analysis of the distribution of WE, IE and SE readings.

¹²Technically, a predicate α fails to be monotonic as soon as there is *some* pair of proposition p and p' such that $\llbracket \alpha \rrbracket(p) \not\models \llbracket \alpha \rrbracket(p')$ and $\llbracket \alpha \rrbracket(p') \not\models \llbracket \alpha \rrbracket(p)$. This property would not be sufficient to derive the prediction that the application of X is vacuous since it allows for some alternative to be stronger than the prejacent.

- (55) John would be surprised if Ann and Bill come to the party.
 \Rightarrow John would be surprised if Bill comes to the party.
- (56) John would be surprised if Ann comes to the party.
 \Rightarrow John would be surprised if Ann and Bill come to the party.

Here, the counterexample to the inference in (55) can be constructed with a situation where John expects Bill to come, but expects Ann not to come. In this situation, the antecedent of (55) is true since Ann's coming would be sufficient for John's surprise, but the consequent is false since Bill coming would not be surprising for John. The counterexample to (56) can be constructed with a scenario where John expects Ann not to come since she doesn't usually come to parties, but John thinks it would not be surprising if Ann comes with Bill since she likes to be with Bill anywhere he goes.

One might think that the latter example can be accounted for in terms of exhaustive interpretation of the *if*-clause even if the predicate itself is downward-monotonic. However, it is not clear if this explanation can account for all cases. The example in (57) below does not seem to be straightforwardly captured in terms of exhaustification since the set of alternatives that would be needed is not easily available in the antecedent. In the following example, the neither the focus alternatives (Rooth 1985) nor the structural alternatives (Katzir 2007) provides the alternatives that would be needed to capture the lack of inference.

- (57) [**Context:** Ann is an old member of the department and she now lives far away.]
 John would be surprised if [Ann comes to the department].
 \Rightarrow John would be surprised if [Ann is visiting the town since her best friend is having a wedding in the town, and **she comes to the department** to say hi to people when she has some free time before the wedding.]

Here, the mere information of Ann coming to the department would surprise John since she lives far away, but this information together with the background information in the *if*-clause in the consequent would not surprise John.

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 Crnič 2011 for monotonic analyses that explains the apparent lack of monotonic inferences based on context shift). Here, I formulate a non-monotonic semantics for *be happy* based on the ordering-based semantics for desire predicates by Heim (1992) (see Villalta 2008 and Rubinstein 2012 for refined versions of the counterfactual semantics of desire predicates).

- (58) $\llbracket \text{be happy} \rrbracket^{w, Sim}(p)(x)$ is
- defined only if $p(w) = 1$ and x believes that p , and
 - True iff $\forall w' \in \mathbf{DOX}_w^x [Sim_{w'}(p) \leq_{x,w}^{\text{pref}} Sim_{w'}(\neg p)]^{13}$

¹³This semantics for *be happy* is crucially different from Heim's (1992) semantics of *want* in requiring the preference ordering between the two sets of worlds to be *non-strict* rather than *strict*. This is necessary to capture the fact that *John is happy that Ann and Bill came* is true even if it would have

- (59) $Sim_w(p)$
 $:= \{ w' \in W \mid w' \in p \text{ and } w' \text{ resembles } w \text{ no less than any other world in } p \}$
- (60) $p \leq_{x,w}^{pref} p'$ 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, 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.¹⁴ More concretely, below is an example of a counter-model for the inference in (53):

- (61) a. **John's belief:** $DOX_j^w = \{w'\}$
 b. **Similarity relations**
- $Sim_{w'}(A \wedge B) = A \wedge B$
 - $Sim_{w'}(\neg[A \wedge B]) = B \wedge \neg A$
 - $Sim_{w'}(B) = B \wedge \neg A$
 - $Sim_{w'}(\neg B) = A \wedge \neg B$
- c. **Preference ordering:** $[A \wedge \neg B] <_{j,w}^{pref} [A \wedge B] <_{j,w}^{pref} [B \wedge \neg A]$

More generally, we can show that the semantics for *happy* in (58) satisfies the property in (50) since, for any pair of distinct propositions p and p' , we can find a similarity relation and a preference ordering such that $\llbracket \text{happy} \rrbracket^{w, Sim}(p)(x)$ and $\llbracket \text{happy} \rrbracket^{w, Sim}(p')(x)$ do not entail each other.¹⁵

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

- (62) $\llbracket \text{be surprised} \rrbracket^{w, Sim}(p)(x)$ is
- defined only if $p(w) = 1$ and x believes that p , and
 - True iff $\forall w' \in DOX_w^x [Sim_{w'}(\neg p) <_{x,w}^{exp} Sim_{w'}(p)]$

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

been equally desirable for him if only Chris came (and that these two propositions are similarly close to the actual world). This contrasts with *John wanted Ann and Bill to come*, which is empirically false in the above situation.

¹⁴Thus, 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.

¹⁵X and accordingly (50) is defined to compare the *logical* relationship that holds regardless of contextual parameters like *Sim*. Such a logical relationship does not hold between sentences containing the predicate in (58) with distinct complements since the entailment doesn't hold under some *Sim* and a preference ordering.

(64) $p <_{x,w}^{\text{exp}} p'$ iff $\forall w' \in p' \exists w'' \in p : x$ considers w'' more likely than w' in w

A concrete counter-model for the inference in (56) is the following:

- (65) a. **John's belief:** $\text{DOX}_j^w = \{w'\}$
 b. **Similarity relations**
- $\text{Sim}_{w'}(A) = A \wedge \neg B$
 - $\text{Sim}_{w'}(\neg A) = \neg A \wedge \neg B$
 - $\text{Sim}_{w'}(A \wedge B) = A \wedge B$
 - $\text{Sim}_{w'}(\neg[A \wedge B]) = \neg A \wedge \neg B$
- c. **Expectedness ordering:** $[A \wedge B] =_{j,w}^{\text{exp}} [\neg A \wedge \neg B] <_{j,w}^{\text{exp}} [A \wedge \neg B]$

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:

- (66) John {knows/predicted/told me} that Ann and Bill would come.
 \Rightarrow John {knows/predicted/told me} that Bill would come.

This is natural under the Hintikka 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 (58). Thus, they are non-monotonic and an application of X above them is predicted to be vacuous. Similar lexical semantic distinction between cognitive/communication predicates and emotive predicates have been shown to account for other selectional properties of attitude predicates, such as mood selection in Romance languages (Villalta 2008) and the acceptability of embedded epistemic modals (Anand and Hacquard 2013). According to the present proposal, the existence/absence of IE readings can be seen as another empirical domain where this distinction is significant.

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

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

3.4.2 Syntactic properties of X

3.4.2.1 Obligatoriness and the scope of X

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

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

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

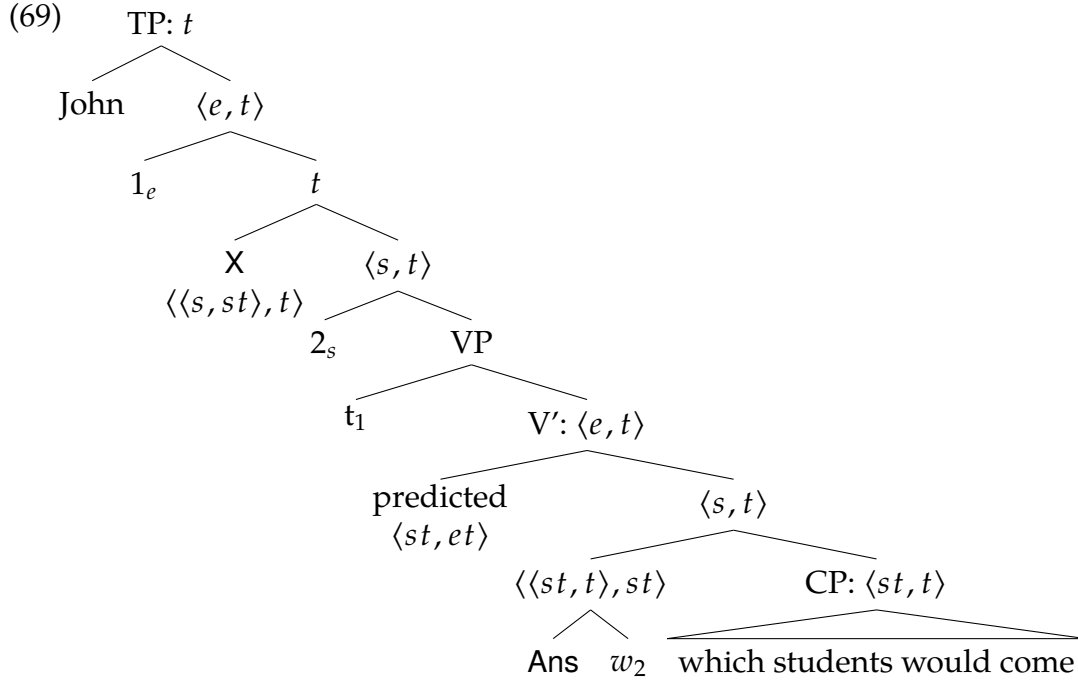
(67) At least one student predicted who came. (K&R: 16)

If X is globally applied to (67), it is predicted to be true only if no student made any actually false prediction about which student came. This reading seems to be unavailable. Also, the following example shows that X cannot scope above the adverb *frequently*.

(68) John frequently predicted which students would come.

If X took scope above *frequently* in the above example, it would be true if John frequently made true predictions about who would come and not frequently made false predictions about who would come. Again, this reading seems to be unavailable. The weakest reading (68) can get is the reading where it was frequently the case that John made true predictions about who would come and didn't make false predictions about who would come.

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

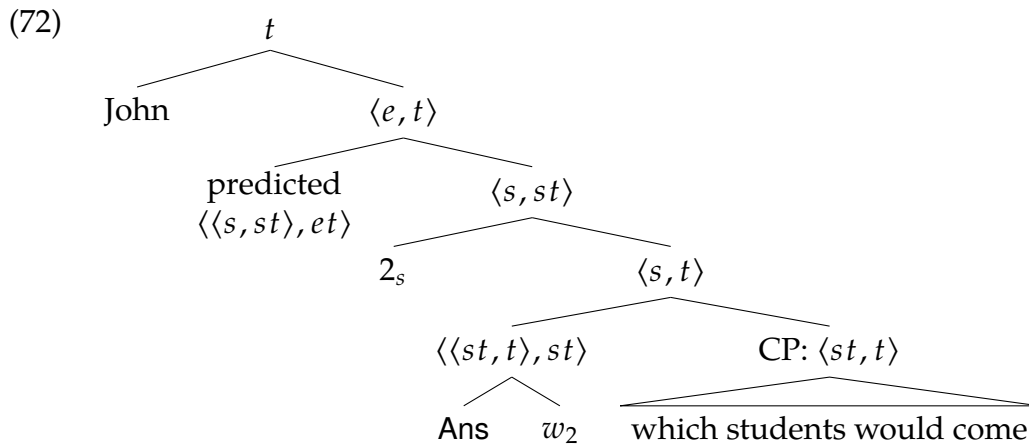


In the formulation of the analysis where X is a syntactic operator—as the one I have been developing in this chapter—the above two syntactic properties of X have to be stipulated. Another way to formulate the analysis is to do away with the idea that X is a free-standing syntactic operator, and encode X in the lexical semantics of responsive predicates. In this formulation, for example, the denotation of *predict* will be defined as follows, where X is now a metalanguage abbreviation of the exhaustive operator in (71).

$$(70) \quad \llbracket \text{predict} \rrbracket^w = \lambda \mathcal{P}_{\langle s, st \rangle} \lambda x. X(w)(\lambda w \lambda w'. \text{predict}(x, \lambda w''. \mathcal{P}(w'')(w'), w)$$

$$(71) \quad X(w) := \lambda \mathcal{P}_{\langle s, st \rangle}. \mathcal{P}(w)(w) \wedge \forall w'' \left[\begin{array}{l} \{w' \mid \mathcal{P}(w')(w'')\} \subset \{w' \mid \mathcal{P}(w')(w)\} \\ \rightarrow \neg \mathcal{P}(w)(w'') \end{array} \right]$$

Here, *predict* itself is a quantifier that binds into the world argument position of *Ans*, as illustrated in the following LF in (72).



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

In this formulation, too, one has to stipulate the obligatoriness of X. The stipulation is simply shifted from syntax to lexical semantics. That is, it is stipulated in the lexical semantics that (70) is the correct denotation of *predict* and not the one below.

$$(73) \quad \llbracket \text{predict} \rrbracket^w = \lambda p_{\langle s, t \rangle} \lambda x_e. \mathbf{predict}(x, p, w)$$

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

3.4.2.2 Proliferation of exhaustivity operators?

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

There are at least two empirical facts about exhaustivity in embedded questions that does not seem to be captured by the standard EXH-operator. One is the restriction on the scope of exhaustification discussed above. The scope of EXH is generally not limited syntactically. Rather, it is restricted by global pragmatic constraints like the Strongest Meaning Hypothesis (SMH) (Dalrymple et al. 1998; Chierchia et al. 2012). In section 3.6.2, I will discuss a problem with an analysis of exhaustivity of embedded questions in terms of EXH and a constraint on its distribution based on the SMH, in relation to Nicolae’s (2013) analysis.

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

other alternative-inducing expressions. For example, the sentence in (74) shows that focus is not relevant for the exhaustivity of embedded questions.

(74) [**Situation:** There are three students, Ann, Bill and Chris. Professor Jones only invited Ann and Bill and Professor Lee only invited Chris.]

John predicted [which students [Professor Jones]_F would invite].

- a. $\sim \neg$ [John predicted that **Professor Jones** would invite Ann, Bill and Chris].
- b. $??\sim$ \neg [John predicted that **Professor Lee** would invite Ann and Bill].
- c. $\sim \neg$ [John predicted who **Professor Lee** would invite].

The fact that the sentence does not give rise to the inference in (74b) suggests that focus alternatives are not relevant for the exhaustivity of embedded questions, contrary to what would be expected if the general mechanism of alternative-generation is responsible for the exhaustivity of embedded questions. In the current proposal, on the other hand, it is expected that X does not associate with focus alternatives because X is a quantifier that binds the world argument of Ans.

Indeed, the sentence gives rise to the inference in (74c), but this inference arises from quantity implicature that is independent from the exhaustivity of embedded questions. Under the current proposal, the inference in (74c) is generated by the structure like the following (assuming a grammatical theory of quantity implicature):

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

In (75), X is associated with w_2 , the world argument of Ans while EXH is associated with the focus *Professor Jones*.

3.5 Analyzing SE readings

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

Having accounted for the distribution of WE and IE readings, I now move on to the account of SE readings. Since Groenendijk and Stokhof (1984), SE readings have been analyzed as arising from an independent semantic derivation of an interrogative complement. For example, Heim (1994) and Beck and Rullmann (1999) derive SE readings by applying a special Answerhood operator (their ‘Answer2’) to the embedded complement. Also, Klinedinst and Rothschild (2011) and Nicolae (2013) derive SE readings by placing EXH below the question-embedding predicate, as in (76) below:

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

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

- (i) & (ii) John thinks that Ann didn't come.
(= The 'neg-raising' interpretation)

As one can see from (78) and (79), the current analysis of SE readings parallels the semantic analysis of neg-raising. Roughly speaking, an SE reading is derived by applying the semantic analysis of neg-raising to the propositions negated by X in an IE readings, i.e., the propositions underlined in (78).

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

One desirable consequence of the current view is that it can make sense of [Cremers and Chemla's \(to appear\)](#) data on the Response Times of picture-matching tasks for IE and SE readings: Their experiment shows that it takes longer time for the participants to access SE readings than IE readings.¹⁷ This result makes sense under the current analysis since SE readings are derived from IE readings, and thus the derivation of the former is more complex than that of the latter.

3.5.2 SE readings and neg-raising

In the previous section, I illustrated in informal terms how SE readings are derived from IE readings together with an excluded-middle assumption. In this section, I will provide details of the analysis including the formal implementation of how an excluded-middle assumption is semantically integrated with the IE reading following the semantic literature on neg-raising ([Bartsch 1973](#); [Gajewski 2007](#); [Romoli 2013](#)). In section 3.5.2.1, I discuss the sources of the excluded-middle assumption and the formal implementation of the derivation of SE readings. In section 3.5.2.2, I discuss a particular prediction the current analysis makes about the relationship between predicates that allow SE readings and neg-raising predicates. Finally, in section 3.5.2.3, I will discuss an issue with deriving SE readings of factive predicates in the current analysis.

¹⁷Here is more detail about [Cremers and Chemla's \(to appear\)](#) experimental design and result. Their participants are divided into the IE group and the SE group, and the experiment involves two phases: the 'training phase' and the 'experimental phase'. The crucial target item is a sentence-picture pair where the picture makes the sentence true under its WE and IE readings, but false in its SE reading. In the training phase, using explicit feedback, the participants in the IE group are trained to give the answer 'True' to the target item while those in the SE group are trained to give the answer 'False'. The participants' response times in the experimental phase are recorded, and the result indicated that the 'False' responses to the target by the SE group were slower than the 'True' responses to the target by the IE group, after confounding effects of the sentences and pictures are controlled.

3.5.2.1 The excluded-middle assumption as a soft-presupposition

In this section, I will discuss how the excluded-middle assumption is integrated in the semantic derivation of SE interpretations, which I left vague in the above informal exposition. Following [Gajewski \(2007\)](#), I will treat the excluded-middle assumption as the SOFT PRESUPPOSITION of the relevant embedding predicate in the sense of [Abusch \(2010\)](#). Here, I use SOFT PRESUPPOSITIONS as a descriptive term for those presuppositions that can be suspended easily in a context that entails the speaker's ignorance about whether the presupposition holds. This contrasts with 'hard' presuppositions which would make an utterance simply infelicitous unless it is entailed by the speaker's knowledge state. A well-known example of a soft presupposition trigger is *win*, which presupposes 'to participate'. As shown below, the sentence *John won the race* gives rise to the inference that John participated in the race, and this inference projects from under negation as in (80b) and also from the antecedent of a conditional as in (80c). (Following examples are taken from [Romoli 2013](#).)

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

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

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

Despite this similarity, *win* and the *it*-cleft differ in the defeasibility of the presuppositions they trigger. This can be tested by using a context where the speaker is ignorant about whether the relevant presupposition holds ([Simons 2001](#)). In (82a) below, it is shown that the presupposition of *win* can be suspended if the speaker doesn't know whether the relevant individual participated in the race. On the other hand, (82b) shows that the existential presupposition of the *it*-cleft cannot be suspended in the similar way.

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

SOFT PRESUPPOSITION TRIGGERS refer to the kind of presupposition triggers that give rise to defeasible presuppositions like *win* in above examples. Other examples of soft presupposition triggers discussed in the literature include factive predicates

such as *know*, *discover* etc. as well as aspectual verbs such as *stop* and *start* (Abusch 2010; Simons 2001).

In his analysis of neg-raising, Gajewski (2007) argues that neg-raising predicates trigger excluded-middle presupposition, and further that it is a soft presupposition. This treatment reconciles the following two facts: (i) the lexical idiosyncrasy about which predicates allow a neg-raising interpretation (Horn 1989) and (ii) the defeasibility of excluded-middle inference associated with neg-raising predicates.¹⁸ The triggering of soft presuppositions is a part of lexical properties of a predicate while the ‘softness’ of soft presuppositions allows defeasibility.

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

$$(83) \quad \llbracket \text{guess} \rrbracket^w = \lambda p_{\langle s, t \rangle} \lambda x_e : [\mathbf{guess}(x, p, w) \vee \mathbf{guess}(x, \neg p, w)]. \mathbf{guess}(x, p, w)$$

With (83), we can derive the SE reading of *John guesses which students will come* from the LF in (84) as will be shown below.

$$(84) \quad X [\text{John guesses which students will come}].$$

Given the semantic contribution of *X*, the interpretation of (84) can be restated as in (85) (As in the preceding examples, we assume that Ann and Bill will come, but Chris will not in *w*).

$$(85) \quad \llbracket X \text{ John guesses which students will come} \rrbracket^w \\ = \llbracket \text{guess} \rrbracket^w (A \wedge B)(j) \wedge \neg \llbracket \text{guess} \rrbracket^w (A \wedge B \wedge C)(j)$$

¹⁸The first fact, the lexical idiosyncrasy of neg-raising predicates, can be witnessed by the contrast between *want* and *desire*. Despite their semantic similarity, *want* is a neg-raiser while *desire* is not, as shown from the following:

- (i) a. John doesn’t want Mary to be around. \Rightarrow John wants Mary not to be around.
- b. John doesn’t desire that Mary was around. \nRightarrow John desires that Mary weren’t around.

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

- (ii) I don’t know if John thinks one way or the other about whether Ann will come, but if John thinks that Ann will come, then we will have to do something about it.

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

Due to the excluded-middle presupposition triggered by *guess*, (85) presupposes that John guesses one way or the other about whether $A \wedge B$ is true, and that he guesses one way or the other about whether $A \wedge B \wedge C$ is true. The presuppositions are formally stated as follows:

$$(86) \quad [\mathbf{guess}(x, A \wedge B, w) \vee \mathbf{guess}(x, \neg[A \wedge B], w)] \\ \wedge [\mathbf{guess}(x, A \wedge B \wedge C, w) \vee \mathbf{guess}(x, \neg[A \wedge B \wedge C], w)]$$

Given these presuppositions, (85) is defined and true if and only if the following holds:

$$(87) \quad \llbracket X [\text{John guesses which students will come}] \rrbracket^w = 1 \\ \text{iff } \mathbf{guess}(j, A \wedge B, w) \wedge \neg \mathbf{guess}(j, A \wedge B \wedge C, w) \wedge (86) \\ \text{iff } \mathbf{guess}(j, A \wedge B, w) \wedge \mathbf{guess}(j, \neg[A \wedge B \wedge C], w) \\ \text{iff } \mathbf{guess}(j, A \wedge B, w) \wedge \mathbf{guess}(j, \neg C, w)$$

This is precisely the SE interpretation of *John guesses which students will come* in our world w . Thus, if the embedding predicate triggers the excluded-middle presupposition as in (83), an LF with the matrix X is predicted to have the SE reading unless the excluded-middle presupposition is suspended.

To wrap up, I have argued that the source of excluded-middle assumptions is the soft-presupposition triggered by the embedding predicate. In section 3.5.3, we will discuss how this analysis fare with the judgments concerning SE readings reported in the literature. Before that, in section 3.5.2.2, I will discuss a prediction the current analysis makes regarding the possibility of SE readings and neg-raising. In section 3.5.2.3, I will discuss how the current analysis can be extended to factive predicates.

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

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

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

It is worth noting, however, that factive predicates are not good test cases to evaluate this prediction since relevant excluded-middle inference for factive predicates concerns the *non-factive* component of the semantics of these predicates (for the reasons discussed in section 3.3.3), and its effect cannot be seen as a neg-raising property of the factive predicate itself. Factivity always disrupts neg-raising. I will discuss the general issue of how to analyze the SE readings of factive predicates in the next subsection.

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

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

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

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

This is in contrast to cognitive predicates, such as *estimate* and *guess* which licenses neg-raising more readily than we see in (88):

- (90) 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.
 (91) 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.

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

3.5.2.3 Factive predicates and neg-raising

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

(92) John doesn't know that Ann came. \nRightarrow John knows that Ann didn't come.

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

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

Given the approach to factive predicates discussed in section 3.3.3, it turns out that they are not problematic for the current analysis of SE. What matters for the derivation of SE readings in the current analysis is not the neg-raising property of the responsive predicate itself, but rather whether the *alternatives* for X give rise to a neg-raising interpretation. In section 3.3.3, I previewed the decomposition analysis to be presented in the next chapter, where a factive predicate is decomposed into its non-factive counterpart and an answerhood operator. According to this analysis, the prejacent and the alternatives for *John knows which students came* would look like the following:

(48) John knows which students came.

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

b. **Alternatives:**

$$\left\{ \lambda w'. \llbracket \text{John believes } [[\text{Ans } w''] \text{ which students came}] \rrbracket^{w'} \mid w'' \in W \right\} \\ = \left\{ \lambda w'. \mathbf{DOX}_j^{w'} \subseteq p \mid p \in \left\{ \begin{array}{c} A, B, C \\ A \wedge B, B \wedge C, C \wedge A \\ A \wedge B \wedge C \end{array} \right\} \right\}$$

Assuming that *believe* in (48b) is associated with an excluded-middle presupposition as in (94), the negation of an alternative which looks like (95) is strengthened into the statement with a narrow scope negation as in (96).

(94) $\mathbf{DOX}_j^w \subseteq p \vee \mathbf{DOX}_j^w \subseteq \neg p$ (The excluded-middle assumption)

(95) $\mathbf{DOX}_j^w \not\subseteq p$ ('John believes p '; the negation of an alternative)

(96) $\mathbf{DOX}_j^w \subseteq \neg p$

Note that the statement in (94) is not contradictory since it does not bear factivity, unlike (93).

3.5.2.4 The deductive reading of emotive factives

In section 3.4 above, I analyzed the behavior of the literal reading of emotive factives based on their non-monotonicity. In this section, I discuss the behavior of the deductive reading of emotive factives. Theiler (2014) argues that deductive readings of emotive factives are monotonic, citing following kind of inferences as valid.

- (97) a. In effect, John is happy that Ann and Bill came.
 \Rightarrow In effect, John is happy that Ann came.
 b. In effect, John was surprised that Ann came.
 \Rightarrow In effect, John was surprised that Ann and Bill came.

If true, the correlation between the literalness/deductiveness and monotonicity is an interesting phenomenon. However, it is not clear if the correlation is empirically robust. It seems to me, at least, that the kind of situations that constitute counterexamples to the parallel inferences in the literal case (e.g., John wanted Bill not to come, and he also wanted Ann to come even more so than he wants Bill not to come) serve as counterexamples to the inferences in (97) as well.

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

- (98) a. John is surprised_{deduc} that p . \sim John is surprised_{lit} to know that p .
 b. John is happy_{deduc} that p . \sim John is happy_{lit} to know that p .

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

- (99) a. John X [t is surprised_{lit} [PRO to X [t know [Ans [which students came]]]]].
 b. John X [t is happy_{lit} [PRO to X [t know [Ans [which students came]]]]].

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

3.5.3 Capturing the SE data: defeasibility and embeddability

Above, I discussed how SE readings are captured as a result of the strengthening of IE readings mediated by an excluded-middle assumption coming either from the context or a lexical presupposition associated with the embedding predicate. In this section, I discuss how the current analysis captures the detailed data concerning the distribution of SE readings, focusing on (i) the defeasibility of SE readings and (ii) whether the SE readings can embed under negation.

3.5.3.1 Defeasibility of SE readings

As illustrated in section 3.5.2.1, if a predicate triggers an excluded-middle presupposition, the current analysis predicts that matrix X-exhaustification yields an SE

reading instead of an IE reading. On the other hand, if a predicate does not have an excluded-middle presupposition, an SE reading would not be possible unless the excluded-middle assumption is provided by the context. In section 3.2.2.1, we saw Groenendijk and Stokhof’s (1984) evidence for the SE reading of *know*, which uses an inference of the following form:

- (8) (i) John knows which students came.
 \Rightarrow (ii) John knows which students didn’t come.

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

$$(100) \quad \llbracket \text{know} \rrbracket^w = \lambda p \lambda x : [p(w) \wedge \underline{\text{DOX}_x^w \subseteq p \vee \text{DOX}_x^w \subseteq \neg p}]. \text{DOX}_x^w \subseteq p$$

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

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

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

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

$$(101) \quad \llbracket \mathcal{A} \rrbracket^w(p) = \begin{cases} 1 & \text{if } p = 1 \\ 0 & \text{otherwise} \end{cases}$$

The basic function of this operator is to locally accommodate the presupposition of its scope. Thus, when this operator scopes immediately above a predicate that triggers an excluded-middle presupposition, the presupposition is effectively canceled (since the excluded-middle presupposition is entailed by the assertion). I submit that this is what happens when the excluded-middle presupposition is suspended. That is, when the context explicitly negates the excluded-middle presupposition, \mathcal{A} is inserted immediately above the prejacent of X , as in the LF in (102).

$$(102) \quad [X [\mathcal{A} [\text{John knows which students came}]]].$$

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

$$\begin{aligned} (103) \quad & \llbracket [X [\mathcal{A} [\text{John knows which students came}]]] \rrbracket^w \\ &= \llbracket \mathcal{A} \rrbracket^w(\llbracket \text{knows} \rrbracket^w(A \wedge B)(j)) \\ &\quad \wedge \neg \llbracket \mathcal{A} \rrbracket^w([\lambda p \lambda x : [\mathbf{DOX}_x^w \subseteq p \vee \mathbf{DOX}_x^w \subseteq \neg p]. \mathbf{DOX}_x^w \subseteq p](A \wedge B \wedge C)(j)) \\ &= 1 \text{ iff } \mathbf{DOX}_j^w \subseteq [A \wedge B] \wedge \mathbf{DOX}_j^w \not\subseteq [A \wedge B \wedge C] \end{aligned}$$

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

3.5.3.2 Accommodation and SE readings under negation

Nevertheless, there is one aspect of [Cremers and Chemla's \(to appear\)](#) experimental result that the current analysis so far cannot capture. In their result, although a majority of responses judged target sentences (such as *John knows which squares are red*) true when paired with pictures that validates their IE readings but invalidate their SE readings (e.g., the picture indicating that John knows that all the red squares are red, and has no idea about some of the non-red squares), there are small but significant¹⁹ rate of responses according to which the target sentences are *false* given the same pictures. This is unexpected in the current analysis so far. The false judgment for these items is expected only under their SE readings, but, as discussed in the previous section, my analysis so far maintains that SE readings are unavailable due to the suspension of the excluded-middle presupposition when the context/picture explicitly negates it.

To address this problem, I claim that there are two strategies to avoid presupposition failure in interpreting a sentence with an excluded-middle soft presupposition in a context that explicitly negates it. One strategy is to suspend the excluded-middle

¹⁹The significance here means that the rate of 'False' responses is significantly higher than that of 'False' responses for the True control, i.e., the items that are true under any reading.

presupposition, or, to insert the \mathcal{A} -operator below X. The other strategy is to insert \mathcal{A} above the X-operator, as in (104), which yields the truth-conditions in (105):

$$(104) \quad [\mathcal{A} [X [\text{John knows which students came}]]]$$

$$(105) \quad \begin{aligned} & \llbracket \mathcal{A} [X [\text{John knows which students came}]] \rrbracket^w \\ &= \llbracket \mathcal{A} \rrbracket^w (\llbracket \text{knows} \rrbracket^w (A \wedge B)(j) \\ & \quad \wedge \neg[\lambda p \lambda x : [\mathbf{DOX}_x^w \subseteq p \vee \mathbf{DOX}_x^w \subseteq \neg p]. \mathbf{DOX}_x^w \subseteq p](A \wedge B \wedge C)(j)) \\ &= \begin{cases} 1 & \text{if } \mathbf{DOX}_j^w \subseteq [A \wedge B] \wedge \mathbf{DOX}_j^w \subseteq \neg[A \wedge B \wedge C] \\ 0 & \text{otherwise} \end{cases} \end{aligned}$$

The interpretation in (105) is effectively an SE reading, and thus it would be false under the situation where John is unopinionated about C. Thus, there are these two strategies to avoid a failure of satisfying the excluded-middle presupposition: to suspend, i.e., to locally accommodate, the excluded-middle presupposition, or to accommodate it above X. Given the relevant situation in (9a) above, the sentence *John knows which students came* is predicted to be true under the former strategy while false under the latter strategy.

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

$$(106) \quad \begin{aligned} & [\textbf{Situation: John has no idea whether Chris came or not.}] \\ & \text{John doesn't think that Chris came.} \end{aligned}$$

The reading under which the sentence is true is especially salient if the auxiliary+negation *doesn't* is stressed. As Gajewski (2007) argues, this reading can be derived by placing \mathcal{A} below the negation as in the LF in (107a). On the other hand, the reading under which the sentence is false can be derived by the attachment of \mathcal{A} above X in (107b).

$$(107) \quad \begin{aligned} & \text{a. Not } [\mathcal{A} [\text{John thinks that Chris came}]] \\ & \text{b. } \mathcal{A} [\text{Not } [\text{John thinks that Chris came}]] \end{aligned}$$

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

Now that we established the possibility of two readings, how can we make sense of the response pattern in Cremers and Chemla's (to appear) experimental result, i.e., that the majority of responses are 'True' while small but significant rate of responses are 'False'? I suggest that the pattern can be explained by the preference for True readings of ambiguous sentences, or the general Principle of Charity. That is, confronted with a task to determine the truth value of *John knows which squares are red*, whose presupposition is unsatisfied in the given situation/picture, participants tend to use the local accommodation strategy, as it accords with the Principle of Charity. However, since the global accommodation strategy is in principle possible

and the Principle of Charity is only a pragmatic preference, we also observe a small rate of ‘False’ response based on the attachment of \mathcal{A} above the X-operator. I have to leave open the question of why the Principle of Charity was overridden in individual ‘False’ responses.²⁰

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

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

John doesn’t know which students came.

- a. [Not [X [\mathcal{A} [John knows which students came]]]]. (False)
- b. [Not [\mathcal{A} [X [John knows which students came]]]]. (True)

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

- (109) a. $\neg[\text{John knows } [A \wedge B] \wedge \neg[\text{John believes } C]]$
 $\Leftrightarrow \neg[\text{John knows } [A \wedge B]] \vee \text{John believes } C$
 b. $\neg[\text{John knows } [A \wedge B] \wedge [\text{John believes } \neg C]]$
 $\Leftrightarrow \neg[\text{John knows } [A \wedge B]] \vee \neg[\text{John believes } \neg C]$

In other words, the first reading is a negation of IE while the second reading is a negation of SE. In the situation in (108), the first reading is false whereas the second reading is true.

Again, the analogy with neg-raising is illustrative. A neg-raising example that is parallel to (108) is the one involving double negation, as in (110). The inner negation corresponds to the negation provided by the obligatory X in (108).

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

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

- a. Not [Not [\mathcal{A} [John thinks that Chris came]]] (False)
- b. Not [\mathcal{A} [Not [John thinks that Chris came]]] (True)

Two LFs corresponding to the ones in (108a) and (108b) are given above. The reading derived from the LF in (110a), i.e., the (most) local accommodation reading, is false.

²⁰What might be informative in this connection is the experimental study on the individual variation on the accommodation strategies by Sudo et al. (2012). They conjecture that a certain minority of speakers simply don’t allow parses with the \mathcal{A} -operator. The participants who responded with ‘False’ to the relevant items in Cremers and Chemla’s (to appear) experiment might also be grouped as lacking the parses with \mathcal{A} . If this is the case, the sentences are simply presupposition-failures for them, and they opted for ‘False’ given the forced choice.

On the other hand, the reading derived from the LF in (110b), i.e., the one with accommodation immediately below the higher negation, is true.

Native speakers report mixed judgments on the truth-value of (108) in the given situation, and this is unsurprising given their mixed judgments about (110). It is also worthwhile to note that, when the negation is stressed in (108), the sentence tends to be judged as true. This is compatible with the observation by Gajewski (2007) that the insertion of \mathcal{A} is associated with a stress on the negation immediately above it. In this view, the LF in (108b) would be associated with a stress on the negation while the one in (108a) would not have a similar phonological consequence since X is phonologically null.

Summarizing section 3.5.3, the possibility of IE readings with predicates that trigger an excluded-middle presupposition (and thus ‘select for’ SE readings by default) is accounted for by a suspension of the soft presupposition. The suspension of a presupposition is formalized in terms of local accommodation of the excluded-middle presupposition below X, using the \mathcal{A} -operator. In addition to locally accommodating the presupposition, we can also accommodate it above X. This accounts for the (dispreferred but available) possibility of deriving an SE reading even in the context that explicitly negates the excluded-middle presupposition (Cremers and Chemla to appear). The same mechanism can be applied to a sentence with negation above X. Two possible readings can be derived depending on the position of \mathcal{A} .

3.5.4 Interim summary

The current theory of exhaustivity of embedded questions accounts for the distribution of WE, IE and SE readings. The empirical generalization stated in section 3.2.2.1 is repeated in the following table:

(111)

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

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

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

One thing that should be noted at this point is that the non-monotonicity

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

3.6 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.

3.6.1 [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:

- (112) [**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, (112a) is felicitous while (112b) is odd. According to [Guerzoni and Sharvit \(2007\)](#), this is due to the speaker factivity triggered by *realize*, i.e., that (112b) presupposes speaker's knowledge of the answer to the embedded question *who came*. That is, the oddness of (112b) arises because the context violates the speaker factivity. In contrast, (112a) 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:

- (113) [**Situation:** The speaker doesn't know who passed the exam.]
- Will John **find out** who passed the exam?
 - #Will it **surprise** John who passed the exam?
- (Guerzoni 2007: 119, adapted)
- (114) [**Situation:** The speaker knows who passed the exam.]
- Will John **find out** who passed the exam?
 - 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 (113), the sentence with *find out*, (113a), is felicitous while the sentence with *surprise*, (113b), is odd. This contrast disappears in (114), where the context validates the speaker factivity.

Guerzoni (2007) claims that speaker factivity automatically leads sentences involving *surprise* with an SE complement into a contradiction. The contradiction arises when speaker factivity is taken together with the quality implicature and the primary scalar implicature (in the sense of Sauerland 2004). For an illustration, let us take the sentence *It surprised John who passed the exam*, and assume that the domain of exam-takers is Ann and Bill. The quality implicature, speaker factivity and primary scalar implicature of this sentence are described below. ($\mathbf{K}(p)$ abbreviates 'the speaker knows that p ' and $\mathbf{S}_x(p)$ abbreviates ' x is surprised that p '.)²¹

- (115) It surprised John who passed the exam. [domain of individuals: Ann and Bill]
- SE Quality Implicature:** $\mathbf{K}(\mathbf{S}_j(A \wedge \neg B) \vee \mathbf{S}_j(\neg A \wedge B) \vee \mathbf{S}_j(A \wedge B))$
 - SE Speaker Factivity:** $\mathbf{K}(A \wedge \neg B) \vee \mathbf{K}(\neg A \wedge B) \vee \mathbf{K}(A \wedge B)$
 - SE Primary Scalar Implicature:** $\neg \mathbf{KS}_j(A \wedge \neg B) \wedge \neg \mathbf{KS}_j(\neg A \wedge B) \wedge \neg \mathbf{KS}_j(A \wedge B)$

The conjunction of (115a) and (115b) results in the following statement in (116) (see Guerzoni 2007 for a proof), which contradicts the statement in (115c).

$$(116) \quad \mathbf{KS}_j(A \wedge \neg B) \vee \mathbf{KS}_j(\neg A \wedge B) \vee \mathbf{KS}_j(A \wedge B)$$

Here, the primary scalar implicature arises as the result of neo-Gricean quantity implicature with the following set of alternatives.²²

²¹In Guerzoni's (2007) analysis, generally, the quality implicature, speaker factivity and primary scalar implicature of a sentence of the form *It surprised x Q* under its SE reading can be stated as follows:

- It surprised x Q.
 - Quality Implicature:** $\mathbf{K}(\exists p[\exists w[p = A_{SE}(Q)(w)] \wedge \mathbf{S}_x(p)])$
 - Speaker Factivity:** $\exists p[\exists w[p = A_{SE}(Q)(w)] \wedge \mathbf{K}(p)]$
 - Primary Scalar Implicature:** $\forall p[\exists w[p = A_{SE}(Q)(w)] \rightarrow \neg \mathbf{K}(\mathbf{S}_x(p))]$

²²These alternatives are stipulated by Guerzoni, but the fact that (116) is contradictory with the primary scalar implicature is preserved even if we choose the following set of alternatives based on WE answers.

- (117) 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 (115), 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:

- (118) It surprised John who passed the exam. [domain of individuals: Ann and Bill]
 a. **WE Quality Implicature:** $K(S_j(A) \vee S_j(B) \vee S_j(A \wedge B))$
 b. **WE Speaker Factivity:** $K(A) \vee K(B) \vee K(A \wedge B)$
 c. **WE Primary Scalar Implicature:** $\neg K S_j(A) \wedge \neg K S_j(B) \wedge \neg K S_j(A \wedge B)$

The consistency of the three statements in (118) can be seen by the fact that the conjunction of (118a) and (118b) does not entail the following, assuming that *A* and *B* are logically independent.

- (119) $K(S_j(A)) \vee K(S_j(B)) \vee K(S_j(A \vee B))$

Stated in more general terms, Guerzoni's (2007) analysis makes use of the following logical fact: a conjunction of (120-i) and (120-ii) entails the proposition where the *K*-operator in (120-i) is distributed over the two disjuncts, as in (121), if the operator *O* is veridical, i.e., (120-iii), and that propositions *p* and *q* are mutually exclusive, i.e., (120-iv).

- | | | |
|-------|--------------------------------------|---|
| (120) | i. $K(O(p) \vee O(q))$ | [Quality Implicature] |
| | ii. $K(p) \vee K(q)$ | [Speaker factivity] |
| | iii. $\forall p[O(p) \rightarrow p]$ | [Veridicality of <i>O</i>] |
| | iv. $p \wedge q = \emptyset$ | [<i>p</i> and <i>q</i> are mutually exclusive] |

- (121) **Conclusion from (120i-iv):** $K(O(p)) \vee K(O(q))$

The proposition in (121) contradicts the proposition in (122), which corresponds to the primary scalar implicature of the sentence that has (120-i) as its quality implicature.

- (122) $\neg K(O(p)) \wedge \neg K(O(p))$ [Primary Scalar Implicature]

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

-
- (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.

- (123) a. ??John is surprised by whether Mary drank coffee.
 b. ??John is surprised by whether Mary drank [coffee]_F or [tea]_F

This fact is interesting in its own right, and it would certainly be desirable if the impossibility of SE readings under emotive factives and the observations in (123) are given a unified explanation. However, in this chapter, I will focus on the constraint on exhaustivity of embedded questions and leave the issue illustrated in (123) for a future research. See [Sæbø \(2007\)](#) and [Herbsttritt \(2014\)](#) 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.

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

Although the contrast does exist, I suspect that it can in large part be explained away as the result of another less controversial presupposition of emotive factives, namely that the subject knows the correct answer to the complement. That is, the oddness of (113b) 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.

- (124) 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.

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

One might argue that what is happening in (124-125) 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 (124-125) still seem to require WE readings of the complements.

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

(126) It surprised John who was the winner.

One possible response to this issue is to say that the mechanism that determines whether the interpretation of an embedded question is SE or WE (or IE) is not sensitive to the semantic contributions of particular embedded questions except for the SE/WE(/IE)-ness (ie., the choice of an answerhood operator in Guerzoni's (2007) implementation). That is, what is crucial is that SE readings *necessarily* result in contradiction regardless of the choice of specific words in the complement. This seems to be in line with Gajewski's (2002) formulation of the relationship between ungrammaticality and contradiction/analyticity in natural language. However, it is not clear how the details of such an analysis can be worked out. Contradictions that lead to ungrammaticality in natural language according to Gajewski (2002) are those based on *logical* vocabularies in the sentence, but (126) 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:

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

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

In the above example, although *know* does not trigger speaker factivity, the first sentence explicitly states the speaker's knowledge of the answer to the embedded question. Since *know* is a veridical predicate, we predict a contradiction if the second sentence is interpreted with an SE reading. Thus, Guerzoni (2007) would predict that the second sentence in (127) 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*.²³ I will start with *realize*. Guerzoni and Sharvit (2007) give the following example to illustrate the claim that *realize* selects for a WE reading.

²³Guerzoni (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 chapter. 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.

- (128) #John didn't realize which students came because he didn't realize that Chris didn't come.

The *because*-clause above would be felicitous 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 (128) with the *because*-clause specifying John's false belief sounds felicitous:

- (129) John didn't realize which students came because he incorrectly thinks that Chris came.

Note that (129) can be true either under an SE or IE reading. Taken together with (128), 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*.

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

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 chapter, this behavior of *realize* can be accounted for by analyzing the predicate as a (Strawson-)monotonic predicate that lacks an excluded-middle presupposition. Strawson-monotonicity is in fact plausible for *realize* since the assertion of *x realizes that p* arguably consists of a monotonic doxastic attitude. Also, assuming that the non-factive component of *realize* is 'come to believe', the lack of an excluded-middle presupposition is expected. This is so since the the following 'pseudo' neg-raising inference is clearly invalid while it is predicted to be valid if the non-factive component of *realize* is a neg-raiser.

- (131) John didn't expect Chris to come.
⇒ John came to believe that Chris didn't come.

It is a task for future research to investigate the connection between it and the evidence for speaker factivity of *realize*, as illustrated in (112) 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 dissertation, 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:

- (132) $\llbracket [\text{who came}] [\{\text{mostly}/100\% \text{ correctly}\} [2 [\text{John predicted } p_2]]] \rrbracket$
↑ (Interrogative Raising)

Assuming that *100% correctly* is a quantifier over propositions having the denotation in (133), the LF in (132) is predicted to have the semantic value in (134).²⁴

$$(133) \quad \llbracket 100\% \text{ correctly} \rrbracket = \lambda P_{\langle st, t \rangle} \lambda Q_{\langle s, st \rangle} \lambda w. \forall p [Q(p) \wedge p(w)] \rightarrow P(p)]$$

$$(134) \quad \llbracket (132) \rrbracket^w = 1 \text{ iff } \forall p [\llbracket p \in \llbracket \text{who came} \rrbracket^w \wedge p(w) \rrbracket \rightarrow \llbracket \text{predicted} \rrbracket^w(p)(j)]$$

This semantics correctly predicts that (132) only talks about John's predictions about true answers to *who came*, and says nothing about false answers and false predictions. That is, (132) gives rise to a WE readings rather than IE or SE readings.

3.6.2 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 suggestion by Chierchia et al. (2012). In their grammatical analysis of scalar implicatures, Chierchia et al. (2012) account for the fact that a scalar implicature does not arise with scalar items in Downward Entailing (DE) context based on STRONGEST MEANING HYPOTHESIS (SMH; Dalrymple et al. 1998), which is defined as follows:

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

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

Arguing for a (Strawson) downward-monotonic semantics for *surprise*, Nicolae (2013) accounts for the lack of SE readings for *surprise* in a similar way. Since inserting EXH under *surprise* would lead to an LF whose assertion is logically

²⁴The definition in (133) 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.

weaker than that of the LF without EXH, SMH predicts that *surprise* lacks an SE reading.

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

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

(136) **IE in DE environments**

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

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

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

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

- a. John doesn't know *some* of the students because he knows all of them.
- b. I doubt that John knows *some* of the students because I think he knows all of them.

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

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

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

The contrast between (136) and (137-138) suggests that whatever the constraint on IE readings is of different nature from the global constraint governing scalar implicature of *some* and *or*. In the current analysis, the locality of the constraint on IE readings is formulated in terms of the restriction that X always scopes at VP, as discussed in section 3.5.4.

3.7 Summary

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

The strengthening analysis of SE is supported by a correlation between the tendency to license neg-raising and the tendency to allow SE among question-embedding predicates. Furthermore, the proposed perspective on SE readings as being parasitic on IE readings is in line with [Cremers and Chemla's](#) (to appear) report on the Response Time of truth-value judgment tasks for the two readings: IE readings are accessed faster than SE readings. If SE readings are derived from IE readings, as proposed in this chapter, 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.

Chapter 4

Analyzing veridicality and factivity

4.1 ‘Decomposing’ responsive predicates

The compositional semantics of question-embedding sentences proposed in the previous chapter makes use of the answerhood operator in (1) to semantically combine a question-denotation with a proposition-embedding attitude predicate.

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

As discussed briefly in the previous chapter, treating (1) as a syntactically free-standing operator forces us to adopt *proposition-taking* denotations for responsive predicates, which is in conflict with the view advocated in chapter 2 that responsive predicates are semantically question-taking. In this chapter, I propose an alternative formulation in which responsive predicates themselves are ‘decomposed’ into a proposition-taking predicate meaning and the answerhood operator. For example, *know* is decomposed into ‘believe’ + the answerhood operator. This way, the proposal of chapter 2 is reconciled with the compositional semantics using an answerhood operator. A responsive predicate itself selects for a question and internally involves the semantics of the answerhood operator.

The virtue of the decompositional analysis is not only that it makes the proposal of chapter 2 compatible with the compositional semantics assumed in chapter 3. It enables us to address two remaining problems in the semantics of responsive predicates in straightforward ways: (i) the problem with exhaustification above factive predicates (discussed but left open in the previous chapter) and (ii) the problem of capturing the variability in veridicality.

In section 4.2, I will show that the decompositional picture suggested above enables an analysis of factivity as a limiting case of the existential presupposition associated with the complements of responsive predicates in general. The analysis is implemented with the refined version of the answerhood operator by Dayal (1996), and it will be shown that this analysis leads to a solution to the problem of exhaustification above factive predicates.

Up to this point, the decompositional analysis will be only applied to factive predicates. The task of extending the analysis to non-factive predicates is taken up in sections 4.3 and 4.4. After reviewing the empirical generalizations about

veridicality and factivity of responsive predicates in section 4.3, I will show how the decomposition analysis can be applied to three representative classes of non-factive predicates: the opinion predicates (e.g., *be certain*, *be opinionated*) (section 4.4.1), the communication predicates (e.g., *tell*, *report*) (section 4.4.2) and the *agree*-type predicates (e.g., *agree*, *concur*) (section 4.4.3). After the analysis of individual non-factive predicates, in section 4.4.4, I will discuss more generally about how the current analysis models the distinction between factive and non-factive predicates and veridical and non-veridical predicates. Also, in the same section, it will be argued that Spector and Egré’s generalization—the generalization that a responsive predicate is veridical with respect to interrogative-embedding iff it is veridical with respect to declarative-embedding—straightforwardly falls out from the analysis once declarative complements are analyzed as singleton questions, as advocated in chapter 2.

The notion of ‘decomposition’ adopted in the analysis is revisited in section 4.5. There, I will discuss two ways of fleshing out the notion of the decomposition: the syntactic decomposition of responsive predicates and the encoding of relevant operator-meanings into the lexical semantics of responsive predicates. Finally, the proposed analysis is compared to two lines of prominent existing analyses of the veridicality of responsive predicates, i.e., Spector and Egré (2015) and Theiler (2014); Roelofsen et al. (2014).

4.2 Analyzing factivity

In chapter 2, I proposed that the basic meaning of responsive predicates is question-taking, and that declarative complements of responsive predicates are analyzed as singleton questions. Compositionally, this is done by shifting/coercing the proposition denoted by a declarative complement into the singleton set consisting of the proposition. Schematically, a responsive predicate V + a declarative complement $CP_{[-int]}$ is interpreted in the following way, with the proposition-to-singleton type-shifter ld :

$$(2) \quad \llbracket V \llbracket ld \ CP_{[-int]} \rrbracket \rrbracket^w = \llbracket V \rrbracket^w (\{ \llbracket CP_{[-int]} \rrbracket^w \})$$

$$(3) \quad \llbracket ld \rrbracket^w = \lambda p [\lambda q. q = p]$$

In this section, I argue that this analysis of responsive predicates opens up an analytical possibility in which factivity is a *limiting case* of the existential presupposition of questions embedded under veridical predicates. That is, if it is presupposed that the proposition-set denotation of an embedded question contains a true answer (Dayal 1996), this presupposition would boil down to factivity in a declarative-embedding case since it would require that the unique proposition in the singleton question be true. The analysis of factivity along these lines will be discussed in section 4.2.1. As I detail in section 4.2.2, this view enables a solution to the problem with exhaustification above factive predicates. Importantly, the resulting system will not make an incorrect prediction that non-veridical predicates, such as *agree*

and *be certain*, are factive. The treatment of these non-veridical predicates will be taken up in section 4.3.

4.2.1 Factivity as a limiting case of an existential presupposition

4.2.1.1 Dayal (1996): Embedded questions as definite descriptions

My analysis of factivity will be based on Dayal's (1996) analysis of the existential presupposition of interrogative complements. In this section, I will introduce empirical observations about presuppositions of interrogative clauses, and discuss how they are accounted for by Dayal (1996), who analyzes embedded questions as a kind of definite descriptions.

In the semantic literature, interrogative clauses have been associated with an existential presupposition requiring that the question denoted by the clause have at least one true answer (e.g., Katz and Postal 1964; Karttunen and Peters 1979; Comorovski 1989; Dayal 1996). For example, the following sentence presupposes that there is some student who came to the party.¹

- (4) John knows which students came to the party.

Partly in order to derive this existential presupposition of interrogative complements, Dayal (1996) assimilates the semantics of embedded questions to that of definite descriptions. That is, she argues that an interrogative clause refers to a unique strongest true answer, presupposing that there be such an answer. Compositionally, this is done by positing an answerhood operator that is a counterpart of the definite determiner in the domain of propositions. This operator applies to a set of propositions and returns the strongest true member in the set, presupposing that there be such a member. This operator—which we call Ans_d —is defined as follows:²

$$(5) \quad \llbracket \text{Ans}_d \rrbracket^w := \lambda w' \lambda Q_{\langle st, t \rangle} \cdot \begin{cases} \iota p \in Q \left[\begin{array}{c} p(w') \wedge \\ \forall p' \in Q [p'(w') \rightarrow p \subseteq p'] \end{array} \right] & \text{if } \exists! p \in Q \left[\begin{array}{c} p(w') \wedge \\ \forall p' \in Q [p'(w') \rightarrow p \subseteq p'] \end{array} \right] \\ \text{undefined} & \text{otherwise} \end{cases}$$

In Dayal's (1996) analysis, the answerhood operator has two roles. One is to resolve the type-mismatch between embedded questions and responsive predicates, where the latter is analyzed to be proposition-taking as in the standard Hintikka analysis. The other is to encode the existential and uniqueness presupposition of interrogative complements. Let me illustrate these two roles using the example in (4). The embedded question and the responsive predicate *know* is combined using Ans_d as a type-shifter. That is, (6) below is the LF for (4). (I omit X here for expository purposes.)

- (6) John knows $\llbracket \text{Ans}_d w \rrbracket$ [which students came to the party].

¹Below, I will dispute the empirical status of this claim under non-veridical predicates like *be certain*.

² Ans_d is defined so that it takes an explicit world argument as its first argument. This is to let X bind the world-argument position as in the previous chapter.

Since *which students* is semantically number-neutral (see section 1.3.2), the denotation of the interrogative complement would be the set in (7) (assuming that the domain of individuals consists of a , b and c). We abbreviate this as (8).

$$(7) \quad \llbracket \text{which students came to the party} \rrbracket^w \\ = \left\{ \begin{array}{l} \lambda w.\text{came}(a, w), \lambda w.\text{came}(b, w), \lambda w.\text{came}(c, w), \\ \lambda w.\text{came}^*(a \oplus b, w), \lambda w.\text{came}^*(b \oplus c, w), \lambda w.\text{came}^*(c \oplus a, w), \\ \lambda w.\text{came}^*(a \oplus b \oplus c, w) \end{array} \right\}$$

$$(8) \quad \{A, B, C, A \wedge B, B \wedge C, C \wedge A, A \wedge B \wedge C\}$$

Suppose that a and b came to the party, but c didn't in the evaluation world w . Then, the result of applying Ans_d to (7) would be the proposition that a and b came to the party since it would be the strongest true member in (7). That is, we have the following:

$$(9) \quad \llbracket [\text{Ans}_d w] [\text{which students came to the party}] \rrbracket^w = A \wedge B$$

This proposition can then be combined with the standard denotation of *know*. Thus, we derive the WEAKLY EXHAUSTIVE reading of (4):

$$(10) \quad \llbracket \text{John knows } [\text{Ans}_d w] [\text{which students came to the party}] \rrbracket^w = 1 \\ \text{iff } \text{DOX}_j^w \subseteq A \wedge B$$

As we have seen in the previous chapter, this reading can be strengthened into intermediately and strongly exhaustive readings given a suitable theory of strengthening. Thus, Ans_d here functions as a type-shifter that resolves the type-mismatch between a responsive predicate and an interrogative complement, deriving the weakly-exhaustive reading of question-embedding sentences.

In addition, Ans_d encodes the existential and uniqueness presuppositions. Thus, in a situation where no student came to the party, the existential presupposition of Ans_d would not be satisfied since there would be no true member in (7). The existential presupposition of interrogative clauses discussed above is captured this way in Dayal's system. What is the uniqueness presupposition of Ans_d supposed to capture? It captures the uniqueness presupposition of singular *which*-questions. The presupposition is exemplified in the following sentence.

$$(11) \quad \text{John knows which student came to the party.}$$

The sentence is odd if there is more than one student who came to the party, suggesting that it presupposes that exactly one student did. The uniqueness presupposition encoded in Ans_d captures this presupposition in the following way. Since singular *which*-phrases range over singular individuals, the denotation of *which student came* would look like the following (again, assuming that the domain of students consists of a , b and c):

$$(12) \quad \llbracket \text{which student came to the party} \rrbracket^w \\ = \{ \lambda w.\text{came}(a, w), \lambda w.\text{came}(b, w), \lambda w.\text{came}(c, w) \} \\ = \{A, B, C\}$$

When more than one students came, more than one propositions in this set would be true. In such a case, there wouldn't be a unique strongest proposition among the true ones since the propositions in (12) are logically independent from each other. This means that the uniqueness presupposition of Ans_d would be satisfied only if only one of (12) is true, i.e., only one student came. Hence, the uniqueness presupposition observed in (11) is captured by the uniqueness presupposition encoded in Ans_d . If the *wh*-phrase is number neutral as in (7), the uniqueness presupposition would be satisfied if the existential presupposition is satisfied. This is so because the conjunction of all true 'atomic' propositions are also in a number-neutral question denotation, and this conjunctive answer would serve as the unique strongest true member that satisfies the uniqueness presupposition of Ans_d . This is in line with the empirical observation that *who*-questions and plural *which*-questions, both of which are number-neutral, do not presuppose uniqueness. That is, the following example would be true in situations where there are multiple people/students who came to the party.

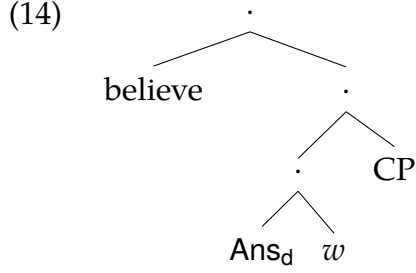
(13) John knows { who/which students } came to the party.

Thus, Dayal's (1996) analysis using the Ans_d -operator correctly captures the presuppositions of interrogative complements. Note, however, that the analysis assumes a different approach to declarative-embedding than the one advocated in chapter 2. Dayal (1996) follows the standard assumption that responsive predicates have proposition-taking denotations and merge with declarative complements directly. In the next section, I will reformulate Dayal's (1996) analysis in the approach that treats declarative complements as a singleton case of embedded questions—the approach advocated in chapter 2. The reformulation is not just for the sake of making Dayal's (1996) analysis compatible with the current view. Rather, the reformulation will enable us to address the two remaining problems mentioned in the beginning of this chapter in a way that would be otherwise impossible.

4.2.1.2 Ans_d with declarative complements

To reformulate Dayal's (1996) analysis within the current approach, I propose that responsive predicates are 'decomposed into' two components: a higher 'core' predicate and Ans_d . Although I will illustrate this analysis employing an LF decomposition in this section for expository purposes, there are different ways to theoretically flesh out the same idea. These include a formulation that encodes Ans_d in the lexical semantics of embedding predicates, in addition to the formulation in terms of an LF decomposition. These different formulations are discussed in section 4.5.

Under the LF decomposition analysis, *know*, for example, is decomposed into the following structure (Note that the world argument to Ans_d is eventually bound by the obligatory exhaustive operator X):



That is, this structure is spelled out as *know*+CP. Assuming the proposition-taking Hintikka analysis of *believe*, this means that *know*+CP has the following semantic value.

$$(15) \quad \llbracket \text{believe} \llbracket [\text{Ans}_d \ w] \ \text{CP} \rrbracket^w = \\ = \lambda x. \begin{cases} \text{DOX}_x^w \subseteq \llbracket \text{Ans}_d \rrbracket^w(w)(\llbracket \text{CP} \rrbracket^w) & \text{if } \llbracket \text{Ans}_d \rrbracket^w(w)(\llbracket \text{CP} \rrbracket^w) \text{ is defined} \\ \text{undefined} & \text{otherwise} \end{cases}$$

In other words, *x* *knows* *Q* presupposes that Ans_d of *Q* is defined, and asserts that *x* believes the Ans_d of *Q*. Since *know* is decomposed as in (14) regardless of the complement type, the analysis in (15) also applies to declarative-embedding sentences.³

What is most relevant for us in the current context is the presupposition of (15). The presupposition of Ans_d is inherited by (15) since the result of a Functional Application is undefined if either the function or the argument in the application is undefined (see section 1.3.1.4). Therefore, *know* presupposes that its question argument has a unique (strongest) true answer. Combined with the analysis of declarative complements as singleton questions, this analysis achieves something that is not achieved in Dayal's (1996) original analysis, namely, an analysis of factivity.

In the analysis of *know* in (15), factivity is derived as a limiting case of an existential presupposition. Declarative complements are singleton questions. Therefore, the existential and uniqueness presuppositions in the case of declarative complements boil down to the presupposition that the unique answer to the singleton question is true. This is illustrated using the declarative complement *that Ann came to the party* in the following. (The proposition that Ann came to the party is abbreviated as *A*.)

$$(16) \quad \llbracket \text{John X 1 believes} \llbracket [\text{Ans}_d \ w_1] \llbracket \text{Id} \llbracket \text{that Ann came to the party} \rrbracket \rrbracket^w \rrbracket^w \text{ is defined} \\ \Leftrightarrow \llbracket \text{Ans}_d \rrbracket^w(w)(\{A\}) \text{ is defined}^4$$

³For the purpose of the current dissertation, I assume that the so-called Gettier problem (Gettier 1963) is given an independent solution, and the conditions required for the 'de-Gettierization' can be plugged in to the denotation of *believe* used in the decomposition of *know*. In this sense, *believe* in the decomposition of *know* is a place-holder for the non-factive counterpart of *know*, which might have more refined semantics than *believe*. One problem that arises in this connection is that, adding further conditions to the truth-conditions of 'believe'-clauses will make the negations of such clauses weaker, and hence will weaken the predicted meanings derived by X. Is such weakened readings empirically adequate for the IE reading of *know*? The problem has to be empirically investigated with possible candidates for the further conditions on 'believe'. I have to leave this issue for future research.

⁴This step assumes that $\llbracket X \llbracket 1 \ \varphi(w_1) \rrbracket^w \rrbracket^w$ is defined iff $\llbracket \varphi(w) \rrbracket^w$ is defined (where $\varphi(w)$ is an LF structure containing a free variable w_1). In other words, X projects the presupposition of its

$$\begin{aligned} &\Leftrightarrow \exists! p \in \{A\} [p(w) \wedge \forall p' \in Q [p'(w) \rightarrow p \subseteq p']] \\ &\Leftrightarrow A(w) \end{aligned}$$

Above, the existential presupposition states that the singleton question $\{A\}$ contains a true answer, which just means that A is true. The uniqueness presupposition is trivially satisfied if the existential presupposition is satisfied. As we will see in the next section, this analysis of factivity leads to a solution to the problem with exhaustification above factive predicates.

One might wonder at this point whether the current analysis *overgenerates* factivity. If responsive predicates in general are decomposed in a way similar to (15), we would predict that all responsive predicates are factive. This is clearly a wrong prediction since responsive predicates such as *be certain*, *agree* and *tell* are non-factive. However, the analysis does not claim that responsive predicates in general have the lexical semantics as in (15). In fact, as I will discuss in section 4.3, responsive predicates differ in the ways in which they ‘embed’ Ans_d in their lexical semantics or compositional structure, and this difference leads to the difference in factivity. In particular, we will see that factivity is predicted only if Ans_d is interpreted with respect to the evaluation world (i.e., the higher predicate is extensional) while it is not if Ans_d can be interpreted at a non-evaluation world (i.e., the higher predicate is intensional).

This point relates to another important feature of the current analysis. The current analysis maintains that factivity is a subcase of an existential presupposition. Then, a prediction would be that any responsive predicate that licenses an existential presupposition of its interrogative complement should be factive:

(17) **Prediction: Existential presupposition entails factivity**

Any responsive predicate that licenses an existential presupposition of its interrogative complement is factive with respect to its declarative complement.

Equivalently, if a responsive predicate is non-factive, then it should not license an existential presupposition. I claim that this prediction is borne out, pace the common empirical assumption that embedded questions *in general* license existential presuppositions. When the embedding predicate is non-factive, as in the case of *be certain*, *agree* and *tell*, we see that embedded questions are not associated with existential presuppositions. This can be seen by the consistency of the utterances in (18-20), where the existence of a true answer to the relevant embedded question is negated. This is contrasted with parallel examples with *know* in (21), which are odd in the same context.

- (18) Unfortunately, none of our students passed the test, but John is mistaken that someone did.
- a. In fact, he **is certain** about which students passed the test.
 - b. However, he **is not certain** about which students passed the test.

prejacent. This assumption can be derived from the denotation of X (given in (23) below) and the assumption that the presupposition triggered in the restrictor of a quantified sentence projects at least existentially.

- (19) Unfortunately, none of our students passed the test, but John is mistaken that someone did. Mary is also mistaken.
 - a. In fact, she **agrees** with John on which students passed the test.
 - b. However, she **does not agree** with John on which students passed the test.
- (20) Unfortunately, none of our students passed the test, but John is mistaken that Ann and Bill did.
 - a. To make matters worse, John **told** Mary which students passed the test (although he was of course wrong).
 - b. It was a good thing that John didn't **tell** Mary which students passed the test.
- (21) Unfortunately, none of our students passed the test.
 - a. #In fact, John **knows** which students passed the test.
 - b. #However, John **does not know** which students passed the test.

Two remarks are in order regarding the above data. First, the judgment concerning *tell* in (20) is subtle, and this relates to the controversy in the literature over the veridicality of communication predicates (e.g., [Karttunen 1977](#); [Groenendijk and Stokhof 1984](#); [Spector and Egré 2015](#)). Also, a reader might have noticed that the sentences in (18-20) still involve existential presuppositions in a way different from (21). Roughly, the existential presupposition in these sentences is not attributed to the common ground, but to the attitude holder: The sentences presuppose that the attitude holder believes that the embedded question has a true answer. In section 4.3, these issues are discussed in relation to the general treatment of non-veridical predicates in the current analysis.

I will conclude this section by stating that the analysis of factivity as a limiting case of factivity makes an empirically correct prediction in (17), which has not been made possible otherwise, i.e., that all responsive predicates that license an existential presupposition of its interrogative complement are factive. Section 4.3 discusses how the current analysis can be extended to capture a related generalization that has been proposed by [Spector and Egré \(2015\)](#), i.e., any responsive predicate is veridical with respect to its interrogative complement iff it is veridical with respect to its declarative complement. Before that, however, we will discuss another virtue of the current analysis of factivity, i.e., that it enables a solution to the problem with exhaustification above factive predicates.

4.2.2 Solution to the problem with exhaustification above factives

The analysis of factivity presented in the previous section provides a solution to the problem with exhaustification above factive predicates. The problem is that exhaustification above a factive predicate turns out to be always vacuous (or run into a presupposition failure), instead of empirically attested intermediately-exhaustive (IE) readings. I will illustrate this using example (22) below.

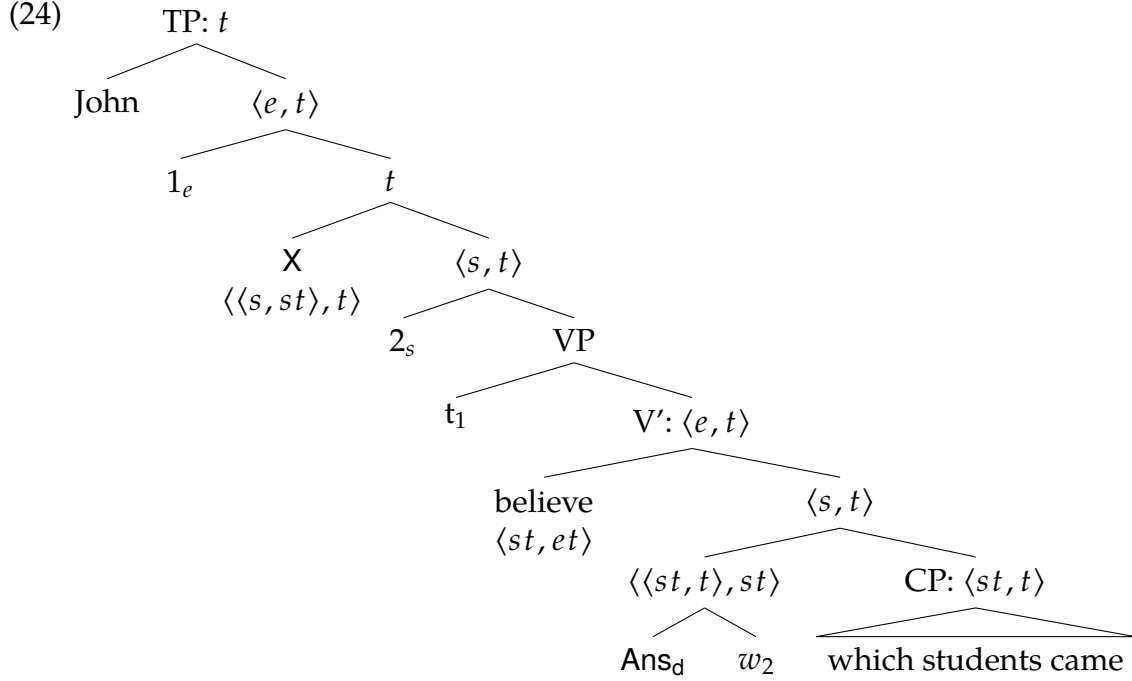
(22) John₁ [X [t₁ knows which students came]].

As stated in chapter 3, I follow [Klinedinst and Rothschild \(2011\)](#) in treating the prejacent for X as the *actual* weakly-exhaustive (WE) reading of the clause while the alternatives as the *possible* WE readings. Thus, example (22) is true iff John knows the actual WE answer, and does not know the possible WE answers that are stronger than the actual WE answer. The problem, however, is that all answers that are stronger than the actual WE answer are false, and so the factivity of *know* would not be satisfied for such answers. Thus, the exhaustification in (22) would be either vacuous or presupposition failure, depending on the definition of the presupposition-projection property of X. What we want as the alternatives for (22) are propositions of the form ‘John *believes* *p*’ rather than ‘John *knows* *p*’.

This problem can be given a solution based on the current analysis of factivity. Here’s the solution in a nutshell: Since *know* is decomposed into *believe* and Ans_d , the prejacent of X in (22) would be ‘John believes the *true* Ans_d of who came’. On the other hand, in the current formulation, treating alternatives for an interrogative complement as its possible answers ([Klinedinst and Rothschild 2011](#)) means that the alternatives for (22) would be propositions of the form ‘John believes the Ans_d -in-*w* of who came’, where *w* is some possible world. To makes the example more concrete, suppose only Ann and Bill came in the actual world. Then, the prejacent of (22) would be ‘John believes that Ann and Bill came’ while the alternatives are propositions of the form ‘John believes *p*’, where *p* is any answer to *who came*. What is crucial here is that neither the prejacent nor the alternatives involves factivity, i.e., presupposes the respective Ans_d -propositions to be true. This is so because factivity arises only when Ans_d is evaluated in the actual world and is applied to a singleton question. In fact, [Klinedinst and Rothschild \(2011: 17\)](#) briefly mentions a possibility of accounting for IE of factives in terms of lexical decomposition, but the possibility is not explored in detail. The current analysis can be seen as an explicit implementation of this idea.

The analysis is formalized as follows. As stated above, the current analysis of exhaustification assumes that the prejacent of exhaustification is based on the actual WE answer while the alternatives are based on the set of possible WE answers. In chapter 3, following [Klinedinst and Rothschild \(2011\)](#), this idea is formalized by treating X as a quantifier binding the world argument of the answerhood operator. That is, X has the definition as in (23) and binds the world pronoun in the sister of Ans_d as in the LF in (24).

$$(23) \quad \llbracket X \rrbracket^w = \lambda \mathcal{P}_{\langle s, st \rangle}. \mathcal{P}(w)(w) \wedge \forall w'' \left[\begin{array}{c} \{w' \mid \mathcal{P}(w')(w'')\} \subset \{w' \mid \mathcal{P}(w')(w)\} \\ \rightarrow \neg \mathcal{P}(w)(w'') \end{array} \right]$$



The denotations of the matrix VP and the two subsequent compositional steps in this structure would look like the following:

$$(25) \quad \llbracket \text{VP} \rrbracket^{w,g} \Leftrightarrow \llbracket \text{believe} \rrbracket^w (\llbracket \text{Ans}_d \rrbracket^w (g(2)) (\llbracket \text{which students came} \rrbracket^w)) (g(1))$$

$$(26) \quad \llbracket [2 \text{ VP}] \rrbracket^{w,g} \Leftrightarrow \lambda w'. \llbracket \text{believe} \rrbracket^w (\llbracket \text{Ans}_d \rrbracket^w (w') (\llbracket \text{which students came} \rrbracket^w)) (g(1))$$

$$(27) \quad \llbracket [X [2 \text{ VP}]] \rrbracket^{w,g} \\ \Leftrightarrow \llbracket X \rrbracket^w (\lambda w \lambda w'. \llbracket \text{believe} \rrbracket^w (\llbracket \text{Ans}_d \rrbracket^w (w') (\llbracket \text{which students came} \rrbracket^w)) (g(1)))$$

In (27), what corresponds to the ‘prejacent’ and the ‘alternatives’ for X would be the following (where w is the evaluation world for X):

$$(28) \quad \textbf{Prejacent} \quad \lambda w'. \llbracket \text{believe} \rrbracket^{w'} (\llbracket \text{Ans}_d \rrbracket^{w'} (w) (\llbracket \text{which students came} \rrbracket^{w'})) (g(1))$$

Alternatives

$$\{ \lambda w'. \llbracket \text{believe} \rrbracket^{w'} (\llbracket \text{Ans}_d \rrbracket^{w'} (w'') (\llbracket \text{which students came} \rrbracket^{w'})) (g(1)) \mid w'' \in W \}$$

Crucially, neither the prejacent nor the alternatives in (28) involves factivity. The prejacent presupposes that the existence presupposition associated with *which students came*—that some student came—is met in w . Each alternative presupposes that some student came in (respective) world w'' . Thus, when the existential presupposition is met (i.e., some students came) in the actual world, the prejacent is simply ‘John believes the true most informative answer to which students came’ and the alternatives include the set of propositions of the form ‘John believes p ’, where p is any (defined) answer to *which students came*. Hence, neither the prejacent nor the set of alternatives involves factivity, and thus the negation by X can be straightforwardly applied. This solution generalizes to other factive predicates, such as *discover* and *show* that are decomposed into their non-factive meanings and Ans_d . The non-factive component for *discover* would be roughly ‘begin to believe’ and that for *show* would be roughly ‘communicate with evidence’.

To sum up, the current analysis of factivity provides a way to solve the problem with exhaustification above factive predicates. Once we flesh out [Klinedinst and Rothschild's \(2011\)](#) idea that alternatives for an interrogative clause are its possible answers, it turns out that the alternatives of a clause containing a factive predicate do not themselves trigger factivity. In the current analysis, factivity arises when Ans_d is evaluated with respect to the actual world and the complement of Ans_d is a singleton. This does not happen in alternatives for a question-embedding sentence, and each alternative would be a non-factive proposition (e.g., 'John believes the Ans_d -answer of *who came*').

4.3 Empirical generalizations about veridicality and factivity

Above, I briefly discussed how the current analysis avoids the problematic prediction that all responsive predicates are factive. As we will see below, the issue of how to deal with non-factive predicates relates to the general issue of how to model the distinction between factive and non-factive responsive predicates as well as the distinction between veridical and non-veridical responsive predicates. In the rest of this chapter, I will propose an analysis of the factive/non-factive and veridical/non-veridical distinction within the current general approach to the semantics of responsive predicates. Here, veridicality of responsive predicates is defined as follows:

(29) **Veridicality with respect to interrogative-embedding**

A responsive predicate V is VERIDICAL WITH RESPECT TO INTERROGATIVE-EMBEDDING, $x \text{ Vs } Q$, iff $x \text{ Vs } Q \Rightarrow \text{For some } p \text{ that is a true answer to } Q, x \text{ Vs } p$.

For example, *know* is veridical with respect to interrogative-embedding because *John knows who came* is true only if John knows some true answer to the question *who came*. On the other hand, *be certain* is not veridical with respect to interrogative-embedding since *John is certain (about) who came* is true even if John is not certain about any true answer to *who came*. In what follows, I sometimes simply call a predicate VERIDICAL when it satisfies the property in (29).

In the current literature, there is disagreement over which responsive predicates are veridical with respect to interrogative-embedding. Thus, before jumping to the analysis, in this section, I will give a brief overview of this empirical debate (section 4.3.1), and conclude that the correct empirical generalization is the one by [Spector and Egré \(2015\)](#), which states that veridical responsive predicates are precisely those predicates that are veridical with respect to declarative-embedding. I will also discuss the relevance of factivity to the generalization in section 4.3.2.

4.3.1 Overview of existing empirical claims

There is a disagreement in the literature over which responsive predicates are veridical in the sense defined above. The controversial cases are communication predicates such as *tell*, *convey* and *report*. According to a more traditional view, defended by Karttunen (1977) and Groenendijk and Stokhof (1984), communication predicates *are* veridical. This view is based on the observation that communication predicates, at least *prima facie*, licenses the veridical inference, as follows:

- (30) John {told Mary/conveyed/reported} who came to the party.
⇒ John {told Mary/conveyed/reported} a correct answer to who came the party.

The observation that communication predicates seem to be veridical even though they are non-veridical in declarative-embedding has been significant in the formation of the semantics of embedded questions in Karttunen (1977) and Groenendijk and Stokhof (1984). This is so since this apparent fact suggests that the general mechanism of question-embedding, rather than the lexical semantics of the predicates, is responsible for veridicality. Thus, both Karttunen (1977) and Groenendijk and Stokhof (1984) propose a semantics for embedded questions which is designed to predict veridicality in general: Karttunen analyzes the extension of embedded questions as the conjunction of its *true* answers while Groenendijk and Stokhof analyze it as the *true* strongly exhaustive answer. Since communication predicates are combined with the extensions of embedded questions, they license the veridical inference as in (30) although the veridicality is not encoded in their lexical semantics. On the other hand, clear cases of non-veridical predicates like *be certain* and *wonder* are analyzed as *intensional* predicates that take intensions of embedded questions.

On the other hand, Tsohatzidis (1993) and Spector and Egré (2015) claim that communication predicates are non-veridical. More generally, Spector and Egré (2015) claim that the class of predicates that are veridical are precisely the class of predicates that are veridical with respect to declarative-embedding. The generalization maintained by the latter view, which I will refer to as Spector and Egré's generalization, can be stated as follows:

- (31) **Spector and Egré's generalization** (Spector and Egré 2015: 7)
A responsive predicate *V* is *veridical* with respect to interrogative-embedding iff *V* is *veridical* with respect to declarative-embedding.⁵

In this dissertation, I take this generalization to be empirically correct. Spector and Egré's (2015) empirical arguments for this generalization are summarized below.

Spector and Egré claim that the veridical inference of communication predicates is in fact defeasible, as it can be explicitly canceled as in the following examples.

⁵Later, I will discuss a related generalization in (i), which is also sometimes called Spector and Egré's generalization in the literature (Roelofsen et al. 2014):

- (i) A responsive predicate *V* is *veridical* with respect to interrogative-embedding iff *V* is *factive* with respect to declarative-embedding.

- (32) a. John {told me/conveyed/reported} who came, but he turned out to be wrong.
 b. Old John told us whom he saw in the fog, but it turned out that he was mistaken (the person he saw was Mr. Smith, not Mr. Brown). (Tsohatzidis 1993)
 c. Every day, the meteorologists tell the population where it will rain the following day, but they are often wrong. (Spector and Egré 2015)

The felicity of (32) indicates that these communication verbs are in fact non-veridical. These predicates are also non-veridical with respect to declarative-embedding, as shown in the following example.

- (33) John {told me/conveyed/reported} that Mary came, but he turned out to be wrong.

Other non-veridical responsive predicates, such as *be certain* and *agree*, pattern with these communication predicates.

In contrast, uncontroversially veridical predicates such as *know* and *realize* are veridical with respect to interrogative embedding. This can be seen by the impossibility of canceling the veridical inference, as in (34).

- (34) John {knew/realized} who came, #but he turned out to be wrong.

These empirical patterns are in line with the generalization in (31) above.

Spector and Egré (2015) point out that further evidence for the correspondence between veridicality in declarative-embedding and in interrogative-embedding comes from semi-minimal pairs of factive and non-factive/veridical responsive predicates in French and Hungarian. French *predire* ‘predict’ and *deviner* ‘guess’ are close in their lexical semantics when they take an animate subject and a complement clause, but differ in factivity, i.e., *deviner* is factive while *predire* is non-factive and non-veridical. The difference in factivity is mirrored in the contrast in the two examples below, where the two verbs take an interrogative clause.

- (35) French, E&S: (56-57)
- a. *Chacun des enquêteurs a **deviné** quels suspects seraient
 Every the investigator has guessed which suspects would.be
 condamnés, mais certains se sont trompés.
 condemned, but some REFL were wrong
 ‘Every investigator guessed[factive] which suspects would be condemned, but some of them got it wrong.’
- b. Chacun des enquêteurs a **prédit** quels suspects seraient
 Every the investigator has predicted which suspects would.be
 condamnés, mais certains se sont trompés.
 condemned, but some REFL were wrong
 ‘Every investigator predicted[non-factive] which suspects would be condemned, but some of them got it wrong.’

The above contrast shows that *deviner* is veridical while *predire* is non-veridical with respect to interrogative-embedding, something that is predicted by Spector and Egré's generalization as factivity is a particular form of veridicality.⁶ Perhaps a more striking piece of evidence comes from *mond* and *elmond* in Hungarian, which is offered by M. Abrusan to Spector and Egré. The verb *mond* is a Hungarian counterpart of English *tell*, and *el* is a perfective particle. What is important for our purpose is that *mond* is itself a non-veridical verb, but *elmond* obligatorily triggers the factive inference, as shown in the contrast in the implications of the following examples.

(36) Hungarian, E&S: (58-59)

- a. Péter azt **mondta** Marinak, hogy az Eiffel-torony össze fog dőlni.
Peter it.ACC told Mary.DAT that the Eiffel-tower PRT will collapse.
'Peter told Mary that the Eiffel tower will collapse.'
⇒ **The Eiffel tower will in fact collapse.**
- b. Péter **el-mondta** Marinak, hogy az Eiffel-torony össze fog dőlni.
Peter EL-told Mary.DAT that the Eiffel-tower PRT will collapse.
'Peter told Mary that the Eiffel tower will collapse.'
⇒ **The Eiffel tower will in fact collapse.**

This contrast is again mirrored by the veridicality of these predicates when they take interrogative complements, i.e., *mond* is non-veridical while *el-mond* is veridical with respect to interrogative-embedding. This is shown in the following examples:

(37) Hungarian, E&S: (60-61)

- a. Péter (azt) **mondta** Marinak, hogy ki fog nyerni.
Peter it.ACC told Mary.DAT, that who will win.INF
'Peter told Mary who will win.'
⇒ **Peter told the truth.**
- b. Péter **el-mondta** Marinak, hogy ki fog nyerni.
Peter EL-told Mary.DAT, that who will win.INF
'Peter told Mary who will win.'
⇒ **Peter told the truth.**

Pairs similar to *deviner* / *predire* can also be found in Japanese. The verbs *yochi-suru* and *yosoku-suru* both roughly mean 'foresee' / 'predict', but the former is factive while the latter is non-veridical. This is illustrated in the following examples:

- (38) a. Sono kenkyusya-wa shigatsu-ni jishin-ga okoru-to **yochi-shita**.
that researcher-TOP April-in earthquake-NOM occur-COMP foresee-did
'That researcher foresaw that an earthquake would occur in April.'
⇒ **An earthquake occurred in April.**

⁶A predicate is factive iff it presupposes the truth of its complement while a predicate is veridical with respect to declarative-embedding iff it entails the truth of its complement (whether as part of its presupposition or as part of its assertion).

- b. Sono kenkyusya-wa shigatsu-ni jishin-ga okoru-to yosoku-shita.
 that researcher-TOP April-in earthquake-NOM occur-COMP predict-did
 ‘That researcher predicted that an earthquake would occur in April.’
 ⇒ An earthquake occurred in April.

The factive/non-factive contrast is mirrored in whether the predicates allow a veridical inference when they embed an interrogative clause, as shown in the following example:

- (39) a. Sono kenkyusya-wa itsu jishin-ga okoru-ka yochi-shita.
 that researcher-TOP when earthquake-NOM occur-Q.COMP foresee-did
 ‘That researcher foresaw when an earthquake would occur.’
 ⇒ The researcher foresaw the correct time when an earthquake occurred.
- b. Sono kenkyusya-wa itsu jishin-ga okoru-ka yosoku-shita.
 that researcher-TOP when earthquake-NOM occur-Q.COMP predict-did
 ‘That researcher predicted when an earthquake would occur.’
 ⇒ That researcher predicted the correct time when an earthquake occurred.

Within English, factive/non-factive pairs with similar lexical semantics can be found outside the class of communication predicates. The English verbs *figure out* and *infer* seem to have similar lexical semantics except that the former is factive while the latter is not. As expected, *figure out* behaves as a veridical predicate while *infer* behaves as a non-veridical predicate when they embed interrogative clauses. The relevant examples that illustrate the contrast is the following:

- (40) a. From what was remaining in the room, John **figured out** that Ann came in while he was away.
 ⇒ Ann came in while he was away.
- b. From what was remaining in the room, John **inferred** that Ann came in while he was away.
 ⇒ Ann came in while he was away.
- (41) a. From what was remaining in the room, John **figured out** who came in while he was away.
 ⇒ John figured out that the person who actually came in did.
- b. From what was remaining in the room, John **inferred** who came in while he was away.
 ⇒ John inferred that the person who actually came in did.

Similar examples can be found in Japanese as well. The pair *sassuru* and *suisoku-suru* both have the lexical semantics of ‘infer’, but the former is veridical with respect to both declarative and interrogative-embedding while the latter is non-veridical with respect to both declarative and interrogative-embedding.

4.3.2 Spector and Egré’s (2015) generalization and factivity

Given the empirical support presented above, I take Spector and Egré’s generalization in (31) to be empirically correct. The empirical patterns so far in fact suggests the

possibility of a stronger empirical generalization, which states the connection between *factivity* with respect to declarative-embedding and veridicality with respect to interrogative-embedding.

(42) **A stronger version of Spector and Egré’s generalization**

A responsive predicate V is *veridical* with respect to interrogative-embedding iff V is *factive* with respect to declarative-embedding.

This generalization is stronger than the original generalization in (31) since factivity is a sub-case of veridicality. In other words, (42) rules out any *non-factive* predicate that are veridical with respect to both declarative and interrogative-embedding while such a predicate is allowed by the original generalization in (31).

Up to this point, we only considered factive predicates as examples of predicates that are veridical with respect to interrogative-embedding. So, the examples so far obey the stronger generalization in (42). In fact, Spector and Egré (2015) themselves suggest the possibility of the stronger generalization in their footnote 8, and the generalization in (42) instead of the original generalization in (31) is sometimes referred to as ‘Spector and Egré generalization’ in the literature (e.g., Roelofsen et al. 2014). However, a quick look into the class of responsive predicates in English reveals that *the stronger generalization is empirically incorrect*. As Egré (2008) points out, *prove* and *be clear* are non-factive responsive predicates, but are veridical with respect to both declarative and interrogative-embedding. This is illustrated in the following examples:

- (43) a. John **proved** which academic degree he has.
 \Rightarrow For some true answer p to the question ‘Which academic degree does John have?’, John proved p . (Veridical wrt interrogative-embedding)
- b. John **proved** that he has a PhD.
 \Rightarrow John has a PhD. (Veridical wrt declarative-embedding)
- c. John didn’t **prove** that he has a PhD.
 \nRightarrow John has a PhD (Non-factive)
- (44) a. It is **clear** who the culprit is.
 \Rightarrow For some true answer p to the question ‘Who is the culprit?’, it is clear that p . (Veridical wrt interrogative-embedding)
- b. It is **clear** that Sue is the culprit.
 \Rightarrow Sue is the culprit. (Veridical wrt declarative-embedding)
- c. It is not **clear** that Sue is the culprit.
 \nRightarrow Sue is the culprit. (Non-factive)

The stronger version of Spector and Egré’s generalization incorrectly states that there would not be predicates that exhibit these behaviors. Hence, I conclude that only the original generalization in (31), but not the stronger generalization in (42), is empirically correct.

4.3.3 The ambiguity of communication predicates

One question that still remains is why a simple interrogative-embedding under *tell* as in (30) has a rather strong veridical implication. In fact, as discussed above, this implication is so strong that previous authors such as [Karttunen \(1977\)](#) and [Groenendijk and Stokhof \(1984\)](#) considered *tell* and other communication verbs to be veridical, leading to their claim that veridicality with respect to interrogative-embedding is independent from veridicality or factivity with respect to declarative-embedding. [Spector and Egré](#) do not offer an explanation for why there is a contrast between the declarative-embedding use and the interrogative-embedding use, but suggest an explanation for why the veridical inference in the interrogative-embedding use *exists*. Their explanation is that responsive communication verbs are systematically ambiguous between the factive version and the non-factive version. Thus, the veridical inference is expected to arise when the factive version is used.

This suggestion is based on the observation that communication verbs with a declarative complement can trigger factive presuppositions in out-of-the-blue contexts (e.g., [Abrusán 2011](#)). Following examples lead to the inference that the complement proposition ‘Fred is the culprit’ is true.

- (45) a. Sue {told Jack/conveyed/reported} that Fred is the culprit.
b. Sue didn’t {tell Jack/convey/report} that Fred is the culprit.
c. Did Sue {tell Jack/convey/report} that Fred is the culprit?
⇒ **Fred is the culprit.**

The fact that the inference projects beyond negation (45b) and a question (45c) indicates that this inference is some form of a non-at-issue PROJECTIVE MEANING ([Tonhauser et al. 2013](#)). The *Hey, wait a minute!* test ([von Stechow 2004](#)) also points to the same conclusion:

- (46) A: Sue told Jack that Fred is the culprit.
B: Hey wait a minute! I didn’t know that Fred is the culprit.

Thus, the facts are compatible with the claim that communication verbs *can* have factive presuppositions, and thus they *can* be veridical with respect to interrogative-embedding in the same vein.

Importantly, however, this account does not account for why there is a stronger preference for the veridical reading in an interrogative-embedding use of communication predicates, as in (47a), than in a declarative-embedding use, as in (47b).

- (47) a. Sue {told Jack/reported/predicted} who was the culprit.
b. Sue {told Jack/reported/predicted} that Fred is the culprit.

After presenting my own analysis of non-veridical predicates and [Spector and Egré’s](#) generalization, I will argue in section 4.4.2 that the contrast naturally falls out given an independently motivated pragmatic principle, i.e., the STRONG MEANING HYPOTHESIS [Dalrymple et al. \(1998\)](#).

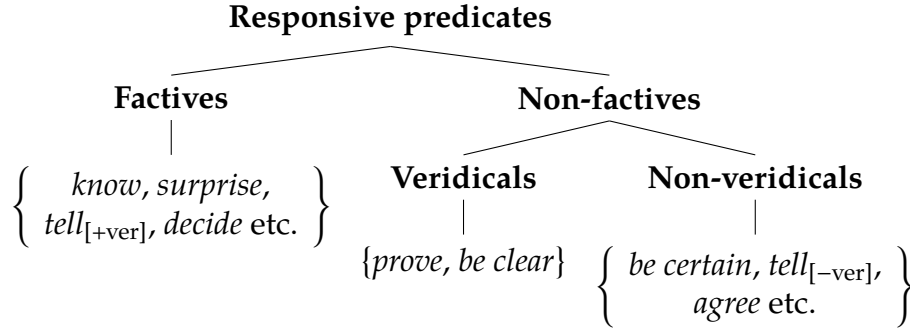


Figure 4-1: The typology of responsive predicates according to veridicality and factivity

The bottom line of the current section is that, despite the claims to the contrary in the earlier literature (Karttunen 1977; Groenendijk and Stokhof 1984), the available evidence indicates that the class of predicates that are veridical with respect to declarative-embedding and the class of predicates that are veridical with respect to interrogative-embedding in fact coincide, as argued by Spector and Egré (2015). The typology of responsive predicates according to factivity and veridicality is summarized in Figure 4-1.

4.4 Analyzing non-factivity and non-veridicality

The above discussion of the empirical picture concerning factivity and veridicality in responsive predicates has left us with the following three questions.

- How can we analyze non-factive predicates as well as non-veridical predicates?
- Why does Spector and Egré’s generalization, (31), hold?
- Why do communication predicates give rise to a veridical inference *by default* when they embed an interrogative-complement while they don’t when they embed a declarative-complement.

In this section, I consider the semantics of three non-factive predicates, *be certain*, *tell* and *agree*, and argue that these predicates, too, are decomposed into a ‘core’ predicate and an answerhood-operator, just like factive predicates. The difference between factive and non-factive predicates lies in the world in which the answerhood operator is evaluated. Specifically, In the factive predicates, the answerhood operator is evaluated in the matrix evaluation world. On the other hand, in the non-factive predicates, it may be evaluated in a world other than the matrix evaluation world. The three predicates are chosen as representative examples of three different classes of non-factive responsive predicates that share intuitive lexical semantics: the OPINION PREDICATES, the VERBS OF COMMUNICATION and the AGREE-TYPE VERBS⁷.

⁷The names for the first two classes come from Karttunen (1977)

4.4.1 *be certain*-type predicates (a.k.a. opinion predicates)

4.4.1.1 Lahiri (2002) on *be certain*

(48) a. $\llbracket \text{John knows which students came} \rrbracket^w = 1$
 iff $\forall p[p \in \llbracket \text{which students came} \rrbracket^w \wedge p(w) \rightarrow \mathbf{know}(j, p, w)]$

b. $\llbracket \text{John is certain (about) which students came} \rrbracket^w = 1$
 iff $\forall p[p \in \llbracket \text{which students came} \rrbracket^w \wedge$
 $\mathbf{consider-possible}(j, p, w) \rightarrow \mathbf{certain}(j, p, w)]$

143

both veridical and non-veridical predicates. The difference between the two resides in the restrictor of universal quantification: veridical predicates like *know* restrict the domain of quantification to be *true* answers while non-veridical predicates involve a restrictor that does not require the domain of quantification to be true ones.

This analysis, however, does not capture the existential and uniqueness presuppositions of embedded questions at least in the current form. Recall that sentences involving responsive predicates have existential and uniqueness presuppositions. Empirically, these presuppositions are evaluated in the actual world if the responsive predicate is factive, but in a domain of worlds that may not contain the actual world (such as the worlds compatible with the agent's beliefs; I will call this domain 'non-actual domain of worlds' for short) if the responsive predicate is non-factive. For example, *wh*-questions embedded under *know* and *be certain* have the following presuppositions:

- (49) a. John knows which students came.
Presupposition: There is a student who came.
- b. John knows which student came.
Presupposition: There is exactly one student who came.
- (50) a. John is certain which students came.
Presupposition: *John believes* that there is a student who came.
- b. John is certain which student came.
Presupposition: *John believes* that there is exactly one student who came.

The analysis in (48) does not capture these presuppositions. On the other hand, the analysis based on Ans_d developed so far in this chapter only considers the existential and uniqueness presuppositions in the *factive* case. My strategy for analyzing non-factive predicates is to generalize the WE reading to non-factive predicates just as in Lahiri (2002), while preserving the analysis of existential and uniqueness presuppositions using Ans_d .

In my analysis of *be certain* to be presented in detail below, I propose to reformulate Lahiri's analysis in terms of Ans_d . Specifically, I treat it as universally quantifying over *worlds in which Ans_d is evaluated*, instead of quantifying over *answers* directly. That is, the analysis of *be certain* in (48b) is reformulated as in (51).

- (51) $\llbracket \text{John is certain which students came} \rrbracket^w$
 $\Leftrightarrow \forall w' [w' \in \text{DOX}_j^w \rightarrow \text{DOX}_x^w \subseteq \llbracket \text{Ans}_d \rrbracket^w(w')(\llbracket \text{which students came} \rrbracket^w)]$

Contrast this with the analysis of *know* in section 4.2, which involves Ans_d evaluated in the evaluation world:

- (52) $\llbracket \text{John knows which students came} \rrbracket^w$
 $\Leftrightarrow \text{DOX}_j^w \subseteq \llbracket \text{Ans}_d \rrbracket^w(w)(\llbracket \text{which students came} \rrbracket^w)$

The analysis of *be certain* in (51) differs from that of *know* (52) in the world-argument with respect to which Ans_d is evaluated. While the world-argument for Ans_d in

RAISING. The operation creates a structure where the interrogative CP serves as a restrictor of a quantificational adverb that quantify over answers.

know is the matrix evaluation world, that in *be certain* is any world compatible with John's beliefs. In other words, the distinction between *know* and *be certain* is that of intensionality: *know* combines with the Ans_d -answer evaluated in the matrix evaluation world while *be certain* binds the world-argument of Ans_d it combines with. I will discuss how the analysis in (51) is compositionally derived below.

According to this analysis, disregarding the presupposition of Ans_d for now, *John is certain which students came* is true iff John believes all the answers that are true in some world compatible with his beliefs. Thus, in the assertive dimension, the analysis mimics Lahiri's (2002) semantics of *be certain* in (48b). The set of propositions John considers possible is equivalent to the set of propositions that are true in some world compatible with his beliefs.⁹ Furthermore, unlike Lahiri's (2002) analysis, the current analysis of *be certain* captures its presuppositional behaviors in (50) once the projection of the presupposition triggered by Ans_d is taken into account.

The analysis of the distinction between veridical and non-veridical predicates in terms of intensionality has been proposed by Groenendijk and Stokhof (1984) although it was aimed to capture the 'traditional' empirical generalization which I argued against in the previous section. Recently, Theiler (2014) and Roelofsen et al. (2014) employed the same approach to analyze Spector and Egré's generalization. However, their overall compositional semantics for embedded questions (based on Inquisitive Semantics) is different from the current analysis in several respects. See section 4.6.2 for a review of Theiler (2014) and Roelofsen et al. (2014), and a comparison with the current proposal.

4.4.1.2 Assertive meaning contribution and exhaustivity

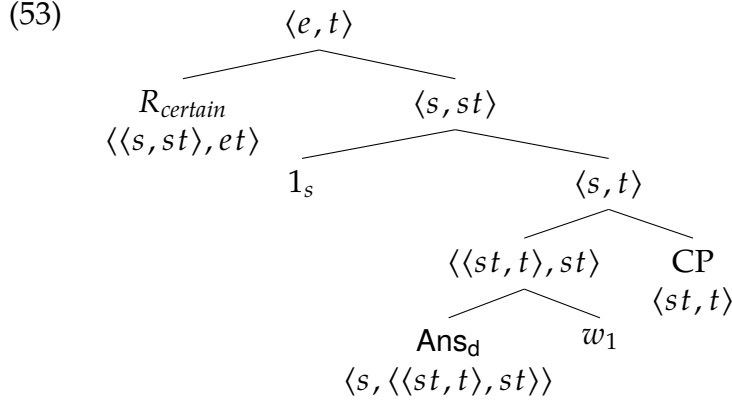
As discussed above, I analyze *x is certain about Q* as '*x* believes every answer to *Q* that is compatible with *x*'s beliefs'. To achieve this compositionally, we first decompose *be certain* into the 'core' predicate R_{certain} and Ans_d , along the lines of the analysis of *know* in the previous section. Furthermore, R_{certain} is analyzed as a quantifier that binds the world argument of Ans_d .¹⁰

⁹John considers *p* possible iff *p* satisfies the following:

(i) $\exists w'[w' \in \text{DOX}_j^w \wedge w' \in p]$

This is precisely the conditions under which *p* is in the set of propositions that are true in some world compatible with John's beliefs.

¹⁰Under the assumption that the binder index is created only with an LF movement, this means that R_{certain} originates from the sister position of Ans_d , and undergoes QR. I will discuss more on the precise formulation of the lexical decomposition in section 4.5.



Given this decomposition, the following denotation for $R_{certain}$ in (54) derives the above-mentioned truth conditions for *John is certain (about) Q* in (55), disregarding the presupposition for now.

$$(54) \quad \llbracket R_{certain} \rrbracket^w = \lambda \mathcal{P}_{\langle s, st \rangle} \lambda x. \forall w' [w' \in \mathbf{DOX}_x^w \rightarrow \mathbf{DOX}_x^w \subseteq \mathcal{P}(w')]$$

$$(55) \quad \llbracket \text{John } R_{certain} [1 [\llbracket Ans_d w_1 \rrbracket] Q] \rrbracket^w \\ \Leftrightarrow \forall w' [w' \in \mathbf{DOX}_j^w \rightarrow \mathbf{DOX}_j^w \subseteq \llbracket Ans_d \rrbracket^w(w')(Q)]$$

Here, $R_{certain}$ binds into the world argument of Ans_d . This is in contrast to the case of *know* presented in the previous section. R_{know} is simply ‘believe’ that selects for a proposition, and the Ans_d -phrase in its sister contains a (locally) free world variable in the sister position of Ans_d (see (14)).

What the truth-conditions in (55) entails is that John’s belief worlds are *homogenous* with respect to every answer of Q . It states that if the answer $\llbracket Ans_d \rrbracket^w(w')(Q)$ and John’s beliefs are compatible, then $\llbracket Ans_d \rrbracket^w(w')(Q)$ holds in all of x ’s belief worlds. Otherwise, $\llbracket Ans_d \rrbracket^w(w')(Q)$ and x ’s belief worlds are simply incompatible. This means that question-embedding sentences involving *be certain* are always interpreted strongly-exhaustively by virtue of its meaning.

This is so regardless of whether the exhaustivity operator X is applied.¹¹ The reading is strongly-exhaustive without X , and applying X wouldn’t add any additional information. I claim that this is an empirically correct prediction. The following sentence only has a reading where John has a complete opinion for each student about whether they came or not.

(56) John is certain which students came.

The sentence would be false if John does not have an opinion about some of the answers.

¹¹The reader might have noticed that it is technically impossible to apply X in the structure as in (53) if X is a quantifier binding into the world argument of Ans_d . This is so since $R_{certain}$ already binds the variable in (53). Thus, the discussion about X here applies under the assumption that this technical problem is solved in one way or the other. In other words, what is claimed in the discussion here is that even if it is technically possible to apply X , it wouldn’t add any additional exhaustive effect.

4.4.1.3 Presuppositions

In the previous section, I discussed how the current analysis predicts the non-factivity of *be certain* given any plausible theory of presupposition projection out of universal quantification. Here, I will look closely into the presuppositions of sentences involving *be certain*, and discuss how the behaviors can be accounted for given specific theories of presupposition projection.

As I discussed above, the fact that *be certain* is non-veridical does not necessarily mean that the existence and uniqueness presuppositions of its interrogative complement do not manifest themselves at all. This can be seen in the projection of the uniqueness presupposition in *be certain* + an interrogative complement. In the following examples, we get the inference that John *believes* that exactly one student came.

- (57) a. John is certain (about) which student came.
b. John is not certain (about) which student came.

The same conclusion can be drawn from the following example involving sluicing.¹² We see in (58a) below that the sentence in (57b) is odd when the context makes it explicit that John thinks it is possible that multiple students came (although it is also a possibility that a single student did). This contrasts with (58b) where the context guarantees that John believes that exactly one student came.

- (58) a. John believes that there were either one or two students who came to the party.
He is not certain which student.
b. John believes that there was only one student who came to the party.
He is not certain which student.

Another kind of examples that reveals the presupposition projection property of *be certain* is sentences with a presupposition trigger (other than *Ans_d*) embedded in the complement of *be certain*, such as the following:

- (59) John is certain whether Ann stopped smoking.
(60) John is not certain whether Ann stopped smoking.

Here, we get the inference that John believes that Ann used to smoke. This observation is corroborated by the following examples in (61-62).

- (61) a. I think it is possible that Ann has never smoked, but if she used to smoke at all, which is also a possibility, she might or might not be smoking now.
So, # I am not certain whether Ann stopped smoking.
b. I think Ann used to smoke, but she might or might not be smoking now.
So, I am not certain whether Ann stopped smoking.
(62) a. We know that it might or might not be that Ann used to smoke.
Are you certain whether she stopped smoking?

¹²I thank Aron Hirsch for bringing up these examples.

- b. We know that Ann used to smoke.
Are you certain whether she stopped smoking?

In these examples, the relevant sentences are infelicitous if the context explicitly denies the agent's belief that Ann used to smoke, as in (61a) and (62a), unlike the cases where the context supports the belief, as in (61b) and (62b).

How are these behaviors accounted for in the current analysis of *be certain*? The data can be accounted for if *be certain* projects the presupposition of its scope *universally*. To see this, consider (63), which summarizes the predictions of the universal projection and the existential projection of the presupposition in *John is certain about Q* (In this section, I only consider universal projection and existential projection for expository purposes. The predictions of the Strong Kleene-based account is discussed in 4.4.5.):

- (63) $\forall w'[w' \in \mathbf{DOX}_j^w \rightarrow \mathbf{DOX}_j^w \subseteq \llbracket \mathbf{Ans}_d \rrbracket^w(w')(Q)]$ (Assertion)
 a. $\forall w'[w' \in \mathbf{DOX}_j^w \rightarrow \llbracket \mathbf{Ans}_d \rrbracket^w(w')(Q) \text{ is defined}]$ (\forall -projection)
 b. $\exists w'[w' \in \mathbf{DOX}_j^w \wedge \llbracket \mathbf{Ans}_d \rrbracket^w(w')(Q) \text{ is defined}]$ (\exists -projection)

The statements in (63a) and (63b) are instantiated as follows in the case of (57a), *John is certain (about) which student came*, and (59), *John is certain whether Mary stopped smoking*:

- (64) John is certain (about) which student came.
 a. $\forall w'[w' \in \mathbf{DOX}_j^w \rightarrow \llbracket \mathbf{Ans}_d \rrbracket^w(w')(\llbracket \text{which student came} \rrbracket^w) \text{ is defined}]$
 $\Leftrightarrow \forall w'[w' \in \mathbf{DOX}_j^w \rightarrow \exists! x[\mathbf{student}(x, w) \wedge \mathbf{came}(x, w')]]$ (\forall -projection)
 b. $\exists w'[w' \in \mathbf{DOX}_j^w \wedge \llbracket \mathbf{Ans}_d \rrbracket^w(w')(\llbracket \text{which student came} \rrbracket^w) \text{ is defined}]$
 $\Leftrightarrow \exists w'[w' \in \mathbf{DOX}_j^w \wedge \exists! x[\mathbf{student}(x, w) \wedge \mathbf{came}(x, w')]]$ (\exists -projection)
- (65) John is certain whether Mary stopped smoking.
 a. $\forall w'[w' \in \mathbf{DOX}_j^w \rightarrow \llbracket \mathbf{Ans}_d \rrbracket^w(w')(\llbracket \text{whether Mary stopped smoking} \rrbracket^w) \text{ is defined}]$
 $\Leftrightarrow \forall w'[w' \in \mathbf{DOX}_j^w \rightarrow \mathbf{SmokedPast}(\mathbf{m}, w')]$ (\forall -projection)
 b. $\exists w'[w' \in \mathbf{DOX}_j^w \wedge \llbracket \mathbf{Ans}_d \rrbracket^w(w')(\llbracket \text{whether Mary stopped smoking} \rrbracket^w) \text{ is defined}]$
 $\Leftrightarrow \exists w'[w' \in \mathbf{DOX}_j^w \wedge \mathbf{SmokedPast}(\mathbf{m}, w')]$ (\exists projection)

The data we observed above are consistent with the predictions of the universal projection, which states that every world compatible with John's beliefs validates the relevant presuppositions triggered in the scope of *be certain*, i.e., John believes these presuppositions. On the other hand, the observations are incompatible with the existential prediction, which merely states that the relevant presuppositions are compatible with John's beliefs. The existential projection predicts that examples (58a), (61a) and (62a) above—the examples with a context stating that the relevant presupposition is compatible with John's beliefs although John does not believe it—should be felicitous, contrary to fact. Hence, the data so far are accounted for by the universal projection, but not by the existential projection, of presuppositions in the current analysis of *be certain*.

Nevertheless, universal projection seems to be incompatible with the pattern we observe in *be certain* + a declarative complement, such as (66). The assertion of (66) would be analyzed as (67) in the current proposal.

(66) John is certain that Ann came.

(67) $\forall w' [w' \in \mathbf{DOX}_j^w \rightarrow \mathbf{DOX}_j^w \subseteq \llbracket \mathbf{Ans}_d \rrbracket^w(w')(\{\llbracket \text{Ann came} \rrbracket\})]$

The question is how the presupposition of \mathbf{Ans}_d in (67)—that Ann came—is projected. The predictions of the the existential projection and the universal projection are summarized as follows:

- (68) a. $\exists w' [w' \in \mathbf{DOX}_j^w \wedge \mathbf{came}(\mathbf{ann})(w')]$ (\exists -projection)
 b. $\forall w' [w' \in \mathbf{DOX}_j^w \rightarrow \mathbf{came}(\mathbf{ann})(w')]$ (\forall -projection)

In prose, these predicted presuppositions correspond to the following statements:

- (69) a. It is compatible with John's beliefs that Ann came. (\exists -projection)
 b. John believes that Ann came (\forall -projection)

Empirically, (66) seems to presuppose that it is compatible with John's beliefs that Ann came. This can be confirmed by the behavior of the following examples, where (66) is embedded under negation and polar question.

- (70) a. John is not certain that Ann came.
 b. Is John certain that Ann came?

Both of these examples presuppose that it is compatible with John's beliefs that Ann came. Thus, *prima facie*, the prediction of the existential projection is compatible with the actual presupposition of sentences with *be certain+that* complement observed above, but the prediction of the universal projection is not. The universal projection would make an incorrect prediction that sentences in (70) presuppose that John believes that Ann came.

We seem to have a dilemma here. The presupposition triggered by \mathbf{Ans}_d in *be certain* + an interrogative complement seems to project universally whereas that in *be certain* + a declarative complement seems to project existentially. A part of this dilemma, however, can be resolved by saying that the presuppositions project universally by default, but will be locally accommodated when the universal projection would make an assertion trivial. More precisely, I am assuming that presupposition projection out of universally quantified sentences is subject to the following principle:

(71) **Universal projection modulo triviality**

Presuppositions in the scope of universally quantified sentences project universally unless the universal projection would make the sentence necessarily contextually trivial.

- A sentence is NECESSARILY CONTEXTUALLY TRIVIAL if (i) its presupposition entails its assertion, (ii) its presupposition contradicts its assertion, or (iii) its presupposition resolves the question it raises.

- When the universal projection would result in triviality, the presupposition is locally accommodated.

In (66), the universal projection would make the sentence necessarily contextually trivial since the presupposition would in fact be equivalent to the assertion. In (70a), the universal projection would contradict the assertion. In (70b), the universal projection would already resolve the question. Thus, the principle would predict that the presuppositions triggered by Ans_d would be locally accommodated in these examples. For example, (66) and (70a) would be analyzed as follows, with the relevant presupposition being accommodated in the scope (underlined):

$$(72) \quad \begin{array}{ll} \text{a. } \forall w' \left[\begin{array}{l} w' \in \text{DOX}_j^w \rightarrow \\ \underline{\text{came(ann)}(w')} \wedge \text{DOX}_j^w \subseteq \llbracket \text{Ans}_d \rrbracket^w(w')(\{\llbracket \text{Ann came} \rrbracket\}) \end{array} \right] \\ \text{b. } \neg \forall w' \left[\begin{array}{l} w' \in \text{DOX}_j^w \rightarrow \\ \underline{\text{came(ann)}(w')} \wedge \text{DOX}_j^w \subseteq \llbracket \text{Ans}_d \rrbracket^w(w')(\{\llbracket \text{Ann came} \rrbracket\}) \end{array} \right] \end{array}$$

However, this is only a part of the solution to the dilemma since the account so far leads us to expect that *be certain+that* is not presuppositional, and it lacks an account of why *be certain+that* seems to presuppose that the complement is compatible with the agent's beliefs. In the rest of this section, I offer a preliminary account of the existential inference based on scalar implicature. In section 4.4.5, I offer another account based on the theory of presupposition projection in Strong Kleene logic.

The account of the existential inference in *be certain* + declaratives I suggest in this section employs a scalar implicature. An assumption needed for this account is that the following two sentences are scalar alternatives.

- (73) a. John is certain that Ann came.
b. It is compatible with John's beliefs that Ann came.

The sentence (73a) is stronger than its alternative, (73b). Thus, the declarative sentence in (73a) does not lead to any scalar implicature. However, the negated sentence in (74a) is weaker than the negated alternative in (74b), thus leading to the scalar implicature indicated in (75).¹³

- (74) a. John is not certain that Ann came.
b. It is not compatible with John's beliefs that Ann came.
- (75) \neg [It is not compatible with John's beliefs that Ann came]
 \Leftrightarrow It is compatible with John's beliefs that Ann came.

That is, the scalar implicature of (74a) results in the existential claim, just as the negation of the universal claim in (76) implicates the existential claim.

- (76) John didn't eat all of the cookies. \Rightarrow John ate some of the cookies.

¹³Similar ideas can be found in Chemla (2010) and Romoli (2015) who aim to account for the projection property of soft-triggers in terms of scalar implicatures.

Thus, by adding an additional assumption about the scalar alternative of *be certain that*, its existential inference in downward entailing environments can be accounted for as a scalar implicature.¹⁴

One problem with this account is that it does not straightforwardly extend to the existential inference in polar questions, as in (70b). In section 4.4.5, I argue that the dilemma posed by *certain-that* can be resolved in the theory of presupposition projection based on Strong Kleene logic, and thus the additional account based on scalar implicature would be unnecessary.

4.4.2 *tell* and other communication predicates

Another class of a non-veridical predicates is communication predicates such as *tell*, *show*, *report*, *communicate*, *inform*, *disclose* etc. Communication predicates present two special challenges: (i) an elusive nature of the ‘restrictor’ of universal quantification over worlds if we are to analyze their non-veridical use in a way similar to the analysis of *be certain* presented in the previous section, and (ii) the analysis of the systematic ambiguity between veridical and non-veridical uses, as well as the fact that the veridical use is preferred in interrogative-embedding.

4.4.2.1 Assertive meaning contribution and exhaustivity

The veridical use of *tell*, or $tell_{[+ver]}$, can be analyzed in a way similar to other veridical predicates, such as *know*. In this analysis, $tell_{[+ver]}$ would be decomposed into R_{tell} and Ans_d , where the former has the following denotation:

$$(77) \quad \llbracket R_{tell_{[+ver]}} \rrbracket^w = \lambda p_{\langle s,t \rangle} \lambda y \lambda x. \mathbf{tell}(x, y, p, w)$$

Given this, *John tells Mary who came* in its veridical reading is analyzed as follows. I here omit X from the structure for expository purposes.

$$(78) \quad \llbracket \text{John } R_{tell_{[+ver]}} \text{ Mary } [\llbracket Ans_d w \rrbracket \text{ who came}] \rrbracket^w \\ \Leftrightarrow \mathbf{tell}(x, y, \llbracket Ans_d \rrbracket^w(w)(\llbracket \text{who came} \rrbracket), w)$$

The resulting truth conditions state that John tells Mary the *true* strongest answer to *who came*, capturing the appropriate veridical interpretation. Moreover, the analysis predicts an existential presupposition interpreted with respect to the actual world (of which factivity is a sub-case) as will be illustrated below.

Turning to the non-veridical use of *tell* (or $tell_{[-ver]}$), Lahiri (2002) suggests (and ultimately rejects) an analysis where $tell_{[-ver]}$ universally quantifies over the answers that the agent *believes*. In other words, *John told_[-ver] Mary who came* is true iff John

¹⁴ One might wonder why *believe-that*—which would be semantically equivalent to *be certain-that* after accommodation—does not seem to have the same existential inference:

- (1) John does not believe that Ann came. $\overset{??}{\Rightarrow}$ It is compatible with John’s beliefs that Ann came.

This data, however, can be accounted for by the neg-raising property of *believe*. That is, although *believe* has the same alternative as *be certain*, the scalar implicature is not generated as it conflicts with the excluded-middle presupposition associated with *believe*.

told Mary all the answers to *who came* that John *believes*. In the current analysis, these truth conditions would be formulated as in (80).

(79) John tells Mary who came.

$$(80) \quad \forall w' [\mathbf{DOX}_j^w \subseteq \llbracket \text{Ans}_d \rrbracket^w(w')(\llbracket \text{who came} \rrbracket) \\ \rightarrow \mathbf{tell}(j, m, \llbracket \text{Ans}_d \rrbracket^w(w')(\llbracket \text{who came} \rrbracket), w)]$$

Although Lahiri rejects this analysis on the ground that it fails to capture the traditional judgment that *tell* is veridical with respect to interrogative-embedding, one might think that this is a plausible analysis for *tell*_[−ver]. However, this analysis does not quite capture the intuitive meaning of *tell*_[−ver] since (79) can be true even if John lied to Mary about who came:

(81) John told Mary who came, but it turned out that he was lying.

When we consider the fact that telling (in the non-veridical sense) can be successful even in insincere communications in general, finding the right restrictor for the universal quantification in (80) instead of the agent's belief becomes elusive. Giving it a trivial restrictor would not work either, as it would incorrectly predict that (79) means that John tells Mary that everyone came. I do not have a knock-down argument against the possibility of analyzing the non-veridical use of *tell* in terms of universal quantification à la (80). However, the difficulty makes another approach to the meaning of the non-veridical *tell* more attractive. This approach analyzes the non-veridical *tell* in terms of existential quantification (see Spector and Egré 2015 and Roelofsen et al. 2014 for similar ideas). That is, (79) would be analyzed as in (82).

$$(82) \quad \exists w' [\mathbf{tell}(j, m, \llbracket \text{Ans}_d \rrbracket^w(w')(\llbracket \text{who came} \rrbracket^w), w)]$$

The analysis captures the non-veridicality since (82) only requires for John to tell Mary some *possible* answer to *who came*, whether or not it is the true one. What is attractive about this analysis is that the problem of finding a suitable restrictor simply does not arise. In other words, (82) does not commit us to a particular claim about what kind of answer has to be communicated by John to Mary in order for (79) to be true.

Thus, the two versions of *tell*, i.e., *tell*_[+ver] and *tell*_[−ver], are analyzed as follows:

$$(83) \quad \begin{array}{ll} \text{a. } \llbracket R_{\text{tell}[+ver]} \rrbracket^w = \lambda p_{\langle s, t \rangle} \lambda y \lambda x. \mathbf{tell}(x, y, p, w) \\ \text{b. } \llbracket R_{\text{tell}[-ver]} \rrbracket^w = \lambda \mathcal{P}_{\langle s, st \rangle} \lambda y \lambda x. \exists w' [\mathbf{tell}(x, y, \mathcal{P}(w'), w)] \end{array}$$

In the veridical case, the predicate refers to the Ans_d -answer in the actual world. On the other hand, the non-veridical version involves an existential quantification over the world with respect to which Ans_d is evaluated. Following the empirical claim by Spector and Egré (2015), I assume that this ambiguity exists regardless of whether the complement is declarative or interrogative. Below, I will discuss how the current analysis predicts these predicates to be factive and non-factive, respectively, when they embed declarative complements. These analyses can be generalized to other communication predicates with a simple modification of the relation **tell** in the scope of respective quantifications.

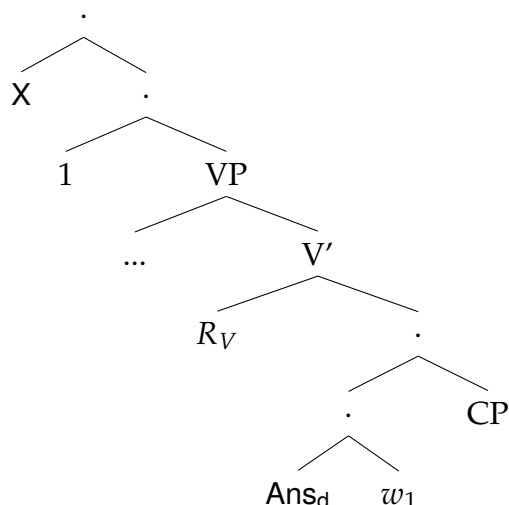
Do these analyses capture the exhaustivity of veridical and non-veridical readings of *tell*? I discuss this issue using the following examples.

(84) John tells_[+ver]/tells_[-ver] Mary which students came.

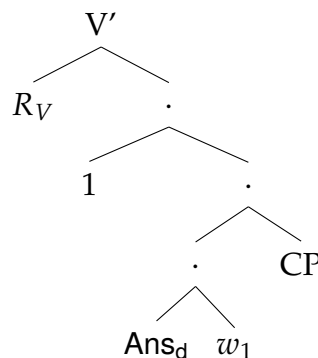
In the case of *tell*_[+ver], the prediction of the analysis is straightforward. The baseline interpretation gives us its WE reading. The obligatory operator X above the predicate derives the IE reading, which would be paraphrased as ‘For all students that came, John tells Mary that they came; for all students that didn’t come, John doesn’t tell Mary that they came’. This reading can be strengthened into the SE reading: ‘For all students that came, John tells Mary that they came; for all students that didn’t come, John tells Mary that they didn’t come’.

In the case of *tell*_[-ver], the situation is trickier since the world-argument of *Ans_d*, which X is supposed to bind, is already bound by *R_{tell[-ver]}*. This is a general problem with non-factive predicates, whose core predicate is an intensional predicate binding the world argument of *Ans_d*. Schematically, the crucial difference in the decomposition of factive predicates and non-factive predicates are illustrated in the following trees.

(85) a. **Factive predicate**



b. **Non-factive predicate**



In a factive predicate, X binds the world variable in the sister position of *Ans_d*, but the variable in the same position is bound by *R_V* in a non-factive predicate.

This means that the exhaustive operator X implemented as a quantifier binding into the world argument for *Ans_d* cannot be applied to a non-factive responsive predicate. Under the assumption that the binder index is created only through an LF movement, the situation can be restated in terms of complementary distributions of X and *R_V* (for a non-factive V) in the sister position of *Ans_d*. Only one of X or *R_V* for a non-factive V is syntactically generated in the sister position of *Ans_d* and undergo QR. If *R_V* is generated in the position, then X is not be generated. See section 4.5 for a more detailed discussion on the overall syntactic assumptions on the decomposition of factive and non-factive predicates.

The prediction then would be that *tell*_[-ver] would only license the reading exemplified by (86) below since X cannot be applied in a structure involving *R_{tell[-ver]}*.

- (86) $\llbracket \text{John } R_{\text{tell}[-\text{ver}]} [1 \llbracket \text{Ans}_d w_1 \rrbracket \text{ which students came} \rrbracket] \rrbracket^w$
 $\Leftrightarrow \exists w' [\text{tell}(\mathbf{j}, \mathbf{m}, \llbracket \text{Ans}_d \rrbracket^w(w')(\llbracket \text{which students came} \rrbracket^w), w)]$

The reading is the so-called MENTION-SOME (MS) reading: ‘John told Mary *some* answer to *which students came*’. WE and IE readings are not derived although situations compatible with these readings are also compatible with the MS reading simply because the former readings are stronger than the MS reading. I will discuss SE readings shortly below.

The absence of WE and IE readings can be defended in the following way. By the general format of WE and IE readings, WE and IE readings of (87) would have the following paraphrases, for some predicate of propositions C .

- (87) John told_[-ver] Mary who came, but he turned out to be wrong.

WE For every answer p to *who came* such that $C(p)$, John told p to Mary.

IE For every answer p to *who came* such that $C(p)$, John told p to Mary; For every answer p to *who came* such that $\neg C(p)$, John didn’t tell p to Mary.

C in these formats corresponds to the set of true propositions in the case of $\text{tell}_{[+\text{ver}]}$. Above, I argued that we cannot find a suitable C in the case of $\text{tell}_{[-\text{ver}]}$. In other words, there is no C (that is not ‘true’) that fits the following schematic sentences such that it makes (88a) contradictory while (88b) true.

- (88) a. #John told_[-ver] Mary who came, but he turned out to be wrong. Moreover, what he told Mary was C .
 b. John didn’t tell_[-ver] Mary who came because what he told Mary was C .

Neither the set of propositions believed by John nor the trivial predicate that is true of all propositions fits C in these schematic sentences. This fact is compatible with the analysis which does not generate WE and IE readings to begin with.

What about SE readings? The SE reading of sentence (87) would be paraphrased as follows if it existed.

- (89) **SE** For every answer p to *who came*, John told Mary p or John told Mary $\neg p$.

In the analysis of the exhaustivity for factive predicates presented in the previous chapter, I argued that SE readings are derived from IE readings given excluded-middle assumption associated with the embedding predicate. In this sense, SE readings for factive predicates are parasitic on the derivation for IE readings. This might make one think that the current analysis predicts that $\text{tell}_{[-\text{ver}]}$ would lack an SE reading. However, the dependence of SE readings on IE readings does not necessarily hold for non-factive predicates since the excluded-middle presupposition associated with a non-factive predicate itself is equivalent to (what would be described as) its SE reading. For example, if such a presupposition is associated with $\text{tell}_{[-\text{ver}]}$, it would presuppose that the subject tells p or $\neg p$ to the dative object for any relevant proposition p . This presupposition is encoded in the following denotation of $R_{\text{tell}[-\text{ver}]}$.

$$(90) \quad \llbracket R_{tell[-ver]} \rrbracket^w = \lambda \mathcal{P}_{\langle s, st \rangle} \lambda y \lambda x. \begin{cases} \exists w' [\text{tell}(x, y, \mathcal{P}(w'), w)] & \text{if } \forall w' \left[\begin{array}{l} \text{tell}(x, y, \mathcal{P}(w'), w) \vee \\ \text{tell}(x, y, \neg \mathcal{P}(w'), w) \end{array} \right] \\ \text{undefined} & \text{otherwise} \end{cases}$$

This presupposition would entail the SE reading paraphrased in (89). Thus, the current analysis predicts $tell_{[-ver]}$ and other non-veridical communication predicates to give rise to SE interpretations as long as they have excluded-middle presuppositions.

Empirically, the judgment as to whether non-veridical communication predicates allow MS readings, SE readings, or both is rather subtle. Yet, the following examples from Spector and Egré (2015) show that $predict_{[-ver]}$ selects for an SE reading: $tell_{[-ver]}$ is false in a situation where the subject's prediction is not complete (and accordingly it's negation is true) while it is true in a situation where the subject's prediction is complete. (The names of the characters are changed from Spector and Egré's actual examples.)

- (91) **[Situation (Incomplete prediction):** John wondered who would attend a certain party among four students, Ann, Bill, Chris, and Dana. He predicted that Ann and Bill would go and made no prediction about the others—he actually said that he had no idea about Chris and Dana. In fact, it turned out that neither Ann nor Bill attended the party.]
- a. John predicted which of the four students would attend the party, but he proved wrong. **(Judgment: False)**
 - b. John didn't predict which of the four students would attend the party because he didn't make any prediction about Chris and Dana. **(Judgment: True)**
- (92) **[Situation (Complete prediction):** John wondered who would attend a certain party among four students, Ann, Bill, Chris, and Dana. He predicted that Ann and Bill would go and that Chris and Dana would not. In fact, the reverse turned out to be true: only Chris and Dana attended the party.]
- John predicted which of the four students would attend the party, but he proved wrong. **(Judgment: True)**

Similar judgments hold for $tell_{[-ver]}$, as illustrated in the following variants of the above examples using $tell$:

- (93) **[Situation (Incomplete telling):** There are four students, Ann, Bill, Chris, and Dana, and everyone is invited to a certain party. John told me that Ann and Bill would go and didn't tell me anything about the others—he actually said that he had no idea about Chris and Dana. In fact, it turned out that neither Ann nor Bill attended the party.]
- a. John told me which of the four students would attend the party, but he proved wrong. **(Judgment: False)**
 - b. John didn't tell me which of the four students would attend the party because he didn't tell me anything about Chris and Dana. **(Judgment: True)**

- (94) [**Situation (Complete telling)**]: There are four students, Ann, Bill, Chris, and Dana, and everyone is invited to a certain party. John told me that Ann and Bill would go and that Chris and Dana would not. In fact, the reverse turned out to be true: only Chris and Dana attended the party.]

John told me which of the four students would attend the party, but he proved wrong. (Judgment: True)

On the other hand, communication predicates that resist neg-raising, such as *write down* (discussed in the previous chapter), seem to select for MS readings. This is exemplified in the following example.

- (95) [**Situation (Incomplete ‘writing down’)**]: There are four students, Ann, Bill, Chris, and Dana, and everyone is invited to a certain party. Every student has a specific dietary restriction, and John was supposed to leave a note to the party host regarding which students will attend the party, so that the host can learn something about which foods to prepare (and not to prepare) for the party. In the note, John wrote down the following: ‘Ann and Bill will attend the party’, but didn’t write anything about Chris and Dana. However, John in fact had the intention to confuse the host (because he wanted to ruin the party for whatever reasons), and knew that Ann and Bill would not attend the party.]

- a. John wrote down which of the four students would attend the party, but he proved wrong. (Judgment: True)
- b. #John didn’t write down which of the four students would attend the party because he didn’t write down that Chris and Dana wouldn’t come.

The fact that (95a) is true suggests that the non-veridical *write down* allows an MS reading. Furthermore, the fact that the *because*-clause after the negated clause in (95b) is infelicitous suggests that an SE reading is in fact unavailable for the non-veridical *write down*. The first clause in (95b) is true under the veridical reading, but the reason suggested in the *because*-clause is incompatible with the veridical reading.

Thus, empirically, there seems to be a lexical variation within non-veridical communication predicates as to whether an SE reading or an MS reading is licensed. This fact is consistent with the current analysis in view of the lexical variation in whether a predicate has an excluded-middle presupposition. The predicates like *tell*_[–ver] and *predict*_[–ver] come with the excluded-middle presuppositions, and so they select for SE readings.¹⁵ On the other hand, the predicates like *write down*_[–ver] do not have the excluded-middle presuppositions, and thus they select for MS readings. As discussed in the previous chapter, the distinct nature of the *write down*-type predicates can be independently detected by the fact that they resist neg-raising.

¹⁵The account in fact states that SE readings arise from the presupposition. Thus, the basic prediction of the account is that the sentences in (91) and (93) would be presupposition failures. Thus, it has to be assumed in the current account that the judgments noted in (91) and (93) arise from local accommodation of the excluded-middle presuppositions.

4.4.2.2 Presuppositions

Given that there is an ambiguity between veridical and non-veridical versions of *tell*, Spector and Egré’s generalization predicts that there should be an ambiguity between factive and non-factive readings of *tell* in its declarative-embedding use. As reviewed in section 4.3.1, Spector and Egré (2015) claim that this prediction is in fact correct. In addition to the non-factive reading, there is a reading of *tell* which leads to a factive inference, as follows.

(96) John didn’t tell Mary that Fred is the culprit. \Rightarrow Fred is the culprit.

The current analysis accounts for both factive and non-factive readings of *tell* once we make general assumptions about presupposition projection. In particular, $tell_{[+ver]}$ is predicted to have an existential presupposition evaluated with respect to the actual world. Factivity is simply a sub-case of this existential presupposition. On the other hand, $tell_{[-ver]}$ is predicted to have the existential presupposition evaluated with respect to *some* world. This presupposition does not entail factivity in the declarative case. Below, I illustrate these predictions for $tell_{[+ver]}$ and $tell_{[-ver]}$ in turn.

Above, I argued that *John tells_[+ver] Mary who came* has the following as its assertive meaning.

(97) $\text{tell}(\mathbf{j}, \mathbf{m}, \llbracket \text{Ans}_d \rrbracket^w(w)(\llbracket \text{who came} \rrbracket^w), w)$

This presupposes that $\llbracket \text{Ans}_d \rrbracket^w(w)(\llbracket \text{who came} \rrbracket^w)$ is defined. In other words, there is an existential presupposition evaluated with respect to the actual world w , i.e., someone came in w . In the declarative case, this presupposition boils down to factivity. That is, *John tells_[+ver] Mary that Ann came* is analyzed as in (98), which presupposes (99), given the existential presupposition triggered by Ans_d .

(98) $\text{tell}(\mathbf{j}, \mathbf{m}, \llbracket \text{Ans}_d \rrbracket^w(w)(\{\lambda w. \llbracket \text{Ann came} \rrbracket^w\}), w)$

(99) $\llbracket \text{Ans}_d \rrbracket^w(w)(\{\lambda w. \llbracket \text{Ann came} \rrbracket^w\})$ is defined $\Leftrightarrow \text{came}(\text{ann})(w)$

Thus, we capture the factive inference of $tell_{[+ver]}$ in its declarative-embedding use as the presupposition triggered by Ans_d projected by $tell_{[+ver]}$.

Turning to $tell_{[-ver]}$, the current analysis states that *John tells_[-ver] Mary who came* has the following assertive meaning:

(100) $\exists w' [\text{tell}(\mathbf{j}, \mathbf{m}, \llbracket \text{Ans}_d \rrbracket^w(w')(\llbracket \text{who came} \rrbracket^w), w)]$

Following the common observations and experimental evidence (Beaver 2001; Chemla 2009), I assume that presuppositions project out of existential quantification existentially. This means that (100) has the following presupposition:

(101) $\exists w' [\llbracket \text{Ans}_d \rrbracket^w(w')(\llbracket \text{who came} \rrbracket^w)$ is defined]

As the domain of quantification in (101) is the whole logical space, (101) turns out to be a very weak presupposition that it is logically possible that someone came. The declarative counterpart of this presupposition is also very weak, and certainly it does not entail factivity. For example, *John told_[-ver] Mary that Ann came* is predicted to presuppose the following:

(102) $\exists w'[\llbracket \text{Ans}_d \rrbracket^w(w')(\{\lambda w. \llbracket \text{Ann came} \rrbracket^w\}) \text{ is defined}] \Leftrightarrow \exists w'[\text{came}(\text{ann})(w')]$

This merely states that it is logically possible that Ann came. As such, the analysis correctly captures the non-factivity of $\text{tell}_{[-\text{ver}]}$.¹⁶

4.4.2.3 Preference for the veridical reading in interrogative-embedding

Before finishing the discussion of *tell*, I suggest a solution to one of the puzzles concerning communication predicates left open in the existing literature, namely, why the veridical reading is preferred in the interrogative-embedding use of communication predicates while there is no such preference in the declarative-embedding use. The current analysis offers an approach to this puzzle, provided a pragmatic principle that favors a stronger interpretation, i.e., Strongest Meaning Hypothesis (SMH; Dalrymple et al. 1998). The solution makes use of the fact that $x \text{ tells}_{[+\text{ver}]} y Q$ and $x \text{ tells}_{[-\text{ver}]} y Q$ end up having the same assertive meaning when Q is a declarative complement while the former is always stronger than the latter when Q is an interrogative complement. Thus, SMH would not prefer one reading over the other in declarative-embedding while it prefers the veridical reading over the non-veridical reading in interrogative-embedding, assuming that SMH only targets assertive meanings.

Let me illustrate the solution summarized above using the following examples:

- (103) a. John tells_[+ver] Mary who came.
 b. John tells_[-ver] Mary who came.
 (104) a. John tells_[+ver] Mary that Ann came.
 b. John tells_[-ver] Mary that Ann came.

The definedness conditions and the truth conditions given definedness of the two interrogative-embedding examples in (103) are the following:

- (105) a. $\llbracket (103a) \rrbracket^w$ is defined. $\Leftrightarrow \llbracket \text{Ans}_d \rrbracket^w(w)(\llbracket \text{who came} \rrbracket^w)$ is defined.
 If defined, $\llbracket (103a) \rrbracket^w = 1 \Leftrightarrow \text{tell}(\mathbf{j}, \mathbf{m}, \llbracket \text{Ans}_d \rrbracket^w(w)(\llbracket \text{who came} \rrbracket^w), w)$
 b. $\llbracket (103b) \rrbracket^w$ is defined $\Leftrightarrow \exists w'[\llbracket \text{Ans}_d \rrbracket^w(w')(\llbracket \text{who came} \rrbracket^w)$ is defined]
 If defined, $\llbracket (103a) \rrbracket^w = 1 \Leftrightarrow \exists w'[\text{tell}(\mathbf{j}, \mathbf{m}, \llbracket \text{Ans}_d \rrbracket^w(w')(\llbracket \text{who came} \rrbracket^w), w)]$

Focusing on the truth conditions written in the second lines of (105a) and (105b), we see that the truth conditions of (105a) is always stronger than that of (105b) (as long

¹⁶Note, however, that the analysis does not make $\text{tell}_{[-\text{ver}]}$ completely non-presuppositional. It predicts that $\text{tell}_{[-\text{ver}]}$ presupposes its declarative complement to be logically possible. Prima facie, this makes an incorrect prediction in the following kind of example:

- (1) John told Mary that $1 + 1 = 3$.

If (1) presupposes that it is logically possible that $1 + 1 = 3$, it would be mysterious why (1) can be a felicitous utterance. I take this to be an instance of the general problem with contradictory complements in possible-world semantics. Although *John believes that $1+1=3$* and *John believes that $1+1=55$* have intuitively distinct truth conditions, they cannot be distinguished in possible world semantics. Once this problem is addressed, e.g., in terms of hyperintensionality, the problem we see with the presupposition of *tell* presumably goes away.

However, the situation is different in the declarative case. Below are the definedness conditions and the truth conditions given definedness of the declarative-embedding sentences in (104) above.

- Here, crucially, the truth conditions *given definedness* for the veridical reading and the non-veridical reading are equivalent: they both state that John told Mary that Ann came. If SMH is defined to only compare assertive meanings,¹⁷ a consequence of the equivalence is that there would be no preference for one reading over the other in the declarative case.

(107) John didn't tell Mary who came # because he told her a lie.

4.4.3 *agree*-type predicates

¹⁷One might call this a STRAWSON STRONGEST MEANING HYPOTHESIS following the term Strawson Entailment from von Fintel (1999)

other two classes of predicates. Based on these facts, I will develop an analysis of the *agree*-type predicates using a different lexical semantic format than those for the *be certain*-type predicates and the communication predicates.

4.4.3.1 Assertive meaning contribution and exhaustivity

Let us first consider the examples in the following (I will discuss the ‘reciprocal’ use of *agree* as in *John and Mary agree that Ann came* later):

- (108) a. John agrees with Mary on which students came.
b. John agrees with Mary that Ann came.

Unlike *be certain*, there is much disagreement in the literature about what the truth conditions of (108a) are (see Beck and Rullmann (1999), Spector and Egré (2015) and Lahiri (2002) for different views). In this dissertation, I follow Chemla and George’s (2015) experimental result in describing the truth conditions of (108a), while also referring to earlier empirical claims in Beck and Rullmann (1999), Spector and Egré (2015) and Lahiri (2002) along the way.

According to Chemla and George’s (2015) experimental result, the truth conditions of (108a) are the following:

- (109) $\llbracket \text{John agrees with Mary on which students came} \rrbracket^w = 1$ iff
- for every answer p to *which students came* such that Mary believes p , John believes p ; and
 - for every answer p to *which students came* such that Mary does not believe p , John does not believe (i.e., is unopinionated about or disbelieves) p .

One aspect of the meaning of *agree* that sets it apart from *be certain* is that it allows the subject to have a *partial* opinion about the answers to the embedded question. According to the truth conditions in (109), it is possible for John to be unopinionated about some of the answers unless the other participant believes the answer. For example, (108a) would be true in the following situation:

- (110) **Situation** Mary believes that Ann and Bill came and Chris didn’t. John believes that Ann and Bill came, but is unopinionated about whether Chris came.

Thus, partial opinionatedness by the subject is allowed, but what about the opinionatedness by the other participant, i.e., Mary in the case of (108a)? Although the truth conditions in (109) is compatible with Mary having a partial opinion, Spector and Egré (2015) point out that (108a) in fact *presupposes* complete opinionatedness by Mary. This is illustrated in the following examples:

- (111) a. Mary is not sure about which of the ten students came. For some students, she has a definite opinion. For others, she has no idea. I can tell you this:
#John agrees with Mary about which of the ten students came.

- b. Mary is certain about which of the ten students came. She has a definite opinion about all of them. I can tell you this:
John agrees with Mary about which of the ten students came.

The last sentence in (111a) sounds odd in contrast to the same sentence in (111b). This suggests that the sentence presupposes complete opinionatedness on the embedded question by Mary.¹⁸ Thus, the description of the meaning of (109) can be refined as follows:

(112) $\llbracket \text{John agrees with Mary on which students came} \rrbracket^w$ is

- defined iff Mary is completely opinionated about *which students came*, and
- if defined, true iff for every answer p to *which students came* such that Mary believes p , John does not believe (i.e., is unopinionated about or disbelieves) p .

The truth conditions in (109)/(112) are different from the descriptions in Beck and Rullmann (1999) and Lahiri (2002). First, Beck and Rullmann (1999) require full alignment of positive and negative beliefs between the two participants. Thus, in order for (108a) to be true, for each answer p , John and Mary either both believe p , both believe $\neg p$ or are both unopinionated about p . This is stronger than (109) since (109) allows Mary believe $\neg p$ and John to be unopinionated about p . Also, Lahiri's (2002) description is different from (109) since, for him, (108a) is true as long as the set of answers that John believes is the superset of the answers that Mary believes. In their experiment, Chemla and George (2015) show that Lahiri's (2002) truth conditions make an incorrect prediction in the following kind of situation.

(113) **Situation** Mary believes that Ann and Bill came and Chris didn't. John believes that Ann, Bill and Chris came.

According to Chemla and George, (108a) is judged as false in this kind of situation. This is predicted by the truth conditions in (109) whereas Lahiri's (2002) truth conditions predict (108a) to be true in this situation.

The truth conditions in (109)/(112) can be analyzed as a type of intermediately-exhaustive (IE) reading. Given the analysis of IE presented in chapter 3, the condition in the second clause of (109) derives from matrix exhaustification by the operator X. This is to say that the 'baseline' interpretation of (108a) before the exhaustification is applied would be the following:

(114) For every answers p to *which students came*, if Mary believes p , John believes p .

¹⁸Chemla and George's (2015) experimental result does not confirm this presupposition. I suspect that this is due to the fact that their experimental procedure allows participants to disregard the difference between *x agrees with y on Q* from the reciprocal-agree construction *x and y agree on Q*, where the latter does not have the relevant presupposition.

This reading, which can be categorized as a type of weakly-exhaustive (WE) reading, turns out to be exactly the same as that in Lahiri (2002). Only, the WE reading is (correctly) predicted to be unavailable in the current analysis because of the obligatoriness of X.

How can we formally analyze the lexical semantics of *agree* so that (i) it derives the baseline reading in (114), and (ii) the appropriate IE reading can be derived from it by the application of X? A natural (but ultimately unsuccessful) hypothesis is to use the format of *be certain*-type predicates. Under such an analysis, *agree* would be decomposed as in (115), and the core predicate R_{agree} has the denotation in (116).

$$(115) \quad [R_{agree} [\text{Ans}_d \text{ CP}]]^{19}$$

$$(116) \quad \llbracket R_{agree} \rrbracket^w = \lambda \mathcal{P}_{\langle s, st \rangle} \lambda y_e \lambda x_e. \forall w' [\mathbf{DOX}_y^w \subseteq \mathcal{P}(w') \rightarrow \mathbf{DOX}_x^w \subseteq \mathcal{P}(w')]$$

Disregarding the presupposition of Ans_d , this analysis states that the baseline truth conditions of (108a)—*John agrees with Mary on which students came*—would be that all answers to *which students came* that are believed by Mary are also believed by John. More formally, this is stated as follows:

$$(117) \quad \forall w' [\mathbf{DOX}_m^w \subseteq \llbracket \text{Ans}_d \rrbracket^w(w') (\llbracket \text{which students came} \rrbracket^w) \\ \rightarrow \mathbf{DOX}_m^w \subseteq \llbracket \text{Ans}_d \rrbracket^w(w') (\llbracket \text{which students came} \rrbracket^w)]$$

At this point, the truth conditions predicted by this entry is a weakly exhaustive one, the one equivalent to (114).

So far, so good. However, a problem arises when we try to apply X above this predicate. Since R_{agree} in (116) is an intensional predicate that binds the world argument of Ans_d , X cannot appear in the same LF and quantify into the world argument of Ans_d . This is the same problem that we encountered when we attempted to apply X to *tell*_[−ver] in section 4.4.2.

Thus, the IE readings of *agree* cannot be derived from the analysis in (116).²⁰ What then would be the correct analysis of *agree* that would yield the desired IE readings when X is applied? To derive the desired IE reading of (108a), the prejacent of X has to be a proposition of the form ‘John believes *p*’ where *p* is the strongest answer to the question that Mary believes (see Sharvit 2002 for a similar analysis), and alternatives for X have to be the set of propositions of the form ‘John believes *p*’, where *p* is any possible answer to the question. That is, we want the following as the prejacent and the alternatives for X.

- (118) **Prejacent** John believes the strongest answer to *which students came* that Mary believes.

¹⁹I assume that the word order of *x R_{agree} with y CP* comes about by the head movement of R_{agree} .

²⁰A way to derive the appropriate IE reading with the analysis of *agree* in (116) would be to encode X in the lexical semantics of R_{agree} , and make it scope immediately above the consequent of the implication and below the universal quantification over worlds. This account further needs a stipulation that the **DOX** in the antecedent of the conditional is also exhaustified. The application of X only to the consequent would predict a contradiction whenever *y* believes at least two answers, one is weaker than the other. I claim that adopting the analysis in (116) while making these extra stipulations is less desirable than adopting the alternative analysis proposed below which does not require these extra assumptions to derive the appropriate IE readings.

$$\text{Alternatives} \quad \left\{ \text{John believes } p \mid p \in \left\{ \begin{array}{c} A, B, C, \\ A \wedge B, B \wedge C, C \wedge A, \\ A \wedge B \wedge C \end{array} \right\} \right\}$$

Note the parallel of this to the prejacent and alternatives for X in X *John knows which students came* in the following:

(119) X [John knows which students came]

Prejacent John believes the strongest true answer to *which students came*.

$$\text{Alternatives} \quad \left\{ \text{John believes } p \mid p \in \left\{ \begin{array}{c} A, B, C, \\ A \wedge B, B \wedge C, C \wedge A, \\ A \wedge B \wedge C \end{array} \right\} \right\}$$

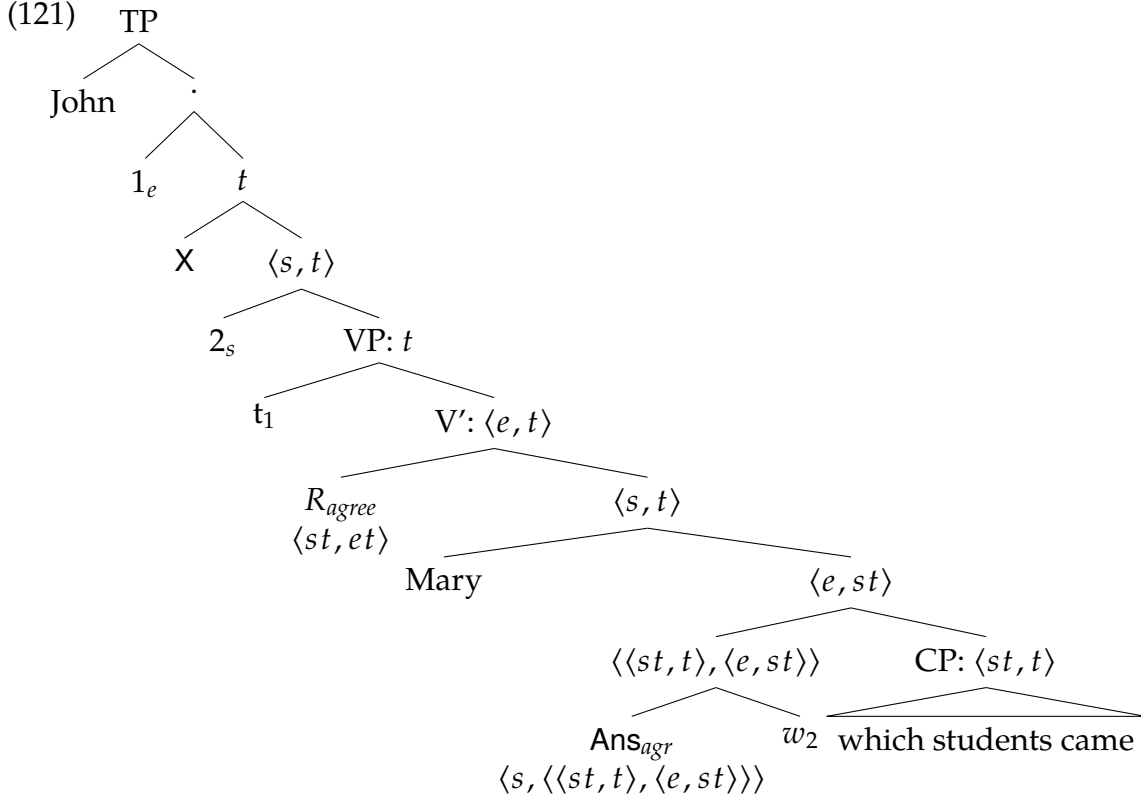
The only difference between (118) and (119) is that the prejacent in the former talks about the strongest answer that *Mary believes* while that in the latter talks about the strongest *true* answer.

My analysis of *agree* is inspired by this parallel. First of all, I define a special answerhood operator Ans_{agr} which takes an individual and a question as arguments, and returns the strongest answer to the question the individual believes.

$$(120) \quad \llbracket \text{Ans}_{agr} \rrbracket^w = \lambda w' \lambda Q_{\langle st, t \rangle} \lambda x. \left\{ \begin{array}{l} \iota p \in Q[\mathbf{DOX}_x^{w'} \subseteq p \wedge \forall p' \in Q[\mathbf{DOX}_x^{w'} \subseteq p \rightarrow p \subseteq p']] \\ \text{if } \left[\begin{array}{l} \exists! p \in Q[\mathbf{DOX}_x^{w'} \subseteq p \wedge \forall p' \in Q[\mathbf{DOX}_x^{w'} \subseteq p' \rightarrow p \subseteq p']] \\ \wedge \forall p \in Q[\mathbf{DOX}_x^{w'} \subseteq p \vee \mathbf{DOX}_x^{w'} \subseteq \neg p] \end{array} \right] \\ \text{undefined otherwise} \end{array} \right.$$

Instead of picking up the strongest *true* answer of the given question, Ans_{agr} picks up the strongest answer *that the given individual believes*. Furthermore, in addition to the usual uniqueness and existential presuppositions, Ans_{agr} has the excluded-middle presupposition (i.e., $\forall p \in Q[\mathbf{DOX}_x^w \subseteq p \vee \mathbf{DOX}_x^w \subseteq \neg p]$) which effectively guarantees the individual's complete opinionatedness about the question.

Given this special answerhood operator, I analyze the LF representation of (108a)—*John agrees with Mary on which students came*—as in (121), with the argument *Mary* introduced as the external argument of Ans_{agr} .



Defining the denotation of R_{agree} as ‘believe’, as shown in (122), we can derive the semantic value of the prejacent of X as in (123).

$$(122) \quad \llbracket R_{agree} \rrbracket^w = \lambda p_{\langle s, t \rangle} \lambda x. \mathbf{DOX}_x^w \subseteq p$$

$$(123) \quad \llbracket [\text{John } [R_{agree} [\text{Mary } [\text{Ans}_{agr} w_2] [\text{which students came}]]]] \rrbracket^{w, g} \\ \Leftrightarrow \mathbf{DOX}_j^w \subseteq \llbracket \text{Ans}_{agr} \rrbracket^w (g(2))(\mathbf{m})(\llbracket \text{which students came} \rrbracket^w) \\ \text{i.e., ‘John believes the strongest answer to } w_2 \text{ that is believed by Mary in world } g(2).’$$

What this asserts is equivalent to the WE reading of the sentence *John agrees with Mary on which students came* paraphrased in (114). The presupposition of (123) will be discussed in the next section. What is important here is that, applying X above R_{agree} as in (121) would derive the desired IE reading. The alternative value corresponding to (123) would be the set of propositions of the form ‘John believes p ’ for any answer of *which students came*.

To wrap up, we have seen that *agree* exhibits an IE reading, and that neither the lexical semantic format for *be certain*-type predicates nor that for communication predicates captures this fact. I proposed a semantics for *agree* based on a revised answerhood operator that returns the strongest answer that a given individual believes. Given this semantics, the IE reading can be captured by the application of X, as in the case of veridical predicates such as *know*.

4.4.3.2 Presuppositional behaviors of *agree*

Next, let us discuss the presuppositional behaviors of *agree* and how they are accounted for in the analysis developed in this section. First of all, what are the empirically attested presuppositions of the sentences involving *agree*, such as the following?

- (124) a. John agrees with Mary on which students came.
b. John agrees with Mary that Ann came.

The presupposition of (124b) is less controversial than that of (124a): (124b) presupposes that Mary believes that Ann came. This can be confirmed by the same inference we can draw from the negated and polar-question versions of (124b):

- (125) a. John does not agree with Mary that Ann came.
⇒ Mary believes that Ann came.
b. Does John agree with Mary that Ann came?
⇒ Mary believes that Ann came.

On the other hand, what kind of presupposition (124a) carries is less established. First of all, as I discussed in section 4.4.3.1, I follow Spector and Egré (2015) in assuming that (124a) presupposes Mary's complete opinionatedness about which students came. Furthermore, the existential and uniqueness presuppositions of the interrogative complements of *agree*, as in (124a) and (126), project in a specific way.

- (126) John agrees with Mary about which student came.

Intuitively, (126) seems to presuppose that Mary believes that exactly one student came. This is also supported by the fact that the negated sentence in (127a) and the polar question in (127b) leads to the same inference.

- (127) a. John doesn't agree with Mary about which student came.
⇒ Mary believes that exactly one student came.
b. Does John agree with Mary about which student came?
⇒ Mary believes that exactly one student came.

I will discuss later whether the sentences also presupposes that *John* believes that exactly one student came.

4.4.3.3 Accounting for the presuppositions

It turns out that the presuppositional behaviors of *agree* discussed above can be straightforwardly accounted for by the presupposition triggered by Ans_{agr} . To see this, let us consider the predicted interpretations of the three types of sentences discussed in the previous section, i.e., *agree*+plural-*which*, *agree*+singular-*which* and *agree*+*that*. Below are the semantic values of the examples of each of the three types of *agree*-sentences.

- (128) a. $\llbracket \text{X} [1 \llbracket \text{John agrees with Mary on } [\llbracket \text{Ans}_{agr} w_1 \rrbracket \text{ which students came} \rrbracket] \rrbracket \rrbracket^{w,g}$
 $\Leftrightarrow \llbracket \text{X} \rrbracket^w (\lambda w \lambda w'. \text{DOX}_j^w \subseteq \llbracket \text{Ans}_{agr} \rrbracket^w (w') (\llbracket \text{which students came} \rrbracket^w) (\mathbf{m}))$

- b. $\llbracket \text{John agrees with Mary on } [\llbracket \text{Ans}_{agr} w_1 \rrbracket \text{ which student came}] \rrbracket^{w,g}$
 $\Leftrightarrow \llbracket X \rrbracket^w (\lambda w \lambda w'. \text{DOX}_j^w \subseteq \llbracket \text{Ans}_{agr} \rrbracket^w (w') (\llbracket \text{which student came} \rrbracket^w) (\mathbf{m}))$
- c. $\llbracket \text{John agrees with Mary } [\llbracket \text{Ans}_{agr} w_1 \rrbracket \text{ Id that Ann came}] \rrbracket^{w,g}$
 $\Leftrightarrow \llbracket X \rrbracket^w (\lambda w \lambda w'. \text{DOX}_j^w \subseteq \llbracket \text{Ans}_{agr} \rrbracket^w (w') (\{\lambda w. \llbracket \text{Ann came} \rrbracket^w\}) (\mathbf{m}))$

Assuming that X projects the presupposition of its prejacent,²¹ we have the following definedness conditions for the above three sentences.

- (129) a. (128a) is defined $\Leftrightarrow \llbracket \text{Ans}_{agr} \rrbracket^w (w) (\llbracket \text{which students came} \rrbracket^w) (\mathbf{m})$ is defined.
- b. (128b) is defined $\Leftrightarrow \llbracket \text{Ans}_{agr} \rrbracket^w (w) (\llbracket \text{which student came} \rrbracket^w) (\mathbf{m})$ is defined.
- c. (128c) is defined $\Leftrightarrow \llbracket \text{Ans}_{agr} \rrbracket^w (w) (\{\lambda w. \llbracket \text{Ann came} \rrbracket^w\}) (\mathbf{m})$ is defined.

As in the definition repeated below, $\llbracket \text{Ans}_{agr} \rrbracket^w (w) (Q) (x)$ triggers the presupposition that there is a unique strongest answer to Q that x believes. In addition, it also presupposes that x is completely opinionated about Q .

$$(120) \quad \llbracket \text{Ans}_{agr} \rrbracket^w = \lambda w' \lambda Q_{\langle st, t \rangle} \lambda x. \begin{cases} \text{if } \left[\begin{array}{l} \exists! p \in Q[\text{DOX}_x^{w'} \subseteq p \wedge \forall p' \in Q[\text{DOX}_x^{w'} \subseteq p \rightarrow p \subseteq p']] \\ \wedge \forall p \in Q[\text{DOX}_x^{w'} \subseteq p \vee \text{DOX}_x^{w'} \subseteq \neg p] \end{array} \right] \\ \text{undefined otherwise} \end{cases}$$

Assuming the complement denotations in (130) for simplicity, the presuppositions of the statements in (128) would be the ones in (131), respectively:

- (130) a. $\llbracket \text{which students came} \rrbracket^w = \{A, B, C, A \wedge B, B \wedge C, C \wedge A, A \wedge B \wedge C\}$
- b. $\llbracket \text{which student came} \rrbracket^w = \{A, B, C\}$
- c. $\llbracket \text{Id that Ann came} \rrbracket^w = \{A\}$
- (131) a. $\exists! p \in (130a)[\text{DOX}_m^w \subseteq p \wedge \forall p' \in (130a)[\text{DOX}_m^w \subseteq p' \rightarrow p \subseteq p']]$
 $\wedge \forall p \in (130a)[\text{DOX}_x^{w'} \subseteq p \vee \text{DOX}_x^{w'} \subseteq \neg p]$
- b. $\exists! p \in (130b)[\text{DOX}_m^w \subseteq p \wedge \forall p' \in (130b)[\text{DOX}_m^w \subseteq p' \rightarrow p \subseteq p']]$
 $\wedge \forall p \in (130b)[\text{DOX}_x^{w'} \subseteq p \vee \text{DOX}_x^{w'} \subseteq \neg p]$
- c. $\exists! p \in \{A\}[\text{DOX}_m^w \subseteq p \wedge \forall p' \in \{A\}[\text{DOX}_m^w \subseteq p' \rightarrow p \subseteq p']]$
 $\wedge \forall p \in \{A\}[\text{DOX}_x^{w'} \subseteq p \vee \text{DOX}_x^{w'} \subseteq \neg p]$

In prose, these are equivalent to the following, respectively.

- (132) a. There is a unique strongest answer in (130a) that Mary believes in w , and that Mary has a determinate opinion about each proposition in (130a).
- b. There is a unique strongest answer in (130b) that Mary believes in w , and that Mary has a determinate opinion about each proposition in (130b).
- c. There is an answer in $\{A\}$ that Mary believes in w , and that Mary has a determinate opinion about A .

²¹See footnote 4 for the details of this assumption.

These presuppositions turn out to entail what we observed for the corresponding sentences in the previous section. The presupposition of *agree+plural-which* in (131a) entails that Mary believes some member of (130a). As long as Mary believes some member of (130a), there will be a unique strongest member of (130a) such that Mary believes given that both (130a) and Mary's beliefs are closed under conjunction. Second, the presupposition of *agree+singular-which* in (131b) is satisfied as long as Mary believes only one proposition among (130b). Furthermore, the excluded-middle component tells us that Mary disbelieves other propositions in (130b). Together, the predicted presuppositions entail that Mary believes that exactly one student came. Finally, the presupposition of *agree-that* in (131c) simply says that Mary believes *A*, as the uniqueness requirement is vacuous when the question is a singleton.

4.4.3.4 Presupposition with respect to the subject?

Note that the account so far predicts an asymmetry between the subject and the 'with'-phrase. That is, it predicts existential and uniqueness presuppositions to be met with respect to the belief state of the 'with'-phrase, but it does not predict any presupposition with respect to the subject's belief state. Is this prediction correct? Chemla and George's (2015) result speaks against it: there is an existential presupposition also with respect to the agent's belief state. In other words, the following kind of sentence is judged as infelicitous:

- (133) Although Mary believes that Ann came, John believes that no student came.
So, John does not agree with Mary about which students came.

A parallel judgment holds about uniqueness. The uniqueness presupposition of *which student came* seems to be projected into John's belief as well as Mary's belief in the following sentence:

- (134) Although Mary believes that Ann came, John believes that Ann and Bill came.
So, John does not agree with Mary about which student came.

A further problem is that, despite the symmetric behavior of the presupposition of *agree + interrogatives*, the presupposition of *agree + declaratives* behaves asymmetrically. That is, *John agrees with Mary that Ann came* just presupposes that Mary believes that Ann came. In fact, if the sentence presupposed that both John and Mary believes that Ann came, the presupposition would entail the assertion.²²

I do not have a complete solution to this problem, but I will suggest an idea that at least provides an approach to the problem. The idea is based on the distinction

²²One might wonder if the principle in (71) above, which prevents a presupposition projection from resulting in a trivial utterance would work here as well. That is, *agree* always projects presuppositions with respect to both the agent and the 'with'-participant modulo cases where that would result in triviality. However, such an account is problematic since it does not answer why there is an asymmetry between the agent and the 'with'-participant in the declarative case, i.e., why doesn't *John agrees with Mary that Ann came* only presupposes that Mary believes that Ann came.

between the reciprocal and non-reciprocal uses of *agree*. The reciprocal use of *agree* is exemplified in (135), which involves a plurality as its subject and lacks the *with*-phrase, as in the construction in (136).

(135) John and Mary agree on which student came.

(136) John agrees with Mary on which student came.

Following Lahiri (2002), I assume that the semantic value of the construction of the form in (135) can be analyzed as the conjunction of two non-reciprocal constructions, i.e., (137) below:

(137) John agrees with Mary on which student came and Mary agrees with John on which student came.

So far, my analysis has assumed that *agree* in (136) is always non-reciprocal, i.e., there is an asymmetry between John and Mary in the interpretation of (136) unlike in the case of (135). However, the symmetry of the existential and uniqueness presuppositions in (136) suggests that this assumption is incorrect, suggesting that *agree* in (136) also has a reciprocal reading. I analyze the reciprocal *agree*, or *agree*_[+rec], as follows:

(138) $\llbracket \text{agree}_{[+rec]} \rrbracket^w = \lambda Q_{\langle st, t \rangle} \lambda X. \forall x, y \leq_a X [\llbracket R_{agree} \rrbracket^w (\llbracket \text{Ans}_{agr} \rrbracket^w (w)(Q)(y))(x)]$
 (\leq_a stands for the ‘atomic part of’ relation, i.e., $x \leq_a X \Leftrightarrow x \leq X \wedge \mathbf{Atom}(x)$)

Then, depending on whether *agree* has a non-reciprocal reading or a reciprocal reading, (136) has the following two analyses (Here, I disregard X as it is irrelevant):

- (139) a. $\llbracket \text{John agrees}_{[-rec]} \text{ with Mary on which students came} \rrbracket^w$
 $\Leftrightarrow \mathbf{DOX}_j^w \subseteq \llbracket \text{Ans}_{agr} \rrbracket^w (w)(\llbracket \text{which students came} \rrbracket^w)(\mathbf{m})$
 b. $\llbracket \text{John agrees}_{[+rec]} \text{ with Mary on which students came} \rrbracket^w$
 $\Leftrightarrow \forall x, y \leq_a \mathbf{j} \oplus \mathbf{m} [\mathbf{DOX}_x^w \subseteq \llbracket \text{Ans}_{agr} \rrbracket^w (w)(\llbracket \text{which students came} \rrbracket^w)(y)]$

The statement in (139b) projects the presupposition triggered by Ans_{agr} with respect to both John and Mary. Thus, the presupposition with respect to the subject is correctly accounted for in the reciprocal reading. I have to leave open the question of how the *with*-phrase in (139b) ends up constituting a collective DP with the subject. I simply note here that the syntactic alternation called RECIPROCAL ALTERNATION observed for predicates, such as *argue*, *banter*, *cooperate* in addition to *agree*, derives the same effect (Levin 1993).

The next question is why *agree+that* does not exhibit the symmetric behavior. The explanation lies in the fact the presupposition of the reciprocal *agree* would entail the assertion in the declarative case, but not in the interrogative case. Below, I summarize the presuppositions predicted by the reciprocal *agree* for *agree* + interrogatives and *agree* + declaratives.

(140) John agrees_[+rec] with Mary on which student came.

Presupposition: John believes that exactly one student came & Mary believes that exactly one student came.

(141) John agrees_[+rec] with Mary that Ann came.

Presupposition: John believes that Ann came & Mary believes that Ann came.

As one can see, the reciprocal presuppositions in the interrogative case does not entail the assertion while that in the declarative case ends up entailing the assertion. Assuming that there is a general dispreference against an utterance whose presupposition entails its assertion, we would predict that the reciprocal *agree* is dispreferred in *agree* + declaratives.

One issue with this account is that *agree*+interrogatives seems to *prefer* the reciprocal reading to the non-reciprocal reading although the current account only captures a *possibility* of the reciprocal reading. A plausible way out would be to assume a lexical preference for the reciprocal *agree*. More empirical investigation is needed to make a concrete theoretical proposal about the preference between the reciprocal and non-reciprocal *agree*.²³

4.4.4 Deriving Spector and Egré's generalization

In the previous section, I considered the semantics of three classes of non-factive responsive predicates: the *be certain*-type predicates, the communication predicates and the *agree*-type predicates. In this section, by comparing the lexical semantic format for these three types of predicates and that for factive predicates presented in section 4.2, I will illustrate how Spector and Egré's generalization can be straightforwardly derived in the current analysis. Spector and Egré's generalization is repeated below.

(31) **Spector and Egré's Generalization**

A responsive predicate *V* is *veridical* with respect to interrogative-embedding iff *V* is *veridical* with respect to declarative-embedding.

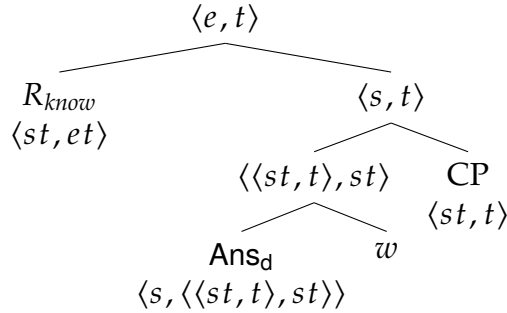
Here is how the generalization is captured in the current analysis in a nutshell. Every responsive predicate *V*, whether it is veridical or non-veridical, is decomposed into a higher 'core' predicate R_V and an answerhood operator Ans_d or Ans_{agr} . In this architecture, there are two ways for a responsive predicate to be veridical with respect to interrogative-embedding: either (i) by having Ans_d evaluated in the matrix evaluation world (as in *know* and *tell*_[+ver]) or (ii) by having a veridical core predicate R_V (as in *prove* and *be clear*). Once our central proposal that declarative complements are singleton questions is taken into account, we see that predicates with either type of semantics turn out to be veridical with respect to declarative-embedding. In case (i), the predicate ends up being factive (and hence veridical) with respect to declarative-embedding while, in case (ii), the predicate ends up veridical, but not necessarily factive. Since there is no other way for a predicate to be veridical with respect to declarative-embedding, veridicality with respect to interrogative-embedding and veridicality with respect to declarative-embedding completely align with each other.

²³Chemla and George (2015) offer experimental data suggesting that only the symmetric/reciprocal reading is robust at least in the interrogative case.

4.4.4.1 Factive predicates

We start by looking at the properties of factive predicates. As exemplified in the following decompositional structure of *know*, factive predicates involve a core predicate that takes a propositional argument, and uses Ans_d instead of Ans_{agr} .

(142) The decomposition of *know*



$$(143) \quad \llbracket R_{know} \rrbracket^w = \lambda p_{\langle s, t \rangle} \lambda x. \mathbf{DOX}_x^w \subseteq p$$

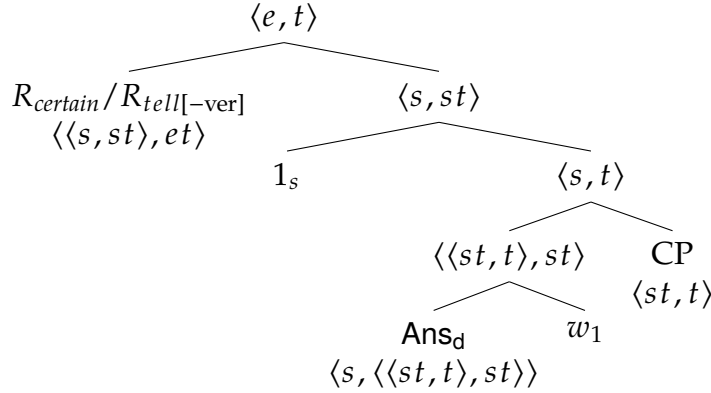
This treatment captures the veridicality of *know* with respect to interrogative-embedding since the world argument of Ans_d is not bound by R_{know} . More precisely, the world argument will be later bound by X , which asserts its ‘prejacent’, i.e., the proposition involving the evaluation world in the place of the world argument of Ans_d .

When a predicate of this type embeds a declarative complement, the predicate ends up being factive. The factivity is captured as a limiting case of the existential presupposition triggered by Ans_d . That is, when the CP in (142) is a declarative complement, the existential presupposition triggered by Ans_d states that the unique proposition in the denotation is true in the matrix evaluation world. Thus, we see that this type of predicates are veridical with respect to interrogative-embedding and factive (and hence veridical) with respect to declarative-embedding.

4.4.4.2 *be certain*-type predicates and the communication predicates

On the other hand, the *be certain*-type predicates and the communication predicates involve core predicates that take a propositional concept as their first argument, and binds the world argument of Ans_d . This is shown in the following decompositional structures of *be certain* and $\text{tell}_{[-\text{ver}]}$ annotated with semantic types.

(144) The decomposition of *be certain/tell*_[−ver]



$$(145) \quad \llbracket R_{\text{certain}} \rrbracket^w = \lambda \mathcal{P}_{\langle s, st \rangle} \lambda x. \forall w' [w' \in \mathbf{DOX}_x^w \rightarrow \mathbf{DOX}_x^w \subseteq \mathcal{P}(w')]$$

$$(146) \quad \llbracket R_{\text{tell}[-\text{ver}]} \rrbracket^w = \lambda \mathcal{P}_{\langle s, st \rangle} \lambda x \lambda y. \exists w' [\text{tell}(x, y, \mathcal{P}(w'), w)]$$

In this case, the world argument of Ans_d is bound by the core predicates R_{certain} or $R_{\text{tell}[-\text{ver}]}$. The difference between the two is in the quantificational force of the quantification over worlds: it is universal in the case of R_{certain} while existential in the case of $R_{\text{tell}[-\text{ver}]}$. In either case, non-veridicality ensues from the treatments, as there is no guarantee in the semantics that Ans_d would be evaluated in the matrix evaluation world. For example, the analysis of *be certain* above accounts for its non-veridicality since Ans_d is evaluated in the worlds compatible with the subject's beliefs, which may consist solely of worlds other than the matrix evaluation world. Also, the analysis of *tell*_[−ver] accounts for its non-veridicality since the analysis states that Ans_d is evaluated in *some* world whether or not it is the matrix evaluation world.

The analyses furthermore accounts for the non-veridicality of these predicates with respect to declarative-embedding. Here's why: the quantifications over worlds in R_{certain} and $R_{\text{tell}[-\text{ver}]}$ would be vacuous when the question is a singleton, and thus the semantic values for *be certain that* and *tell*_[−ver] *that* would look like the following:

$$(147) \quad \begin{aligned} \text{a. } & \llbracket R_{\text{certain}} [1 [\text{Ans}_d w_1] [\text{Id that Ann came}]] \rrbracket^w = \lambda x. \mathbf{DOX}_x^w \subseteq A \\ \text{b. } & \llbracket R_{\text{tell}[-\text{ver}]} [1 [\text{Ans}_d w_1] [\text{Id that Ann came}]] \rrbracket^w = \lambda x. \text{tell}(x, y, A, w) \end{aligned}$$

Since the metalanguage predicates \mathbf{DOX} and tell are non-veridical, the predicates in (147) are non-veridical.

Importantly, this does not mean that the decompositional format in (144) itself guarantees non-veridicality. Rather, the format itself *underspecifies* veridicality, and the veridicality of a predicate V with this decompositional format depends on the veridicality of the metalanguage predicate involved in the core predicate R_V . This means that it is in principle possible for a predicate to have this format, but still be veridical.

This is exactly what happens with veridical non-factive predicates like *prove* and *be clear*. The examples showing the veridicality and non-factivity of these predicates are repeated below:

- (148) a. John **proved** which academic degree he has.
 \Rightarrow For some true answer p to the question ‘Which academic degree does John have?’, John proved p . (Veridical wrt interrogative-embedding)
- b. John **proved** that he has a PhD.
 \Rightarrow John has a PhD. (Veridical wrt declarative-embedding)
- c. John didn’t **prove** that he has a PhD.
 \Rightarrow John has a PhD (Non-factive)
- (149) a. It is **clear** who the culprit is.
 \Rightarrow For some true answer p to the question ‘Who is the culprit?’, it is clear that p . (Veridical wrt interrogative-embedding)
- b. It is **clear** that Sue is the culprit.
 \Rightarrow Sue is the culprit. (Veridical wrt declarative-embedding)
- c. It is not **clear** that Sue is the culprit.
 \Rightarrow Sue is the culprit. (Non-factive)

These predicates can be analyzed to have the decompositional format in (144), yet they are veridical by virtue of the veridicality of the metalanguage predicate involved in R_V . R_{prove} and R_{clear} have the existential semantics just like $tell_{[-ver]}$, as follows:

- (150) a. $\llbracket R_{prove} \rrbracket^w = \lambda \mathcal{P}_{\langle s, st \rangle} \lambda x. \exists w' [\text{prove}(x, \mathcal{P}(w'), w)]$
b. $\llbracket R_{clear} \rrbracket^w = \lambda \mathcal{P}_{\langle s, st \rangle} \exists w' [\text{clear}(\mathcal{P}(w'), w)]$

The metalanguage predicates **prove** and **clear** are veridical. That is, the following holds.

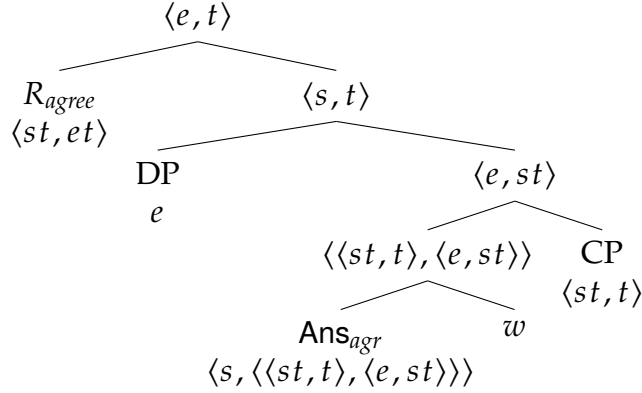
- (151) a. $\forall p \forall x \forall w [\text{prove}(x, p, w) \rightarrow p(w)]$
b. $\forall p \forall w [\text{clear}(p, w) \rightarrow p(w)]$

This suffices to account for their veridicality both with respect to interrogative-embedding and with respect to declarative-embedding. Furthermore, their non-factivity is accounted for. This is so since (i) the metalanguage predicates **prove** and **clear** are not factive, i.e., they don’t presuppose the truth of their propositional argument, and (ii) Ans_d is not evaluated in the matrix evaluation world given the decompositional format.

4.4.4.3 agree-type predicates

Finally, let us consider the last class of non-veridical predicates, i.e., the *agree*-type predicates. In the decomposition of this class of predicates, the core predicate takes a propositional argument and the answerhood operator is Ans_{agr} . The following represents the decomposition of *agree* including the external argument of Ans_{agr} .

(152) The decomposition of *agree*



(153) $\llbracket R_{agree} \rrbracket^w = \lambda p_{\langle s, t \rangle} \lambda x. \mathbf{DOX}_x^w \subseteq p$

(120) $\llbracket \mathbf{Ans}_{agr} \rrbracket^w = \lambda w' \lambda Q_{\langle st, t \rangle} \lambda x.$

$$\left\{ \begin{array}{l} \iota p \in Q[\mathbf{DOX}_x^{w'} \subseteq p \wedge \forall p' \in Q[\mathbf{DOX}_x^{w'} \subseteq p \rightarrow p \subseteq p']] \\ \text{if } \left[\begin{array}{l} \exists! p \in Q[\mathbf{DOX}_x^{w'} \subseteq p \wedge \forall p' \in Q[\mathbf{DOX}_x^{w'} \subseteq p' \rightarrow p \subseteq p']] \\ \wedge \forall p \in Q[\mathbf{DOX}_x^{w'} \subseteq p \vee \mathbf{DOX}_x^{w'} \subseteq \neg p] \end{array} \right] \\ \text{undefined otherwise} \end{array} \right]$$

Non-veridicality of *agree* with respect to interrogative-embedding follows from this analysis since the proposition believed by \mathbf{Ans}_{agr} , i.e., the strongest answer believed by its external argument, is not necessarily a true one. The predicate is non-veridical also with respect to declarative-embedding. According to the current analysis, *John agree with Mary that p* would mean ‘John believes the strongest answer in $\{p\}$ that Mary believes’, presupposing that Mary in fact believes p . Here, p may or may not be true, hence the non-veridicality of *agree* with respect to declarative-embedding.

4.4.4.4 Wrap up

The typology of the lexical semantics of responsive predicates presented in this section is summarized in Figure 4-2 as annotations to the tree in Figure 4-1.

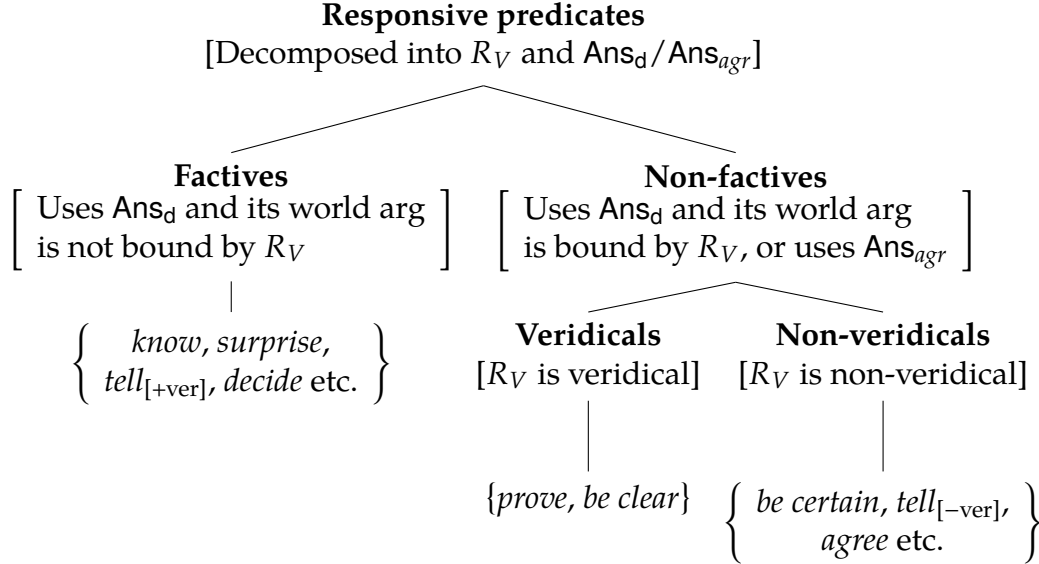


Figure 4-2: Summary of the analysis of the typology of responsive predicates

In the current analysis, the distinction between factive and non-factive predicates is captured in terms of the difference in their decompositional format. Factive predicates involve Ans_d whose world argument is left free by the core predicate R_V while non-factive predicates either (i) involve Ans_d whose world argument is bound by R_V or (ii) uses Ans_{agr} . Although factivity entails veridicality, non-factivity does not necessarily entail non-veridicality. Within non-factive predicates, there are veridical and non-veridical predicates depending on the veridicality of the predicate R_V .

Before closing the section, let me discuss the possibility of accounting for another generalization in the current analysis. The generalization concerns a connection between factivity and question-embeddability, and can be stated as follows:²⁴

(154) **Generalization: factivity entails question-embeddability**

A predicate is factive only if it can embed an interrogative complement.

This generalization follows from the current analysis if we make a further assumption

²⁴Similar generalizations are advocated by a number of authors such as Hintikka (1975), Sæbø (2007) and Egré (2008) although they discuss slightly different generalizations from (154). For example, Hintikka (1975) and Sæbø (2007) aim to explain why *believe* cannot take a question based on the generalization that only factive predicates can take questions, which is the converse of (154). Also, Egré (2008) discusses the generalization that *veridicality* as opposed to factivity entails question-embeddability. See Egré (2008) and references therein for related recent studies.

that Ans_d is the *only* way in which a predicate can be factive. In other words, proposition-taking predicates are never factive by themselves.

An immediate question that arises here concerns factive non-responsive predicates such as *regret* and *resent*. These predicates seem to have a factive presupposition, as illustrated in the following:

- (155) a. John {regrets/resents} that Mary left him.
 b. John doesn't {regret/resent} that Mary left him.
 c. Does John {regret/resent} that Mary left him?
 \Rightarrow Mary left him.

Despite the appearance of factivity, however, several authors have claimed that these predicates only presuppose that the subject believes the complement, instead of the complement being true (Klein 1975; Huddleston and Pullum 2002; Sæbø 2007). Examples showing that support such a claim about *regret* are given below:

- (156) John mistakenly believed that Mary was gone, and he {regretted/resented} that she left him.
 (157) Falsely believing that he had inflicted a fatal wound, Oedipus regretted killing the stranger on the road to Thebes. (Klein 1975)
 (158) Ed believed that he had offended his parents and very much regretted that he had done so, but it turned out that he had been mistaken: they had not in the least been offended. (Huddleston and Pullum 2002)

If this kind of claims can be made for all non-factive non-responsive attitude predicates, then the generalization in (154) would be empirically valid. And, the generalization would be straightforwardly captured in the current analysis once we assume that proposition-embedding predicates cannot be factive by themselves. I would like to leave further empirical investigations of this claim for future studies, and keep it open in this dissertation whether in fact all factive predicates are question-embedding predicates.²⁵

4.4.5 Presupposition projection in terms of Strong Kleene

4.4.5.1 Trivalent approach to presupposition projection

In section 4.4.1, I considered two possibilities for the projection pattern of presuppositions in the scope of universal statements. Below is the summary of the projection patterns of the presupposition $\pi(x)$ triggered in the scope of the universal statement of the following form:

- (159) $\forall x[\varphi(x) \rightarrow \psi(x)_{\pi(x)}]$

²⁵In chapter 2, I claimed that *regret* and *resent* are factive predicates in two places: first to show the independence of factivity from the possibility of embed questions, and secondly to point out problems with Ginzburg's (1995) account. My claim in the former can be replaced with a weaker claim that not all question-embedding predicates are factive. My claim in the latter can be dropped without affecting the other arguments against Ginzburg (1995).

Universal projection $\forall x[\varphi(x) \rightarrow \pi(x)]$

Existential projection $\exists x[\varphi(x) \wedge \pi(x)]$

I argued that presuppositional behaviors of *be certain* can be captured by universal projection, except the behavior of *be certain+that*, which seems to require an independent explanation under the universal projection.

In this section, I discuss the third analytic possibility that can offer a unified treatment of the (seemingly) universal projection of responsive predicates in most cases as well as the existential projection of *be certain* + declaratives. The possibility is to model the presupposition projection using a trivalent logic, in particular, Strong Kleene logic (Kleene 1952). Trivalent approaches to presupposition projection are advocated by Karttunen (1973), Beaver and Krahmer (2001), George (2008) and Fox (2012). Trivalent logic is suited for this purpose since we can understand the third value—the semantic value of a sentence whose presupposition is not met—as the state of uncertainty, and we can model presupposition projection in terms of how the uncertainty ‘projects’. For example, how the usncertainty projects in the case of a conjunction $\varphi \wedge \psi$ can be described as follows using epistemic terms:

(160) $\varphi \wedge \psi$

- If we know that both conjuncts are true, we know that $\varphi \wedge \psi$ is true.
- If, for either conjunct, we know that it is false, we know that $\varphi \wedge \psi$ is false, no matter what we know about the other conjunct.
- Otherwise (i.e., if, for either conjunct, we know that it is true and we don’t know the truth value of the other conjunct), we don’t know the truth value of $\varphi \wedge \psi$.

By representing the state of knowing that a sentence is true as the value 1, the state of knowing that a sentence is false as the value 0, and not knowing its truth value as the third value, i.e., #, we can model the projection of (un)certainly in a conjunction, described in (160), in the following trivalent truth table:

(161)

\wedge	1	0	#
1	1	0	#
0	0	0	0
#	#	0	#

In this picture, then, a conjunction is free from presupposition failure if (i) both conjuncts satisfy their presuppositions, or (ii) one of the conjuncts is such that it satisfies its presupposition and is false. We can generalize this strategy to other operators, achieving a general theory of presupposition projection that does not simply stipulate a projection property for each operator. The result of generalizing this to other logical connectives turns out to be equivalent to the system of Strong Kleene.

Let us then move on to what this approach predicts about the presupposition projection pattern of the universal statement $\forall x[\varphi(x) \rightarrow \psi(x)_{\pi(x)}]$. First of all, the value of $\psi(x)_{\pi(x)}$ is determined as follows:

$$(162) \quad \psi_{\pi} = \begin{cases} 1 & \text{if } \pi \wedge \psi \\ 0 & \text{if } \pi \wedge \neg\psi \\ \# & \text{otherwise} \end{cases}$$

Given this, the universal quantification $\forall x[\varphi(x) \rightarrow \psi(x)_{\pi(x)}]$ receives the three semantic values under the following respective circumstances:

$$(163) \quad \forall x[\varphi(x) \rightarrow \psi(x)_{\pi(x)}] = \begin{cases} 1 & \text{if } \forall x[\varphi(x) \rightarrow \pi(w) \wedge \psi(x)] \\ 0 & \text{if } \exists x[\varphi(x) \wedge \pi(w) \wedge \neg\psi(x)] \\ \# & \text{otherwise} \end{cases}$$

Note that this is simply a generalization of the truth table in (161). In the epistemic terms introduced above, this is to say that the universal quantification is known to be true if all individuals that satisfy the restrictor is known to be true of the scope (i.e., they satisfy both the presupposition and the assertion of the scope). It is known to be false if at least one individual that satisfy the restrictor is known to be false of the scope (i.e., it satisfies the presupposition but does not satisfy the assertion). Otherwise, the value of the universal quantification is unknown.

This means that $\forall x[\varphi(x) \rightarrow \psi(x)_{\pi(x)}]$ is presupposition-free (i.e., it returns 1 or 0) if and only if the following disjunction holds:

$$(164) \quad \forall x[\varphi(x) \rightarrow \pi(w) \wedge \psi(x)] \vee \exists x[\varphi(x) \wedge \pi(w) \wedge \neg\psi(x)]$$

This in turn is equivalent to the following:²⁶

$$(165) \quad \forall x[\varphi(x) \rightarrow \pi(w)] \vee \exists x[\varphi(x) \wedge \pi(w) \wedge \neg\psi(x)]$$

Hence, (165) is the presupposition of the universal statement predicted by the trivalent approach. Similarly, we can derive the presupposition of the existential statement $\exists x[\varphi(x) \wedge \psi(x)_{\pi(x)}]$ as follows:

$$(166) \quad \forall x[\varphi(x) \rightarrow \pi(w)] \vee \exists x[\varphi(x) \wedge \pi(w) \wedge \psi(x)]$$

Note that these presuppositions are intermediate in logical strength between the existential projection and universal projection.

4.4.5.2 Resolving the dilemma posed by *be certain* + declaratives

The Strong Kleene approach is interesting in the context of the current analysis because it offers a way to resolve the dilemma posed by the (seemingly) universal projection behavior by responsive predicates in most cases and the existential projection behavior in *be certain+that*. Let us see how the approach accounts for the data other than *be certain+that* first.

²⁶This is so because if $\forall x[\varphi(x) \rightarrow \pi(w)]$ is true and $\forall x[\varphi(x) \rightarrow \pi(w) \wedge \psi(x)]$ is false, then $\exists x[\varphi(x) \wedge \pi(w) \wedge \neg\psi(x)]$ is true.

Above, I argued that universal projection rather than the existential projection is compatible with the presupposition projection behavior of *be certain* + interrogatives. In the case of the projection of the uniqueness presupposition from the interrogative complement, this claim is supported by the following contrast:

- (58) a. John believes that there were either one or two students who came to the party.
 # He is not certain which student.
 b. John believes that there was only one student who came to the party.
 He is not certain which student.

In the above examples, the presupposition predicted by the existential projection is that it is compatible with John's beliefs that exactly one student came. On the other hand, the presupposition predicted by the universal projection is that John believes that exactly one student came. Only the latter prediction captures the contrast in felicity between (58a) and (58b).

How does the Strong Kleene approach fare with these data? The prediction of the theory is that the sentence *John is certain which student came* as well as its negation *John is not certain which student came* presuppose the following disjunction.

$$(167) \quad \forall w' \left[\begin{array}{l} w' \in \mathbf{DOX}_x^w \rightarrow \\ \exists! x[\mathbf{came}(x)(w')] \end{array} \right] \vee \left[\begin{array}{l} w' \in \mathbf{DOX}_x^w \wedge \\ \exists! x[\mathbf{came}(x)(w')] \wedge \\ \mathbf{DOX}_x^w \not\subseteq \llbracket \mathbf{Ans}_d \rrbracket^w(w')(\llbracket \text{which student came} \rrbracket) \end{array} \right]$$

Since this presupposition is weaker than the universal projection it is obvious that it is predicted to be satisfied in (58b). What about (58a)? The context given in (58a) satisfies the Strong Kleene presupposition since it validates the second disjunct of (167). However, note that whenever the second disjunct of (167) is true, the assertion of the sentence *John is certain which student came* is false (and accordingly, *John is not certain which student came* is true). That is, if the context entails the second disjunct of (167), as in the case of (58a), the assertion of the relevant sentence would be contextually trivial, i.e., it is either contradictory (in the case of *John is certain which student came*) or tautological (in the case of *John is not certain which student came*) given the contextual information. Assuming that contextually trivial utterances are pragmatically infelicitous, the Strong Kleene theory in fact correctly captures that (58a) is infelicitous. Thus, the Strong Kleene theory correctly captures the contrast in (58).

Generally, Fox (2012) points out that the Strong Kleene theory combined with the assumption that contextually trivial utterances are infelicitous predicts that the quantified sentence $\forall x[\varphi(x) \rightarrow \psi(x)_{\pi(x)}]$ is felicitous only in the following two kinds of context: (i) the one that supports the first disjunct of (165) or (ii) the one that supports the disjunction as a whole but does not support either disjunct.

$$(165) \quad \forall x[\varphi(x) \rightarrow \pi(w)] \vee \exists x[\varphi(x) \wedge \pi(w) \wedge \neg\psi(x)]$$

The context that supports the second disjunct would result in contextual triviality as argued above. Fox (2012) further argues that the second kind of context that only supports the disjunction as a whole is pragmatically marked since it requires the two disjuncts to be logically related in the context. As a result, the only *unmarked* context that makes the quantified sentence felicitous is the first kind of context, i.e., the one that supports the universal projection.²⁷ Hence, the account captures the seeming universal projection behavior in universally quantified sentences.

Then, the account, of course predicts that the quantified sentence can be felicitous given a suitable (despite marked) context that supports the disjunction of the form in (165). One way to make such a context natural is to make the two disjuncts exclusive to each other. In the case of *John is certain which student came*, such a context can be constructed by making it impossible for John to believe that exactly one student came without believing that a particular student came. We can see a concrete example of this kind of context in the following:

- (168) **Situation:** The department of linguistics is holding a special party for faculty members, where only one student representative is invited. John, a faculty member, is not aware of the invitation policy, and he believes that more than one students can in principle be invited to the party. John has seen the first draft of the list of invitees (which explicitly states that the list is subject to change), and sees that Ann is the only student who is invited. The speaker A does not know whether John has seen the final version of the list of invitees, where in fact Ann is the only student among the invitees. If John hasn't seen the final version, it is compatible with his beliefs that Ann is the only student to be invited (because he has seen the first draft), and it is also compatible with his beliefs that another student besides Ann is invited. If he has seen the final version, then he believes that Ann, the actual student invitee, is the only student who was invited.

A: Is John certain which student is invited to the party?

B: Yes, because he has seen the final version of the list./

No, because he hasn't seen the final version of the list.

The Strong Kleene theory predicts that the above sentence is felicitous given the context even though John does not believe that one student is invited. The scenario is complex and it is difficult to assess the intuitive judgment, but the felicity of a singular-*which* under *certain* here is improved at least for some speakers I consulted with than in a context that simply denies John's belief that exactly one student came. I would like to postpone further empirical investigation of this particular aspect of the prediction of the Strong Kleene theory for future research.

As I stated above, the Strong Kleene theory is interesting in the current context because it can account for the existential projection behavior of *be certain+that* without invoking any extra mechanism. Below, I illustrate this using example (66), repeated from section 4.4.1, whose semantics is given in (67).

- (66) John is certain that Ann came.

²⁷This strengthening mechanism is likened to the mechanism by which the presupposition of *If p, then q_π* is strengthened from $p \rightarrow \pi$ to π (Karttunen and Peters 1979; van Rooij 2007; von Stechow 2008).

$$(67) \quad \forall w' [w' \in \mathbf{DOX}_j^w \rightarrow \mathbf{DOX}_j^w \subseteq \llbracket \text{Ans}_d \rrbracket^w(w')(\{A\})]$$

The Strong Kleene theory predicts the following presupposition for the statement in (67) according to (165).

$$(169) \quad \forall w' [w' \in \mathbf{DOX}_j^w \rightarrow A(w')] \vee \exists w' [w' \in \mathbf{DOX}_j^w \wedge A(w') \wedge \mathbf{DOX}_j^w \not\subseteq A]$$

This basically says that either A is true in all of John's belief worlds, or A is true in just some of his belief worlds. This is equivalent to simply saying that A is true in some of his belief worlds, or more formally the following:

$$(170) \quad \exists w' [w' \in \mathbf{DOX}_j^w \wedge A(w')]$$

Thus, in the case of *be certain* + declaratives, the existential projection is derived as the basic prediction of the Strong Kleene theory. This is a consequence of the fact that the assertion of the scope of *be certain* + declaratives is equivalent to the presupposition predicted by the universal projection, i.e., the first disjunct of the Strong Kleene prediction. For example, in the above case, the assertion of the scope of (66) is $\mathbf{DOX}_j^w \subseteq A$ and the prediction of the universal projection is also $\mathbf{DOX}_j^w \subseteq A$. Whenever this is the case, it turns out that the Strong Kleene prediction will end up being equivalent to the prediction of the existential projection. Thus, the Strong Kleene theory captures the existential projection behavior of *be certain* + declaratives without any additional mechanisms. Note that a similar result does not obtain for *be certain* + interrogatives and other responsive predicates because the assertion of the scope and the prediction of the universal projection are logically independent in those cases.

Summarizing the section, the trivalent approach to presupposition projection based on Strong Kleene logic provides a solution to the dilemma posed by the projection behavior of *be certain* + declaratives. For *be certain* + declaratives, the prediction of Strong Kleene is equivalent to the existential projection. In cases other than *be certain* + declaratives, the only pragmatically unmarked context that supports the predicted Strong Kleene presupposition is one that supports the universal projection, as suggested by Fox (2012). Thus, we derive the seemingly universal projection behavior for these cases.

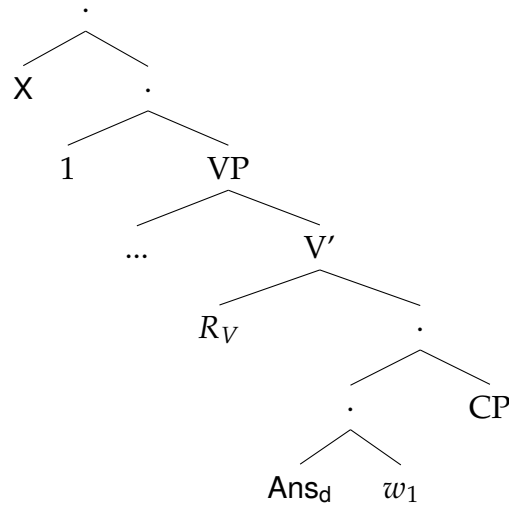
4.5 Decomposition and lexical semantics

In section 4.4, I introduced the view where responsive predicates are decomposed into a higher core predicate and the $\text{Ans}_d/\text{Ans}_{agr}$ -operator. However, I remained vague about the exact syntactic and semantic assumptions behind the decomposition. In this section, I provide several ways to implement the decompositional idea, without committing to any of the particular implementations. The purpose of this section is to show that there are multiple ways to implement the current analysis which may or may not involve the syntactic decomposition. The analysis of responsive predicates presented in this chapter does not hinge on particular assumptions about the syntax and semantics of decomposition (see Dowty 1979 for general discussion on the comparison between studies of word meanings based on syntactic decomposition and model-theoretic lexical semantics).

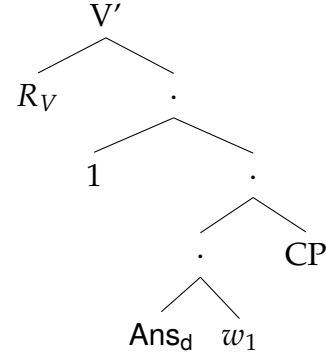
4.5.1 Syntactic decomposition

I first consider a way to syntactically implement the LF decomposition of responsive predicates proposed in this chapter. The decompositional structure of the predicates where the world argument of the answer operator is bound by X and those where it is bound by R_V are repeated below for convenience.

(171) a. **Binding by X**

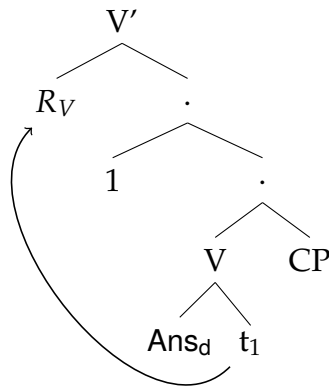


b. **Binding by R_V**



The situation is simpler with the predicates with the structure in (171b). The structure can be derived at LF by generating the complex head consisting of R_V and Ans_d in the syntax and assume that the R_V undergoes a head movement at LF to derive the structure in (171b). The LF movement is illustrated in the following:

(172) **LF movement**

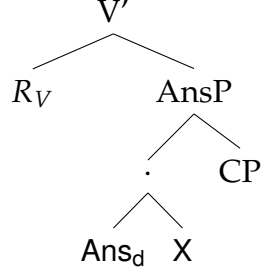


Following [Bhatt and Keine \(2015\)](#), I assume that an LF head-movement leaves a variable in the base position and creates a binder index immediately below the landing site of the movement, as in the standard account of the interpretation of movement structures (e.g., [Heim and Kratzer 1998](#)).

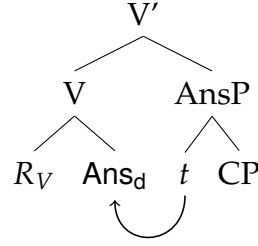
The analysis is less straightforward in the case of (171a) since the world argument is not derived by R_V , but rather is derived by X . Here, I would like to suggest two possible ways to implement the decomposition. The first way is to assume that

the syntax generates the structure in (173a), and that X undergoes movement at LF while Ans_d undergoes PF head movement to form a complex head with R_V . The PF movement is illustrated in (173b).

(173) a. The underlying structure



b. PF movement



Another way is to encode the meaning of X in the lexical semantics of R_V , as suggested in the previous chapter. In this case, the decompositional structure for predicates involving X would end up the same as (171b), and thus the decomposition of all responsive predicates can be reduced to that in terms of LF-movement illustrated in (172).

4.5.2 Encoding Ans_d in the lexical semantics

The current proposal can also be implemented by encoding Ans_d in the lexical semantics of responsive predicates without committing to any form of decomposition. In this implementation, *be certain*, for example, would be analyzed as follows, where Ans_d is now a meta-linguistic abbreviation of the function in (175):

$$(174) \quad \llbracket \text{be certain} \rrbracket^w = \lambda Q_{\langle st, t \rangle} \lambda x. \forall w' [w' \in \mathbf{DOX}_x^w \rightarrow \mathbf{DOX}_x^w \subseteq \text{Ans}_d(w')(Q)]$$

$$(175) \quad \lambda w \lambda Q_{\langle st, t \rangle} \cdot \begin{cases} \iota p \in Q \left[\begin{array}{c} p(w') \wedge \\ \forall p' \in Q [p'(w') \rightarrow p \subseteq p'] \end{array} \right] & \text{if } \exists! p \in Q \left[\begin{array}{c} p(w') \wedge \\ \forall p' \in Q [p'(w') \rightarrow p \subseteq p'] \end{array} \right] \\ \text{undefined} & \text{otherwise} \end{cases}$$

On the other hand, factive predicates like *know* can be analyzed as requiring an extra world argument which is internally passed to the world argument of Ans_d , as shown in the following:

$$(176) \quad \llbracket \text{know} \rrbracket^w = \lambda w' \lambda Q_{\langle st, t \rangle} \lambda x. \mathbf{DOX}_x^w \subseteq \text{Ans}_d(w')(Q)$$

In this case, X can be thought of as originating from the sister position of *know* at LF, and undergoes QR to bind the world argument position.

4.6 Existing analyses of veridicality

In this section, I compare the current account of veridicality of embedded questions with two existing analyses: [Spector and Egré \(2015\)](#) and [Roelofsen et al. \(2014\)](#). I will not discuss in this section the more ‘traditional’ analyses of veridicality, such as

the ones in Karttunen (1977) and Groenendijk and Stokhof (1984), that assume a different empirical picture than the one the current account assumes. See section 4.3.1 above for an empirical argument based on Spector and Egré (2015) against these analyses.

4.6.1 Spector and Egré (2015)

4.6.1.1 Summary

As discussed in section 4.3.1, Spector and Egré (2015) present the following empirical generalization:

(31) Spector and Egré’s Generalization

A responsive predicate V is *veridical* with respect to interrogative-embedding iff V is *veridical* with respect to declarative-embedding.

In order to capture their generalization, Spector and Egré (2015) propose that responsive predicates combines with *some* answer of the question denoted by the interrogative complement, rather than *the unique* true answer. Formally, the simplest formulations of their analysis makes use of the following schema that defines the meaning denotation of a interrogative-embedding version of a responsive predicate V_{int} in terms of its declarative-embedding variant, V_{decl} .

(177) E&S’s interpretation schema for responsive predicates (Version 1)

$$\begin{aligned} \llbracket V_{\text{int}} \rrbracket^w &= \lambda Q_{\langle st, t \rangle} \lambda \vec{x}. \\ &\begin{cases} \exists w' [\llbracket V_{\text{decl}} \rrbracket^w (\text{Ans}_{\text{ES}}^V(w')(Q))(\vec{x})] & \text{if } \exists w' [\llbracket V_{\text{decl}} \rrbracket^w (\text{Ans}_{\text{ES}}^V(w')(Q))(\vec{x}) \text{ is defined}] \\ \text{undefined} & \text{otherwise} \end{cases} \\ &\bullet \text{ Ans}_{\text{ES}}^V(w)(Q) \in \left\{ \begin{array}{l} \lambda w'. \forall p \in Q [p(w) \rightarrow p(w')] \quad (\text{i.e., the WE answer}), \\ \lambda w'. \forall p \in Q [p(w) \leftrightarrow p(w')] \quad (\text{i.e., the SE answer}) \end{array} \right\} \end{aligned}$$

According to this schema, the sentence $x V_{\text{int}} Q$ is true iff there is a world such that $x V_{\text{decl}} p$ is defined and true, where p is the Ans_{ES}^V -answer of Q in that world. This is equivalent to an existential claim about a *possible* answer, i.e., that there is a possible Ans_{ES}^V -answer p of Q such that $x V_{\text{decl}} p$. Here, an Ans_{ES}^V -answer of a question is either a WE answer or an SE answer, depending on the predicate V (e.g., it is an SE answer when V is *know* while it is a WE answer when V is *surprise*). The schema also existentially projects the presupposition of V_{decl} . Thus, $x V_{\text{int}} Q$ is predicted to inherit the presupposition of V_{decl} . For example, *John agrees with Mary on whether Ann came* is predicted to presuppose that Mary believes one way or the other about whether Ann came, assuming that $x \text{ agrees}_{\text{decl}} \text{ with } y \text{ that } p$ presupposes that y believes p (I will discuss more on the presuppositional component of the schema later).

Crucially, (177) does not in itself impose any requirement about veridicality, but it does capture Spector and Egré’s generalization in a straightforward fashion. When V is a veridical predicate, $\llbracket V_{\text{decl}} \rrbracket^w(p)(\vec{x})$ holds only when p is true in w .

Thus, when V is veridical, an answer can satisfy the existential quantification in (177) only when it is true. Let's take a concrete example. According to (177), the semantics of *John knows who came* is analyzed as follows:

$$(178) \quad \llbracket \text{John knows}_{\text{int}} \text{ who came} \rrbracket^w = 1 \\ \text{iff } \exists w' [\llbracket \text{know}_{\text{decl}} \rrbracket^w (\text{Ans}_{\text{ES}}^{\text{know}}(w')(\llbracket \text{who came} \rrbracket^w))(j)]$$

Since *know* is a veridical predicate, $\llbracket \text{know}_{\text{decl}} \rrbracket^w (\text{Ans}_{\text{ES}}^{\text{know}}(w')(\llbracket \text{who came} \rrbracket^w))(j)$ is true only if $\text{Ans}_{\text{ES}}^{\text{know}}(w')(\llbracket \text{who came} \rrbracket^w)$ is true in w . Thus, the relevant answer that John has to know for *John knows who came* to be true must be a true one. This captures the veridicality of *know* with respect to interrogative-embedding, and similarly for other veridical predicates. On the other hand, as I stated above, the schema in (177) itself does not impose any requirement concerning whether $\text{Ans}_{\text{ES}}^V(w')(Q)$ is true or not. Therefore, $\text{Ans}_{\text{ES}}^V(w')(Q)$ can be false if V is a non-veridical predicate, such as *be certain*.

Thus, the schema in (177) captures Spector and Egré's generalization. However, Spector and Egré go on to point out that the schema turns out to be too weak for predicates that select for WE readings, such as *be happy*. Consider the following truth conditions for *John is happy (about) who came* predicted by the schema, assuming that $\text{Ans}_{\text{ES}}^{\text{happy}}(w)(Q) = \lambda w'. \forall p \in Q [p(w) \rightarrow p(w')]$ (i.e., the WE answer).

$$(179) \quad \llbracket \text{John is happy}_{\text{int}} (\text{about}) \text{ who came} \rrbracket^w = 1 \\ \Leftrightarrow \exists w' [\llbracket \text{happy}_{\text{decl}} \rrbracket^w (\text{Ans}_{\text{ES}}^{\text{happy}}(w')(\llbracket \text{who came} \rrbracket^w))(j)] \\ \Leftrightarrow \exists w' [\llbracket \text{happy}_{\text{decl}} \rrbracket^w (\lambda w''. \forall p \in \llbracket \text{who came} \rrbracket^w [p(w') \rightarrow p(w'')])(j)]$$

These truth conditions are too weak since (179) predicts that the sentence can be true as long as there is someone who actually came such that John is happy that they came. In other words, the analysis predicts a *mention-some* reading. This is so because (179) would be true if there is a possible WE answer that John is happy about, and any member of Q is a possible WE answer of Q . This is not an empirically desirable consequence since (179) seems to have a reading stronger than a mention-some reading. This is evidenced by the following example:

- (180) [**Situation:** John is happy that Ann came to the party, but he is not happy about the list of all participants of the party because he wanted Bill, one of the party comers, not to come.]

John is happy about who came to the party. (Judgment: False)

If the mention-some reading predicted by the analysis is correct, the above example should be true given the situation. Furthermore, since Spector and Egré do not assume an existential presupposition for *wh*-complements, the analysis even predicts (179) to be true if John is happy about the tautology. This is so since tautology is the WE answer of *who came* in a world where no one came.²⁸

²⁸Spector and Egré make the same argument using *surprise*, another predicate that empirically selects for a WE reading. However, the argument is more subtle than the one with *be happy* due to the seeming downward-entailingness of *surprise*.

Spector and Egré address this problem by adding a specification about how the presupposition triggered by V_{decl} is *accommodated* in the assertive meaning of V_{int} in the interpretation schema. The revised variant of the schema looks like the following:

(181) **E&S's interpretation schema for responsive predicates (Version 2)**

$$\begin{aligned} \llbracket V_{\text{int}} \rrbracket^w &= \lambda Q_{\langle st, t \rangle} \lambda \vec{x}. \\ &\begin{cases} \exists w' [\llbracket V_{\text{decl}} \rrbracket^w (\text{Ans}_{\text{str}}(w')(Q))(\vec{x}) \text{ is defined} \wedge \llbracket V_{\text{decl}} \rrbracket^w (\text{Ans}_{\text{ES}}^V(w')(Q))(\vec{x})] & \text{if } \exists w' [\llbracket V_{\text{decl}} \rrbracket^w (\text{Ans}_{\text{str}}(w')(Q))(\vec{x}) \text{ is defined}] \\ \text{undefined} & \text{otherwise} \end{cases} \\ &\bullet \text{ Ans}_{\text{str}}(w')(Q) \stackrel{\text{def}}{=} \lambda w'. \forall p \in Q [p(w) \leftrightarrow p(w')] \end{aligned}$$

There are two things to note here. One is that the presuppositions of V_{decl} is *accommodated* into the scope of the existential quantification in the assertive meaning of V_{int} , in addition to being existentially projected as the presupposition of V_{int} . The other thing to note is that, although the Ans_{ES}^V -operator in the assertive component of (181) varies depending on the predicate V , the answer involved in both the accommodated and projected presuppositions is always a strongly-exhaustive one.

To see how this schema solves the problem with predicates like *be happy*, consider the following analysis of *John is happy (about) who came*, based on the new schema:

(182) $\llbracket \text{John is happy}_{\text{int}} (\text{about}) \text{ who came} \rrbracket^w$

- is defined iff $\exists w' [\llbracket \text{be happy}_{\text{decl}} \rrbracket^w (\text{Ans}_{\text{str}}(w')(\llbracket \text{who came} \rrbracket^w))(j) \text{ is defined}]$
- is True iff $\exists w' [\llbracket \text{be happy}_{\text{decl}} \rrbracket^w (\text{Ans}_{\text{str}}(w')(\llbracket \text{who came} \rrbracket^w))(j) \text{ is defined} \wedge \llbracket \text{be happy}_{\text{decl}} \rrbracket^w (\text{Ans}_{\text{ES}}^{\text{happy}}(w')(\llbracket \text{who came} \rrbracket^w))(j)]$

The presupposition and denotation of *be happy_{decl}* are analyzed as follows:²⁹

$$(183) \quad \llbracket \text{be happy}_{\text{decl}} \rrbracket^w = \lambda p_{\langle s, t \rangle} \lambda x. \begin{cases} \text{happy}(x, p, w) & \text{if } p(w) \wedge \text{DOX}_x^w \subseteq p \\ \text{undefined} & \text{otherwise} \end{cases}$$

This states that $\llbracket \text{be happy}_{\text{decl}} \rrbracket^w(p)(x)$ is defined if p is true in w and x believes p . Due to these definedness conditions for $\llbracket \text{be happy}_{\text{decl}} \rrbracket^w(p)(x)$, the definedness conditions and truth-conditions for *John is happy_{int} (about) who came* in (182) would be equivalent to the following:

(184) $\llbracket \text{John is happy}_{\text{int}} (\text{about}) \text{ who came} \rrbracket^w$

- is defined iff $\exists w' [\text{Ans}_{\text{str}}(w')(\llbracket \text{who came} \rrbracket^w)(w') \wedge \text{DOX}_j^w \subseteq \text{Ans}_{\text{str}}(w')(\llbracket \text{who came} \rrbracket^w)]$
- is True iff $\exists w' [\text{Ans}_{\text{str}}(w')(\llbracket \text{who came} \rrbracket^w)(w) \wedge \text{DOX}_j^w \subseteq \text{Ans}_{\text{str}}(w')(\llbracket \text{who came} \rrbracket^w) \wedge \llbracket \text{be happy}_{\text{decl}} \rrbracket^w (\text{Ans}_{\text{ES}}^{\text{happy}}(w')(\llbracket \text{who came} \rrbracket^w))(j)]$

²⁹The predicate **happy** can be thought of as a non-monotonic ordering-based denotation in the previous chapter.

In the assertive component, this says that *John is happy_{int} (about) who came* is true iff John believes the true SE answer to *who came* and asserts that John is happy about the WE ‘counterpart’ of this SE answer. Here, the WE counterpart of an SE answer refers to the WE answer in worlds where the latter is true.

This formulation succeeds in capturing the WE reading of *be happy*. Here’s why: The kind of world that can be a witness of the existential quantification in the truth conditions in (184) is a world where the SE answer in that world is true. In other words, the world has to share the SE answer with the actual world. Accordingly, the WE answer in such a world has to be a true WE answer. Hence, the WE answer referred to in (184) has to be a true WE answer, not just any potential WE answer. In Spector and Egré’s words, *be happy* is analyzed as referring to the ‘positive part’ of the true SE answer to the embedded question. For example, the relevant WE answer is ‘Ann came and Bill came’ when the true SE answer is ‘Ann came, Bill came and Chris didn’t come’. Thus, the analysis correctly predicts that (180) is false given the situation, where John is not happy about the *true* WE answer of the question *who came to the party*. Note that the same result cannot be achieved by simply modifying the presupposition of the original schema in (177) to SE (without accommodation) since the existential quantification in the presupposition and that in the assertion are independent, causing the so-called BINDING PROBLEM (Karttunen and Peters 1979). The accommodation of the presupposition in the scope of the existential quantification in the assertion is a way to resolve this binding problem.

There is another consequence of the current analysis. The presupposition of $x V_{int} Q$, where V_{int} selects for WE answers in the assertive dimension, is predicted to always involve SE answers. Spector and Egré (2015) argue that this is in fact a virtue of the analysis, claiming that the presupposition of the interrogative-embedding use of a responsive predicate generally refers to SE answers, even when the predicate selects for a WE reading in the assertive meaning. They present data purporting to show that the presuppositions of *surprise_{int}* and *agree_{int}* refer to SE answers. Below is the data involving *surprise_{int}*:

- (185) **Situation:** Mary has 10 students, and they all took a certain exam. She definitely did not expect students A, B and C to pass, but she had no specific expectations for others. In fact, students A, B, C passed and no other student did. A, B and C sent her an e-mail to tell her that they passed. She was surprised. Regarding the seven other students, she has no information, i.e. does not know yet whether they passed or not (even though in fact they didn’t pass). Now, John and Sue know all this, i.e. they know both which students passed and which didn’t, they know what Mary knows and doesn’t know, and are aware that she was surprised that A, B and C passed. In fact, they overheard her saying “I can’t believe that A, B and C passed! As to the other 7 students, I don’t know yet whether they passed”. John and Sue are looking at a list of the ten students, and John then tells Sue the following:

#It surprised_{int} Mary which of her 10 students passed. (E&S: (112))

In the given situation, although the true WE answer surprised Mary, she does not know the SE answer. Provided that knowing *p* is a presupposition for being surprised

that p , Spector and Egré (2015) predict (185) to be odd due to a presupposition failure. Parallel judgments hold for other emotive factives such as *be happy*.

4.6.1.2 Comparison

There are two problems with Spector and Egré's (2015) analysis of veridicality. The first problem concerns the stipulative nature of their treatment of presuppositions. The second problem concerns the treatment of the uniqueness presupposition under non-veridical predicates.

Stipulation in the treatment of presuppositions The second problem with Spector and Egré (2015) is that the treatment of presupposition in their schema (181) is stipulative and does not follow from any general theory of presupposition projection. There are two stipulative features in their schema in (181), repeated below for convenience:

(181) E&S's interpretation schema for responsive predicates (Version 2)

$$\begin{cases} \llbracket V_{\text{int}} \rrbracket^w = \lambda Q_{\langle st, t \rangle} \lambda \vec{x}. \\ \quad \begin{cases} \exists w' [\llbracket V_{\text{decl}} \rrbracket^w (\text{Ans}_{\text{str}}(w')(Q))(\vec{x}) \text{ is defined} \wedge \llbracket V_{\text{decl}} \rrbracket^w (\text{Ans}_{\text{ES}}^V(w')(Q))(\vec{x}) \\ \quad \text{if } \exists w' [\llbracket V_{\text{decl}} \rrbracket^w (\text{Ans}_{\text{str}}(w')(Q))(\vec{x}) \text{ is defined}] \\ \text{undefined} \quad \text{otherwise} \end{cases} \end{cases}$$

The first stipulative feature concerns the difference in the exhaustivity of answers involved in the assertion and the presupposition. As discussed above, it is necessary for the analysis to use an SE answer in the presupposition regardless of whether the assertion involves a WE answer. This means that the presupposition of V_{int} cannot be predicted by the presupposition of V_{decl} using standard assumptions about the presupposition projection out of existential quantification (whether it is the existential projection or the universal projection). This is so because the standard assumptions predict that the presupposition triggered in the scope of an existential quantification as in (186) would be projected as in (186a) or (186b), where the relevant kind of answer (i.e., $\text{Ans}_{\text{ES}}^V(w)(Q)$) is preserved.

$$\begin{aligned} (186) \quad & \exists w' [\llbracket V_{\text{decl}} \rrbracket^w (\text{Ans}_{\text{ES}}^V(w)(Q))(x)] \\ & \text{a. } \exists w' [\llbracket V_{\text{decl}} \rrbracket^w (\text{Ans}_{\text{ES}}^V(w)(Q))(x) \text{ is defined}] \quad (\exists\text{-projection}) \\ & \text{b. } \forall w' [\llbracket V_{\text{decl}} \rrbracket^w (\text{Ans}_{\text{ES}}^V(w)(Q))(x) \text{ is defined}] \quad (\forall\text{-projection}) \end{aligned}$$

The second stipulative feature concerns the fact that the presupposition has to be locally accommodated in the scope of the existential quantification as well as being existentially projected. This is also an unconventional treatment of presupposition projection. Presuppositions in the scope of quantification are either projected or locally accommodated, but they do not normally undergo both projection *and* local accommodation. Spector and Egré (2015) need this stipulation to avoid the problem concerning the predicates selecting WE answers. Unless the definedness condition involving an SE answer is locally accommodated in the scope of existential

quantification, the analysis would be unable to capture the correct WE reading of predicates such as *surprise* and *be happy*.

Unlike Spector and Egré's interpretation schema which stipulates the presuppositions of responsive predicates, my theory derives the presuppositions from the specification of the assertive meanings of responsive predicates using general theories of presupposition projection out of quantified sentences.

Uniqueness presupposition Another problem with Spector and Egré's (2015) analysis is that it is not straightforward how the analysis can be extended to capture the behavior of uniqueness presuppositions of singular *which*-questions under non-veridical predicates.

In the previous sections, I argued that the uniqueness presupposition in the complement of non-veridical predicates are projected into the belief state of the relevant attitude holder. For example, the following sentence with *be certain* presupposes that John believes that exactly one student came.

- (187) John is certain (about) which student came.
 \Rightarrow John believes that exactly one student came.

This was captured by the universal projection (or Strong Kleene projection plus pragmatic mechanisms) of the presupposition triggered by Ans_d in the current analysis. However, this is hard to capture in Spector and Egré's (2015) analysis, as I illustrate below.

Below is the definedness condition of (187) predicted by Spector and Egré's schema in (181):

- (188) $\llbracket (187) \rrbracket^w$ is defined iff
 $\exists w' [\llbracket \text{be certain}_{\text{decl}} \rrbracket^w (\text{Ans}_{\text{str}}(w')(\llbracket \text{which student came} \rrbracket^w))(j)$ is defined]

Indeed, Spector and Egré (2015) do not provide a formulation of the uniqueness presupposition. Nevertheless, however we formulate it, the uniqueness presupposition of the embedded singular *which*-question would result in either one of the following two definedness conditions for $\text{Ans}_{\text{str}}(\llbracket \text{which student came} \rrbracket^w)(w')$ in (188):

- (189) a. $\text{Ans}_{\text{str}}(w')(\llbracket \text{which student came} \rrbracket^w)$ is defined only if exactly one student came in w' .
 b. $\text{Ans}_{\text{str}}(w')(\llbracket \text{which student came} \rrbracket^w)$ is defined only if exactly one student came in w .

In the case of (189a), the uniqueness presupposition inherited by (187) would be too weak since it would just require there be a world in which exactly one student came. In the case of (189b), the uniqueness presupposition inherited by (187) would require that exactly one student came in the actual world. This is not the uniqueness presupposition observed in (187).³⁰

³⁰Of course, a typical context that supports the uniqueness presupposition in (187) is one where exactly one student came in the actual world and John knows this. However, as we have seen in section 4.2.1, the sentence does not require the uniqueness presupposition to hold in the actual

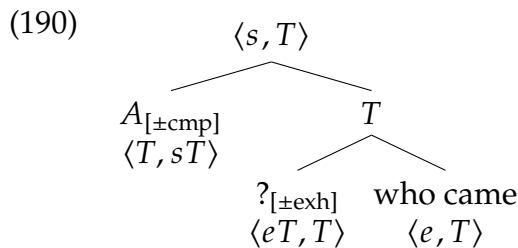
4.6.2 Theiler (2014); Roelofsen et al. (2014)

Several important features of my analysis are shared by the analysis of responsive predicates by Theiler (2014) and Roelofsen, Theiler, and Aloni (2014) despite a difference in the basic semantic framework. In this section, I review their analysis mostly based on Roelofsen et al. (2014) and discuss its relationship to my analysis including the aspects where my analysis has an advantage over their analysis.

4.6.2.1 Summary

At the heart of Theiler's (2014) and Roelofsen et al.'s (2014) analysis of responsive predicates is the view from Alternative Semantics and Inquisitive Semantics that sentence meanings are modeled as sets of propositions of type $\langle st, t \rangle$ regardless of whether they are assertions or questions (e.g., Hamblin 1973; Kratzer and Shimoyama 2002; Ciardelli et al. 2013). Although my analysis is not based on the framework of Alternative/Inquisitive Semantics, the current proposal—that both declarative and interrogative complements of responsive predicates are sets of propositions—can be derived as an instance of this general idea of Alternative/Inquisitive Semantic. As such, the setup of Alternative/Inquisitive Semantics enables us to analyze factivity as a limiting case of factivity, just as in my analysis. In addition to this, Theiler (2014) and Roelofsen et al. (2014) distinguish veridical predicates from non-veridical predicates in terms of intensionality. Combining these analyses of factivity and veridicality leads to an account of Spector and Egré's generalization. Below, I illustrate this by summarizing the analysis of Roelofsen et al. (2014). It is important to note here that the technical details of the analysis are adapted to make the comparison with my analysis as transparent as possible. Especially, in the summary, I will do away with a technical feature of Roelofsen et al. (2014) where basic sentence meanings are DOWNWARD CLOSED, i.e., if a proposition is in the sentence-meaning, a proposition that is stronger than that is also in that sentence-meaning. This makes the exposition and comparison easier without sacrificing the analytical insight.

Theiler (2014) and Roelofsen et al. (2014) analyze the left periphery of embedded questions as involving two operators: $?_{[\pm\text{exh}]}$ and $A_{[\pm\text{cmp}]}$, as shown in the following tree.



world. This can be seen in the following example:

- (18) Two of our students passed the test, but John is mistaken that exactly one did. In fact, he is certain (about) which student passed the test.

The tree is annotated with semantic types, where T abbreviates $\langle st, t \rangle$, i.e., the type for sentential meanings in Alternative/Inquisitive Semantics. Unlike the standard Alternative Semantics where the semantic composition is done by Point-wise Functional Application, the compositional system assumed here uses plain Functional Application.

The prejacent of $?_{[\pm\text{exh}]}$ denotes a function from a sequence of individuals to sentence meanings (i.e., something corresponding to a question ABSTRACT in [Groenendijk and Stokhof 1984](#)), where the sentence meaning is a set of propositions. Abbreviating the type $\langle st, t \rangle$ as T , the denotation of *who came* would be of type $\langle e, T \rangle$ and looks like the following:

$$(191) \quad \llbracket \text{who came} \rrbracket = \lambda x_e \lambda p_{\langle s, t \rangle}. [p = \lambda w. \text{came}(x)(w)]$$

The operator $?_{[\pm\text{exh}]}$ turns this kind of denotation into specific sets of propositions (of type T) that represent the question meanings. Roughly, $?_{[-\text{exh}]}$ returns a proposition-set denotation while $?_{[+\text{exh}]}$ returns a partition in the sense of [Groenendijk and Stokhof \(1984\)](#). In turn, the operator $A_{[\pm\text{cmp}]}$ turns the question denotation into the set of its suitable answers with respect to a world. Here, $A_{[-\text{cmp}]}$ returns the set of propositions that would entail any true ‘mention-some’ answer of the question while $A_{[+\text{cmp}]}$ returns the set of propositions that would entail the true ‘mention-all’ answer.

The four combinations of the two parameters of the operators correspond to the descriptive terms for the ‘readings’ of embedded questions employed in this dissertation in the following way:

(192)

	$?_{[-\text{exh}]}$	$?_{[+\text{exh}]}$
$A_{[-\text{cmp}]}$	Mention-some	Strong exhaustivity
$A_{[+\text{cmp}]}$	Weak exhaustivity	Strong exhaustivity

What this table tells us is that, once $?_{[+\text{exh}]}$ is applied to the prejacent, the outcome is a strongly exhaustive (SE) reading regardless of whether we apply $A_{[-\text{cmp}]}$ or $A_{[+\text{cmp}]}$. On the other hand, if $?_{[-\text{exh}]}$ is applied, the outcome depends on the kind of A -operator we apply on the top of it: $A_{[-\text{cmp}]}$ would derive the mention-some reading while $A_{[+\text{cmp}]}$ would derive the weakly-exhaustive reading. The $A_{[\pm\text{cmp}]}$ -operators will be revised later to account for IE readings.

Formally, $?_{[-\text{exh}]}$ and $?_{[+\text{exh}]}$ are defined as follows. The first argument of these operators is a function from sequences of individuals to sets of propositions, where the sequence can be of any length to allow multiple-*wh* questions.

$$(193) \quad \begin{aligned} \text{a. } \llbracket ?_{[-\text{exh}]} \rrbracket &= \lambda R_{\langle e^n, T \rangle} \lambda p_{\langle s, t \rangle}. \exists \vec{x} [R(\vec{x})(p)] \\ \text{b. } \llbracket ?_{[+\text{exh}]} \rrbracket &= \lambda R_{\langle e^n, T \rangle} \lambda p_{\langle s, t \rangle}. \exists w [p = \lambda w'. \forall p' [\exists \vec{x} [R(\vec{x})(p')] \rightarrow p(w) \leftrightarrow p(w')]] \end{aligned}$$

For example, applying $?_{[-\text{exh}]}$ to (191) would derive the proposition-set denotation as follows.

$$(194) \quad \llbracket ?_{[-\text{exh}]} \text{ who came} \rrbracket = \lambda p_{\langle s, t \rangle}. \exists x [p = \lambda w. \text{came}(x)(w)]$$

On the other hand, applying $?_{[+\text{exh}]}$ to (191) would derive the partition of logical space whose cells correspond to the complete resolution of the question, as follows:

$$(195) \quad \llbracket ?_{[+exh]} \text{ who came} \rrbracket \\ = \lambda p_{\langle s,t \rangle} . \exists w[p = \lambda w' . \forall p' [\exists x[p' = \lambda w'' . \mathbf{came}(x)(w'')] \rightarrow p(w) \leftrightarrow p(w')]]$$

The $A_{[\pm cmp]}$ -operators are applied to these question meanings to derive the set of suitable answers in the given world. The operators are defined as follows:

$$(196) \quad \begin{aligned} \text{a. } \llbracket A_{[-cmp]} \rrbracket &= \lambda Q_T \lambda w \lambda p_{\langle s,t \rangle} . \begin{cases} \exists q \in Q[q(w) \wedge p \subseteq q] & \text{if } \exists q \in Q[q(w)] \\ \text{undefined} & \text{otherwise} \end{cases} \\ \text{b. } \llbracket A_{[+cmp]} \rrbracket &= \lambda Q_T \lambda w \lambda p_{\langle s,t \rangle} . \begin{cases} \forall q \in Q[q(w) \rightarrow p \subseteq q] & \text{if } \exists q \in Q[q(w)] \\ \text{undefined} & \text{otherwise} \end{cases} \end{aligned}$$

As one can see from above, $A_{[-cmp]}$ returns the set of propositions that would entail some true member of the question while $A_{[+cmp]}$ returns the set of propositions that would entail the conjunction of all true members of the question. Furthermore, these operators carry the presupposition that there exists at least one true member of the input question. $A_{[+cmp]}$ can be thought of as the counterpart of Ans_d in my analysis while $A_{[-cmp]}$ does not have any counterpart in my analysis at this point. Mention-some readings will be discussed in chapter 5. From now on, I will confine my discussion to $A_{[+cmp]}$ to make the comparison with my analysis presented so far transparent.

When $A_{[+cmp]}$ is applied to (194), we get the following function from worlds to sets of propositions:

$$(197) \quad \llbracket A_{[+cmp]} \llbracket ?_{[-exh]} \text{ who came} \rrbracket \rrbracket = \lambda w . \\ \begin{cases} \lambda p_{\langle s,t \rangle} . \forall q [\exists x[q = \lambda w' . \mathbf{came}(x)(w')] \wedge q(w) \rightarrow p \subseteq q] & \text{if } \exists x[\mathbf{came}(x)(w)] \\ \text{undefined} & \text{otherwise} \end{cases}$$

Given a world w where someone came, a proposition is in the set returned by (197) iff it entails the conjunction of all true propositions of the form ‘ x came’. In other words, it corresponds to the set of propositions that entails the WE answer. Note that this is a downward-closed set of propositions. That is, it includes not only the weakest proposition needed to resolve the question, but also any proposition that is stronger than it. In Roelofsen et al.’s (2014) final analysis, the $A_{[\pm cmp]}$ -operators are modified so that the downward-closure does not hold. This is to capture the IE reading, or more generally, the sensitivity to false answers in question embedding. This is done by adding a condition to $A_{[\pm cmp]}$ so that they exclude propositions that supports a false answer, as in the following:

$$(198) \quad \begin{aligned} \text{a. } \llbracket A_{[-cmp]} \rrbracket &= \lambda Q_T \lambda w \lambda p_{\langle s,t \rangle} . \begin{cases} \left[\begin{array}{l} \exists q \in Q[q(w) \wedge p \subseteq q] \wedge \\ \neg \exists q \in Q[\neg q(w) \wedge p \subseteq q] \end{array} \right] & \text{if } \exists q \in Q[q(w)] \\ \text{undefined} & \text{otherwise} \end{cases} \\ \text{b. } \llbracket A_{[+cmp]} \rrbracket &= \lambda Q_T \lambda w \lambda p_{\langle s,t \rangle} . \begin{cases} \left[\begin{array}{l} \forall q \in Q[q(w) \rightarrow p \subseteq q] \wedge \\ \neg \exists q \in Q[\neg q(w) \wedge p \subseteq q] \end{array} \right] & \text{if } \exists q \in Q[q(w)] \\ \text{undefined} & \text{otherwise} \end{cases} \end{aligned}$$

These operators guarantee that any proposition that meets the conditions of these operators does not entail a false answer to the question, thus capturing the sensitivity to false answers. For expository purposes, I will use the definitions in (196) for the discussion in this section.

The denotations of responsive predicates are defined to take the kind of set in (197). The denotation of veridical predicates like *know* is defined as follows:

$$(199) \quad \llbracket \text{know} \rrbracket = \lambda f_{\langle s, T \rangle} \lambda x \lambda p. p = [\lambda w. \mathbf{DOX}_x^w \in f(w)]$$

In words, x *knows* f represents the singleton set of propositions that say that x believes the suitable true answer of f . An example is given below:

$$(200) \quad \llbracket \text{John knows } [A_{[+cmp]} [?_{[-exh]} \text{ who came}]] \rrbracket = \\ \lambda p. p = [\lambda w. \mathbf{DOX}_j^w \in \llbracket A_{[+cmp]} [?_{[-exh]} \text{ who came}]](w)]$$

Here, the meaning of the sentence is basically analyzed as the singleton set of propositions which say that John believes the true WE answer of *who came*. Also, since $[A_{[+cmp]} [?_{[-exh]} \text{ who came}]]$ is presuppositional, the unique proposition in the singleton set would be a partial proposition: it is a proposition that is undefined for worlds in which no one came. This leads to the existential presupposition of interrogative complements, just as the presupposition of Ans_d .³¹

Given this derivation of the existential presupposition, factivity can be derived as its sub-case in a similar way to my analysis. For example, a declarative clause *that Ann came* is analyzed as follows:

$$(201) \quad \llbracket \text{that Ann came} \rrbracket = \lambda p. [p = A]$$

$$(202) \quad \llbracket A_{[+cmp]} [\text{that Ann came}] \rrbracket = \lambda w \lambda p. \begin{cases} p \subseteq A & \text{if } A(w) \\ \text{undefined} & \text{otherwise} \end{cases}$$

Embedding a declarative clause like *that Ann came* under *know* would derive the following:

$$(203) \quad \llbracket \text{John knows } [A_{[+cmp]} [\text{that Ann came}]] \rrbracket = \\ \lambda p. p = [\lambda w. \mathbf{DOX}_j^w \in \llbracket A_{[+cmp]} [\text{that Ann came}] \rrbracket(w)]$$

The unique proposition in this singleton set is a partial proposition that is undefined in worlds where Ann didn't come. Thus, factivity is derived as a sub-case of existential presupposition. This is also the case with $A_{[-cmp]}$ since the distinction between $A_{[-cmp]}$ and $A_{[+cmp]}$ collapses when their input set is a singleton.

The distinction between factive and non-factive predicates is made in terms of intensionality. That is, whereas factive predicates like *know* evaluates the answer, f , in the actual world (or more precisely, at the same world as the world where the agent's belief is evaluated), non-factive predicates like *be certain* evaluates f in a shifted world. The denotation of *be certain* looks like the following:

³¹This is not entirely true in the original formulation in Roelofsen et al. (2014) since their definition of $?_{[-exh]}$ includes the proposition corresponding to 'No one came'. As such, the presupposition of $A_{[\pm cmp]}$ is trivially satisfied in the case of interrogative clause in their analysis.

$$(204) \quad \llbracket \text{be certain} \rrbracket \\
= \lambda f_{\langle s, T \rangle} \lambda x \lambda p. \begin{cases} \exists w' [p = [\lambda w. \mathbf{CRT}_x^w \in f(w')]] & \text{if } \exists w' [f(w') \text{ is defined}] \\ \text{undefined} & \text{otherwise} \end{cases} \\
(\mathbf{CRT}_x^w := \text{the set of worlds compatible with } x\text{'s certainty})$$

The analysis is very similar to my analysis of $tell_{[-\text{ver}]}$ in terms of existential quantification. In prose, assuming that the presupposition is satisfied, x is *certain* f represents the set of propositions each of which states that x is certain about a specific answer of f . Here is a more concrete example:

$$(205) \quad \llbracket \text{John is certain } [A_{[+\text{cmp}]} [?_{[-\text{exh}]} \text{ who came}]] \rrbracket = \lambda p. \\
\begin{cases} \exists w' \left[p = \lambda w. \forall q \left[\begin{array}{l} \exists x [q = \lambda w''. \mathbf{came}(x)(w'')] \wedge \\ q(w') \rightarrow \mathbf{CRT}_j^w \subseteq q \end{array} \right] \right] & \text{if } \exists w' [\exists x [\mathbf{came}(x)(w')]] \\ \text{undefined} & \text{otherwise} \end{cases}$$

Roughly, (205) represents a set of propositions each of which says that John is certain that p , where p is the WE answer of *who came* in some specific world. What is important is that this semantics derives non-factivity. This is so because the presupposition of *be certain* embedding a declarative clause turns out to be the statement that A is true in some world. This is illustrated in the following example:

$$(206) \quad \llbracket \text{John is certain } [A_{[+\text{cmp}]} [\text{that Ann came}]] \rrbracket \\
= \lambda p. \begin{cases} p = \lambda w. \mathbf{CRT}_j^w \subseteq A & \text{if } \exists w' [A(w')] \\ \text{undefined} & \text{otherwise} \end{cases}$$

Again, the same result obtains with $A_{[-\text{cmp}]}$. Thus, non-veridicality with respect to declarative-embedding is predicted given the kind of denotation for non-veridical predicates in (204). Hence, the analysis captures Spector and Egré's generalization.

4.6.2.2 Comparison

My analysis of veridicality of responsive predicates shares two features with Theiler (2014) and Roelofsen et al. (2014). One is the analysis of declarative complements as singleton questions, with the consequence of deriving factivity from the presupposition of the answerhood operator (i.e., Ans_d in my analysis and $A_{[\pm\text{cmp}]}$ in Roelofsen et al. 2014). The other is the distinction between factive and non-factive predicates in terms of intensionality at least for the *be certain*-type and the communication predicates: factive predicates evaluate the 'answer' involved in its meaning in the actual world while non-factive predicates quantifies over the worlds with respect to which the 'answer' is evaluated.

Despite the basic similarity, however, there are at least two respects where the current analysis has an advantage over Theiler (2014) and Roelofsen et al. (2014). These concern (i) fine-grained lexical semantics of non-veridical predicates and (ii) the projection of the existential and uniqueness presupposition triggered by interrogative complements. Below, I discuss them in turn. On the top of these issues, it should be stressed that the proposal of the current dissertation fundamentally departs from Theiler (2014) and Roelofsen et al. (2014) in the analysis of exhaustivity.

Although Theiler (2014) and Roelofsen et al. (2014) have a flexible theory of exhaustivity where a free distribution of different readings are predicted, the current proposal offers a theory where the distributions are constrained depending on the matrix predicate.

Fine-grained lexical semantics of non-veridical predicates Although Roelofsen et al.’s (2014) analysis of *be certain* captures its non-veridicality and non-factivity, the analysis does not capture the limited range of readings *be certain* permits. Furthermore, the analysis does not generalize to other non-factive predicates, such as *agree*.

Roelofsen et al.’s (2014) analysis of *be certain* involves an existential quantification over the world with respect to which the $A_{[\pm\text{cmp}]}$ -operator is evaluated. As I suggested above, this parallels my analysis of $\text{tell}_{[-\text{ver}]}$ in section 4.4.2. A consequence of this line of analysis is that *John is certain who came* would be true even if John has a partial certainty about who came. This is so since the reading we get by using $?_{[-\text{exh}]}$ and $A_{[\pm\text{cmp}]}$ in (205) would be true as long as there is a possible WE answer p such that John is certain that p . As we discussed in section 4.4.1, this is not an empirically correct prediction: a partial opinion/certainty cannot make a sentence involving *be certain* true, i.e., an SE reading is necessary for *be certain*.

Furthermore, it is not straightforward how the analysis in terms of existential quantification can be extended to *agree*. In particular, what is difficult is to capture the presupposition of the declarative-embedding use of *agree* in the following kind of example:

- (207) John agrees with Mary that Bill came.
 (Presupposition: Mary believes that Bill came.)

If we analyze *agree* as involving an existential semantics, as in (208) below, we would incorrectly predict that (207) only presupposes that it is possible that Bill came.

$$(208) \quad \llbracket \text{agree} \rrbracket = \lambda f_{\langle s, T \rangle} \lambda x \lambda y \lambda p. \begin{cases} \exists w' [p = [\lambda w. \mathbf{DOX}_x^w \in f(w') \wedge \mathbf{DOX}_y^w \in f(w')]] & \text{if } \exists w' [f(w') \text{ is defined}] \\ \text{undefined} & \text{otherwise} \end{cases}$$

On the other hand, if we analyze *agree* as an extensional predicate like *know*, as in (209) below, we would incorrectly predict that (207) presupposes that Bill came, i.e., that *agree* is factive.

$$(209) \quad \llbracket \text{agree} \rrbracket = \lambda f_{\langle s, T \rangle} \lambda x \lambda y \lambda p. [p = [\lambda w. \mathbf{DOX}_x^w \in f(w) \wedge \mathbf{DOX}_y^w \in f(w)]]$$

Thus, neither (208) nor (209) captures the correct presupposition of *agree-that*.

The projection of existential/uniqueness presuppositions in non-veridical predicates The second problem with Roelofsen et al. (2014) is related to the first problem. In their analysis, the presupposition triggered by the $A_{[\pm\text{cmp}]}$ operator is existentially projected by non-veridical predicates. Therefore, in the interrogative-embedding, the presupposition of the sentence ends up being quite weak: it just requires that it is possible that the question denotation contains a true answer. Nevertheless, as we

have seen throughout this chapter, the existential and uniqueness presupposition of interrogative complements are projected to the belief state of the relevant attitude holder. [Roelofsen et al.’s \(2014\)](#) analysis does not capture this.

4.7 Summary

In this chapter, I refined the semantics of responsive predicates using the idea that they are decomposed into a ‘core’ proposition-taking predicate and an answerhood operator $\text{Ans}_d/\text{Ans}_{agr}$. Two general consequences of the compositional analysis were discussed. First, the compositional analysis enables an analysis of factivity as a limiting case of the existential presupposition, which is associated with complements of responsive predicates in general. This analysis of factivity leads to a solution to the problem with the exhaustification above factive predicates. Second, [Spector and Egré’s](#) generalization falls out as a natural consequence of the compositional picture once declarative complements are analyzed as singleton questions. Both veridicality with respect to declarative-embedding and veridicality with respect to interrogative-embedding can be traced back to one of the two semantic features of the responsive predicate: the veridicality of the core proposition-taking predicate or the fact that the answerhood operator is evaluated with respect to the matrix evaluation world.

Chapter 5

Mention-some and the ‘reducibility’ of responsive predicates

5.1 Introduction

This chapter concerns a general property of a semantics of question-embedding predicates introduced by [George \(2011\)](#) using the notion of ‘reducibility’. Roughly speaking, a semantics of a question-embedding predicate V is called reducible if the truth conditions of a sentence of the form ‘ x Vs Q ’ according to the semantics are paraphrased with boolean combinations of statements of the form x Vs p , where p is a possible answer to Q . Reducibility holds of any semantics that strictly follows the proposition-to-question reduction approach discussed in chapter 1.

[George \(2011\)](#) points out that there are certain counterexamples to reducibility. That is, there are examples that cannot be treated by a semantics with reducibility. The goal of this chapter is twofold. One is to argue that the current account of exhaustivity and factivity can account for the counterexamples discussed by [George \(2011\)](#) once the compositional mechanism is extended to mention-some readings. The other goal is to suggest a revised version of reducibility, which I will call REDUCIBILITY MODULO FACTIVITY. Although the current semantics does not satisfy the reducibility in [George’s \(2011\)](#) sense, it turns out that it satisfies this revised version of reducibility.

5.2 Mention-some and non-reducibility

In the previous chapters, I focused on three kinds of exhaustivity of question-embedding sentences: weak exhaustivity (WE), intermediate exhaustivity (IE) and strong exhaustivity (SE). It is well-known that questions-embedding sentences have yet another kind of reading that is weaker than WE. This reading is referred to as the mention-some (MS) reading ([Hintikka 1976, 1978](#); [Groenendijk and Stokhof 1984](#)). For example, the following sentence has a reading that is true as long as John knows *some* place in the neighborhood that sells gas.

- (1) John knows where one can get gas around here.

This reading is distinct from the WE reading since (1) under this reading can be true even if John does not know all of the places in the neighborhood that sell gas.

There are debates in the literature about whether semantics has to generate the mention-some reading as an independent reading or it has to be accounted for in pragmatics. In the semantic approach (Groenendijk and Stokhof 1984:§6.5.3; George 2011; Fox 2013; Theiler 2014), the embedded question in (1) is assigned a semantic object that is distinct from what it assigns to WE or SE. On the other hand, the pragmatic approach (Groenendijk and Stokhof 1984:§6.5.2; van Rooij 2004) claims that the embedded question in (1) is assigned the same semantic object as WE or SE questions, but accept a weak interpretation due to a pragmatic mechanism. More specifically, Groenendijk and Stokhof (1984: §6.5.2) hypothesize that mention-some questions are those questions whose speaker's pragmatic goals are achieved by partial answers. For example, in the following discourse, typically, the questioner's pragmatic goal is to find *some* place in the neighborhood that she can get gas. Thus, even though the question semantically has an SE reading, the partial answer in B suffices to achieve this goal.

- (2) A: Where can I get gas around here?
B: At the Shell on Memorial Drive.

One of the arguments against the pragmatic approach offered by Groenendijk and Stokhof (1984) themselves and by George (2011) comes from embedded examples of mention-some questions, as in (1). The mention-some reading of (1) has a distinct truth-conditions from its IE or SE readings. In the pragmatic approach, the difference in truth conditions can only be captured if the pragmatic considerations affect the semantic interpretation of the embedded clause, contrary to the standard assumption that pragmatics does not feed the compositional semantic interpretation (However, see van Rooij (2004) for a pragmatic account of embedded mention-some questions with a theory where semantic evaluation is sensitive to the relative utility of information states).¹

I will not offer any new contribution to the above debate itself. Rather, I will offer a solution to a puzzle that both semantic and pragmatic accounts preferably have

¹Another relatively more recent objection against the pragmatic approach comes from the observation that mention-some readings are syntactically restricted (George 2011; Fox 2013). The following example is from Fox (2013):

- (i) **Situation:** There was no gas in the Boston area for a couple of days (say...the aftermath of a storm). Josh got a huge tank truck and delivered gas to various gas stations.
- a. Where can we get gas? (✓MS)
 - b. Where did Josh deliver gas? (*MS)

The two sentences in (i) are contextually equivalent. Thus, if a *wh*-question receives a mention-some reading when certain pragmatic conditions are met, both sentences in (i) should behave equally with respect to whether they allow a mention-some reading. Empirically, there seems to be contrast in (i): (ia) easily receives a MS reading, but (ib) doesn't. See George (2011) and Fox (2013) for further pairs along the same lines, and their semantic analyses of mention-some that are designed to capture the syntactic/semantic constraint on mention-some readings.

to address in some way or the other. The puzzle is pointed out by [George \(2011\)](#), and concerns the fact that the truth-conditions of sentences with *know* embedding a mention-some question cannot be described simply by knowledge of some true answer. Relevant examples are the following:

(3) [**Situation:** There are three gas stations in the neighborhood: gas station A, B and C. Currently, one can get gas at A and B, but C is closed. The following holds regarding John's and Mary's beliefs:

- John believes that one can get gas at A and C, and he is unopinionated about whether one can get gas at B.
- Mary believes that one can get gas at A, but she is unopinionated about whether one can get gas at B and C.
- For everything else, John and Mary have exactly the same set of beliefs.]

- a. John knows where one can get gas. (Judgment: False)
- b. Mary knows where one can get gas. (Judgment: True)

The embedded question *where one can get gas* is interpreted as a mention-some question, as indicated by the fact that (3b) is true although Mary does not know that one can get gas at B. At the same time, the falsity of (3a) suggests that mere knowledge of some true answer to the question is not sufficient for the sentences to be true. Since there is a true answer that John knows in the situation in (3), (3a) would be true if the truth conditions of the sentence only required John to know some true answer.

What is the additional condition that has to be met for a sentence as in (3) to be true? The pair in (3) indicates that the additional condition is for the knower *not* to believe a false answer to the embedded question. We will henceforth call this condition the NO-FALSE-ANSWER condition.

[George \(2011\)](#) uses the above kind of example to argue for what he calls the NON-REDUCIBILITY of knowledge-*wh*. Roughly, REDUCIBILITY holds when the truth-conditions of *V+wh* can be reduced to the truth-conditions of *V+that*. More precisely, [George \(2011\)](#) offers the following definition.

(4) **Reducibility** (George 2011: 145, adapted)

A responsive predicate *V* has the REDUCIBILITY PROPERTY if, for every two entity-denoting terms *a* and *b*,

- if for every declarative clause *p*,
 $a \text{ Vs } \textit{that } p \text{ is true iff } b \text{ Vs } \textit{that } p \text{ is true}$
- then for every interrogative clause *Q*,
 $a \text{ Vs } Q \text{ is true iff } b \text{ Vs } Q \text{ is true.}$

The example in (3) shows that *know* lacks this property despite the traditional assumption since [Karttunen \(1977\)](#) that (4) is a universal property of responsive

predicates. In (3), although John and Mary know exactly the same set of propositions, they differ in whether they know a question, i.e., where one can get gas. What is crucial here is that the belief that one can get gas at B does not count as knowledge since it is false that one can get gas at B. Hence, whether one believes this proposition or not does not count as a difference in knowledge.

A reader might have noticed that non-reducibility has already been introduced (although implicitly) in this dissertation in the discussion of intermediate exhaustivity (IE) in chapter 3. Below, I repeat a representative example showing the IE reading of *know*.

- (5) **Situation:** Ann and Bill came, but Chris didn't. John believes that everyone came. Mary believes that Ann and Bill came, and she is unopinionated about Chris.
- a. John knows which students came. (Judgment: False)
 - b. Mary knows which students came. (Judgment: True)

Just like (3) above, this example exhibits non-reducibility. John and Mary has exactly the same set of knowledge while differ in which questions they know (see also George (2011: §4.2) on non-reducibility in earlier accounts of responsive predicates including Spector's (2005) IE semantics for *know*). Here, too, the phenomenon can be described in terms of the no-false-answer condition: (5a) is false because John believes a false answer 'Chris came'.

Thus, it is reasonable to expect that our account of IE in terms of matrix exhaustification can be extended for the no-false-answer condition involved in mention-some readings. In the next section, I argue that George's non-reducibility data can be accounted for in terms of matrix exhaustification, once the current semantics is extended to mention-some questions.²

²George (2011) also offers another counterexample to reducibility using the predicate *forget*. This is exemplified as follows (George 2011: 170–171, adapted):

- (i) Scenario for 'forget'
 - a. John and Mary both once knew, and have forgotten, that one can gas at A.
 - b. For the entire time period under consideration, up to the present, John has known that one can get gas at A.
 - c. Mary has always been unopinionated about whether one can get gas at A.
 - d. Neither John nor Mary has ever had any other knowledge or beliefs about the availability of gas.
 - e. With respect to all topics except where one can buy a newspaper, John and Mary have forgotten exactly the same propositions at exactly the same times.
 - f. With the exception noted in (ib) and (ic), John and Mary have always possessed exactly the same knowledge.
- (ii)
 - a. John forgot where one can get gas. (Judgment: False)
 - b. Mary forgot where one can get gas. (Judgment: True)

Unlike in the case with *know*, I claim that this judgment arises with the basic *WE* reading of *forget*. Roughly, I analyze the basic lexical semantics of *forget* as follows:

- (iii) $\llbracket(\text{ia})\rrbracket^w = 1$ iff for all true answers to 'Where one can get gas?' such that John used to know, he forgot them.

5.3 Exhaustification in mention-some readings

The current approach to the no-false-answer condition employs matrix exhaustification using the operator X . In this section, I will show that George’s (2011) example can be captured once we extend this approach to mention-some questions. The analysis can be informally illustrated as follows. First of all, ignoring the no-false-answer condition for now, we can represent the interpretation of *know-wh* embedding a mention-some question as a disjunction of *know-that* embedding each true answers (Groenendijk and Stokhof 1984). For example, the interpretation of (6) can be paraphrased as in (7), given the situation in (3) where one can get gas at A and B, but not at C.

- (6) John knows where one can get gas.
- (7) John knows that one can get gas at A, or
John knows that one can get gas at B, or
he knows that one can get gas at A and B

The way I derive the no-false-answer condition in mention-some readings is to make the result of applying X to the sentence be equivalent to applying X to each disjunct in the paraphrase with *know-that*. That is, the analysis to be proposed makes (8) equivalent to (9) (keeping the alternatives constant).

- (8) X [John knows where one can get gas]
- (9) [X [John knows that one can get gas at A]], or
[X [John knows that one can get gas at B]], or
[X [John knows that one can get gas at A and B]]

The paraphrase in (9) captures the no-false-answer condition as can be seen by the following further paraphrase of (9):

- (10) John knows that one can get gas at A *and he believes nothing more*, or
John knows that one can get gas at B *and he believes nothing more*, or
John knows that one can get gas at A and B *and he believes nothing more*.

Each disjunct corresponds to a true answer, and the exhaustification requires that John does not believe anything stronger than the true answer. Thus, we correctly capture the no-false-answer condition in a mention-some reading. For example, every disjunct of (10) requires that John does not believe that one can get gas at C. This accounts for the contrast in George’s (2011) example in (3) above.

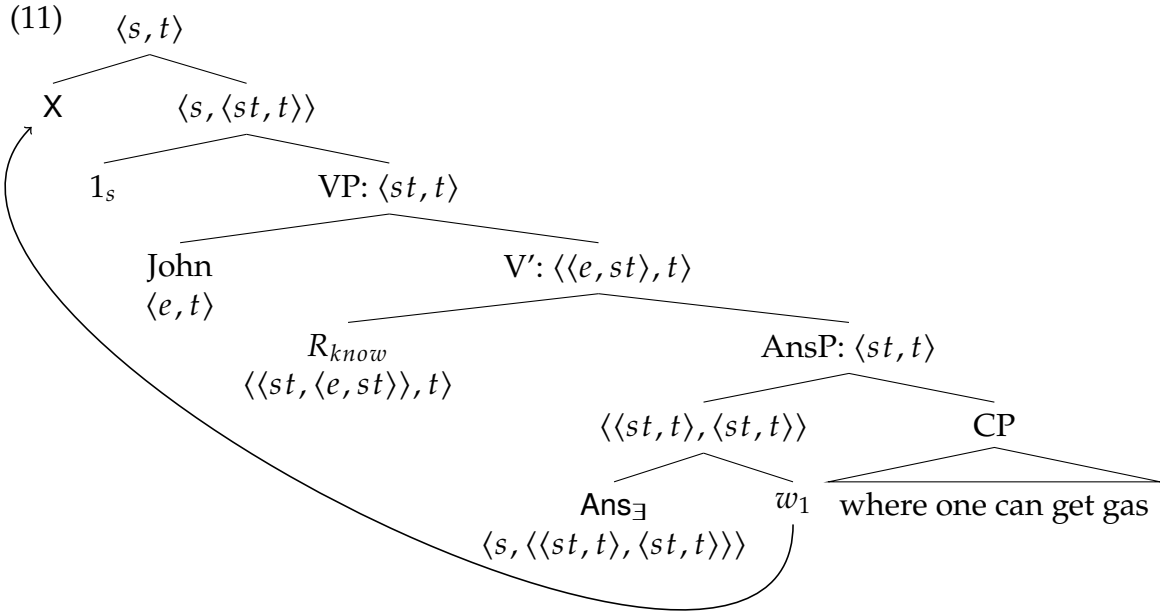
This accounts for the contrast in the judgments in (ii) in terms of the difference in the domain of the universal quantification.

As a theoretical implementation, two possibilities suggest themselves. One is to generalize Ans_{agr} , and analyze *forget* as ‘disagreement to past self’, and the other is to encode the WE meaning to the intensional predicate R_{forget} . Here, I provide the latter option ($\text{PastBel}(x, p, w)$ and $\text{PresBel}(x, p, w)$ respectively state that x formerly believed p in w and x currently believes p in w).

- (iv) $\llbracket R_{forget} \rrbracket^w$
 $= \lambda \mathcal{P}_{\langle s, st \rangle} \lambda x. \forall w' [\text{PastBel}(x, \mathcal{P}(w'), w) \wedge \mathcal{P}(w')(w) \rightarrow \neg \text{PresBel}(x, \mathcal{P}(w'), w)]$

Below, I formulate the above idea in a compositional analysis of embedded mention-some questions within the current general approach to embedded questions. Note that this is just to show a concrete implementation of the no-false-answer condition in mention-some questions, and the semantics of mention-some presented below is not intended to be a significant contribution to the theory of mention-some *par se*. The general idea is in principle compatible with any semantic account of embedded mention-some that represents the disjuncts in (7) in some way or the other so that X can be applied to them. Such semantic accounts include [Groenendijk and Stokhof \(1984: §6.5.3\)](#), [George \(2011\)](#), [Fox \(2013\)](#) and [Theiler \(2014\)](#).³

My account of mention-some makes use of a designated answerhood operator, Ans_\exists , that returns the *set* of true answers instead of the single strongest true answer. Also, I will revise the definition of the X-operator so that it takes a function that maps each world to a set of alternatives. The LF structure of (8) would then look like the following (I assume that the subject *John* is in the VP-internal position for simplicity). The definitions of Ans_\exists and X are given (12) and (13).



$$(12) \quad \llbracket \text{Ans}_\exists \rrbracket = \lambda w \lambda Q_{\langle st, t \rangle} \cdot \begin{cases} \{ p \in Q \mid p(w) \} & \text{if } \exists p \in Q[p(w)] \\ \text{undefined} & \text{otherwise} \end{cases}$$

$$(13) \quad \llbracket X \rrbracket = \lambda \mathcal{P}_{\langle s, \langle st, t \rangle \rangle} \lambda w. \exists p \in \mathcal{P}(w) \left[\begin{array}{c} p(w) \wedge \\ \forall p' \in \text{ALT}(\mathcal{P}) [p' \subset p \rightarrow \neg p'(w)] \end{array} \right]$$

$$\text{where } \text{ALT}(\mathcal{P}) := \bigcup_{w' \in W} \mathcal{P}(w')$$

³In the case of [George \(2011\)](#), what would correspond to the disjunction operation in the paraphrase in (7) corresponds to an existential quantification encoded in the lexical semantics of responsive predicates. Thus, in order for X to scope below it, as in (9), X also has to be encoded in the lexical semantics of responsive predicates. Note that encoding X in the lexical semantics of responsive predicate is also compatible with my own account.

The overall compositional system is lifted to Hamblin semantics. That is, we use both ordinary Functional Application (FA) and Point-wise Functional Application (PFA) introduced in chapter 3.⁴ The definition of PFA is repeated below:

(14) **Point-wise Functional Application**

Let γ be a node whose daughters are $\{\alpha, \beta\}$, and

$\forall a \in \llbracket \alpha \rrbracket \forall b \in \llbracket \beta \rrbracket [b \in \text{dom}(a)]$. Then, $\llbracket \gamma \rrbracket = \{a(b) \mid a \in \llbracket \alpha \rrbracket, b \in \llbracket \beta \rrbracket\}$

This enables the embedding predicate to apply to *each* of the true answers returned by Ans_\exists in a point-wise fashion. The set of propositions derived this way corresponds to the disjuncts in the disjunctive paraphrase of mention-some readings in the above informal sketch. X applies to a function from worlds to such a set. Hence, we derive the interpretation corresponding to the paraphrase in (9).

The ordinary-semantic values of other lexical items are revised to the singleton set of their ‘standard’ intensions. For example, the denotation of R_{know} is the following:

$$(15) \quad \llbracket R_{\text{know}} \rrbracket^w = \{\lambda p_{\langle s, t \rangle} \lambda x_e \lambda w. \mathbf{DOX}_x^w \subseteq p\}$$

Given this setup, the semantic values of some of the crucial compositional steps in (11) will be the following. Here, to make the exposition simple, we assume that $\llbracket \text{Ans}_\exists \rrbracket^g(g(1))(\text{CP})$ is defined, i.e., there is somewhere one can get gas in world $g(1)$.

$$(16) \quad \llbracket \text{AnsP} \rrbracket^g = \left\{ p \in \left\{ \begin{array}{c} A, B, C \\ A \wedge B, B \wedge C, C \wedge A \\ A \wedge B \wedge C \end{array} \right\} \middle| p(g(1)) \right\} \quad (\text{via FA})$$

$$(17) \quad \llbracket V' \rrbracket^g = \left\{ p \in \left\{ \begin{array}{c} \lambda x \lambda w. \mathbf{DOX}_x^w \subseteq A \\ \lambda x \lambda w. \mathbf{DOX}_x^w \subseteq B \\ \lambda x \lambda w. \mathbf{DOX}_x^w \subseteq C \\ \lambda x \lambda w. \mathbf{DOX}_x^w \subseteq A \wedge B \\ \lambda x \lambda w. \mathbf{DOX}_x^w \subseteq B \wedge C \\ \lambda x \lambda w. \mathbf{DOX}_x^w \subseteq C \wedge A \\ \lambda x \lambda w. \mathbf{DOX}_x^w \subseteq A \wedge B \wedge C \end{array} \right\} \middle| p(g(1)) \right\} \quad (\text{via PFA})$$

⁴I will also assume that the rule of Predicate Abstraction (PA) has the same definition as before. Thus, we derive a function into Hamblin sets as a result of PA. This naïve view is problematic if we want binding into each Hamblin alternative, as in the case with the QR of *nobody* out of *who likes nobody*. However, the naïve view suffices for our current purpose as X has to be defined to take as its argument a function that maps each world to the set of alternatives based on true answers in that world. It is known that Predicate Abstraction in Hamblin Semantics causes empirical as well as theoretical problems. See Shan (2004) and Novel and Romero (2010) for general discussion and possible solutions. I leave it for future research how the current assumption about PA can be integrated into the general compositional system of Hamblin semantics that can treat abstraction in one way or the other.

$$(18) \quad \llbracket [1 \text{ VP}] \rrbracket = \lambda w'. \left\{ p \in \left\{ \left\{ \begin{array}{l} \lambda w. \mathbf{DOX}_j^w \subseteq A \\ \lambda w. \mathbf{DOX}_j^w \subseteq B \\ \lambda w. \mathbf{DOX}_j^w \subseteq C \\ \lambda w. \mathbf{DOX}_j^w \subseteq A \wedge B \\ \lambda w. \mathbf{DOX}_j^w \subseteq B \wedge C \\ \lambda w. \mathbf{DOX}_j^w \subseteq C \wedge A \\ \lambda w. \mathbf{DOX}_j^w \subseteq A \wedge B \wedge C \end{array} \right\} \middle| p(w') \right\} \right. \quad (\text{via PA})$$

$$(19) \quad \mathbf{ALT}(\llbracket [1 \text{ VP}] \rrbracket) = \left\{ \left\{ \begin{array}{l} \lambda w. \mathbf{DOX}_j^w \subseteq A \\ \lambda w. \mathbf{DOX}_j^w \subseteq B \\ \lambda w. \mathbf{DOX}_j^w \subseteq C \\ \lambda w. \mathbf{DOX}_j^w \subseteq A \wedge B \\ \lambda w. \mathbf{DOX}_j^w \subseteq B \wedge C \\ \lambda w. \mathbf{DOX}_j^w \subseteq C \wedge A \\ \lambda w. \mathbf{DOX}_j^w \subseteq A \wedge B \wedge C \end{array} \right\} \right\} \quad (\text{By the def. of ALT})$$

$$(20) \quad \llbracket [X [1 \text{ VP}]] \rrbracket = \lambda w'. \left\{ \left\{ p' \in \left\{ \left\{ \begin{array}{l} \lambda w. \mathbf{DOX}_j^w \subseteq A \\ \lambda w. \mathbf{DOX}_j^w \subseteq B \\ \lambda w. \mathbf{DOX}_j^w \subseteq C \\ \lambda w. \mathbf{DOX}_j^w \subseteq A \wedge B \\ \lambda w. \mathbf{DOX}_j^w \subseteq B \wedge C \\ \lambda w. \mathbf{DOX}_j^w \subseteq C \wedge A \\ \lambda w. \mathbf{DOX}_j^w \subseteq A \wedge B \wedge C \end{array} \right\} \middle| p'(w') \right\} \left[\begin{array}{l} p(w) \wedge \forall p' \in \mathbf{ALT}(\llbracket [1 \text{ VP}] \rrbracket) \\ [p' \subset p \rightarrow \neg p'(w)] \end{array} \right] \right\} \quad (\text{via FA})$$

Assuming that one can get gas at A and B, but not at C in w , the truth conditions of the LF (11) would be equivalent to the following disjunctive statement:

$$(21) \quad \llbracket [X [1 \text{ VP}]] \rrbracket(w) = 1 \\ \text{iff } \exists p \in \left\{ \left\{ \begin{array}{l} \lambda w. \mathbf{DOX}_j^w \subseteq A \\ \lambda w. \mathbf{DOX}_j^w \subseteq B \\ \lambda w. \mathbf{DOX}_j^w \subseteq A \wedge B \end{array} \right\} \left[\begin{array}{l} p(w) \wedge \forall p' \in \mathbf{ALT}(\llbracket [1 \text{ VP}] \rrbracket) \\ [p' \subset p \rightarrow \neg p'(w)] \end{array} \right] \right\} \\ \text{iff } \left(\begin{array}{l} \lambda w. [[\mathbf{DOX}_j^w \subseteq A] \wedge \neg[\mathbf{DOX}_j^w \subseteq A \wedge B] \wedge \neg[\mathbf{DOX}_j^w \subseteq A \wedge C]] \vee \\ \lambda w. [[\mathbf{DOX}_j^w \subseteq B] \wedge \neg[\mathbf{DOX}_j^w \subseteq A \wedge B] \wedge \neg[\mathbf{DOX}_j^w \subseteq A \wedge B \wedge C]] \vee \\ \lambda w. [[\mathbf{DOX}_j^w \subseteq A \wedge B] \wedge \neg[\mathbf{DOX}_j^w \subseteq A \wedge B \wedge C]] \end{array} \right)$$

This correctly captures the no-false-answer condition in a mention-some reading. The statement in (21) is true iff John believes some true answer to the question while not believing any false answer.

Note that the system presented in the current section subsumes the compositional semantics with Ans_d presented in the previous chapter. Ans_d would be defined to be the following function that returns a singleton set of propositions.

$$(22) \quad \llbracket \text{Ans}_d \rrbracket := \lambda w. \lambda Q_{\langle st, t \rangle}.$$

$$\left\{ \begin{array}{l} \left\{ \iota p \in Q \left[\forall p' \in Q \left[\frac{p(w) \wedge p'(w)}{p \subseteq p'} \right] \right] \right\} \\ \text{undefined} \end{array} \right. \quad \text{if } \exists! p \in Q \left[\frac{p(w) \wedge \forall p' \in Q [p'(w) \rightarrow p \subseteq p']}{\text{otherwise}} \right]$$

In an LF like the following, the result of the Predicate Abstraction is a function that maps each world to the singleton set consisting of the alternative involving the true most informative answer in that world.

(23) [X [1 [John R_{know} [[Ans_d w_1] who came]]]]

Since the revised version of X existentially quantifies over this kind of singleton sets, the truth conditions of the whole structure would be equivalent as in the previous non-Hamblin system.

Before moving on to the next section, let me stress again that the current analysis of mention-some is not intended to be making a substantial contribution to the semantics of mention-some par se. One of the important issues not addressed in the current analysis is the syntactic and semantic constraints on mention-some. [George \(2011\)](#) and [Fox \(2013\)](#) observe that the presence of existential quantification or a weak modal in the interrogative clause is necessary for a mention-some interpretation (see footnote 1). The current analysis does not predict this kind of constraints since the distribution of Ans_∃ is not constrained beyond semantic types.

5.4 Reducibility revisited

In the previous section, I argued that the current analysis of responsive predicates can capture [George's \(2011\)](#) data simply by extending the analysis to mention-some readings. Remember that [George's \(2011\)](#) data as well as the intermediate exhaustivity of factive predicates show that *know* and other factive predicates lack the reducibility property. The reducibility property is repeated from section 5.2 in the following:

(4) **Reducibility** ([George 2011](#): 145, adapted)

A responsive predicate *V* has the REDUCIBILITY PROPERTY if, for every two entity-denoting terms *a* and *b*,

- if for every declarative clause *p*,
 $a \text{ Vs } \text{that } p \text{ is true iff } b \text{ Vs } \text{that } p \text{ is true}$
- then for every interrogative clause *Q*,
 $a \text{ Vs } Q \text{ is true iff } b \text{ Vs } Q \text{ is true.}$

The fact that the current analysis accounts for the data that are counterexamples to reducibility means that the current analysis does not predict responsive predicates in general to possess the reducibility property. In this section, we discuss the general nature of the current analysis of responsive predicates that makes some responsive predicates lack reducibility as formulated in (4), and point out that a

related property is in fact predicted to hold for responsive predicates in general in the current account.

Why does some predicates lack the reducibility property in the current account? To see this, let us restate the schematic sentences such as *a Vs that p* in (4) in their LF representations proposed in the current analysis. The restatement would look like the following (In the illustration below, for expository purposes, I will use the variables *a, b, Q* both as linguistic expressions as well as their semantic values):

(24) Reducibility in the current LF representation

A responsive predicate *V* has the REDUCIBILITY PROPERTY if, for every two entity-denoting terms *a* and *b*,

- if for every declarative clause *p*,
 $[X [a [R_V [\text{Ans}_{d/MS} [\text{Id } p]]]]$ is true iff
 $[X [b [R_V [\text{Ans}_{d/MS} [\text{Id } p]]]]$ is true.
- then for every interrogative clause *Q*,
 $[X [a [R_V [\text{Ans}_{d/MS} Q]]]$ is true iff
 $[X [b [R_V [\text{Ans}_{d/MS} Q]]]$ is true.

This property does not generally hold when *V* is a factive predicate. The following situation would make the antecedent of the conditional in (24) true while the consequent false.

(25) Counterexample to reducibility

- R_V is a veridical predicate and upward monotonic.
- For all $p \in Q$ such that $p(w)$, $\llbracket R_V \rrbracket^w(p)(a) = \llbracket R_V \rrbracket^w(p)(b) = 1$.
- For some $p' \in Q$ such that $\neg p'(w)$, $\llbracket R_V \rrbracket^w(p')(a) = 1$ and $\llbracket R_V \rrbracket^w(p')(b) = 0$
- For any other $p'' \in Q$ such that $\neg p''(w)$,
 $\llbracket R_V \rrbracket^w(p'')(a) = \llbracket R_V \rrbracket^w(p'')(b) = 0$

The antecedent in (24) would be true in this situation since the presupposition of $\text{Ans}_{d/MS}$ is met only for true *p*, and $\llbracket R_V \rrbracket^w(p)(a) = \llbracket R_V \rrbracket^w(p)(b) = 1$ for all true *p*. ($\llbracket R_V \rrbracket^w(p)(a)$ and $\llbracket R_V \rrbracket^w(p)(b)$ would be both undefined for false *p*.) On the other hand, the consequent in (24) would be false since the exhaustification by *X* requires the subject not to be R_V -related to false propositions. The situation would validate $\llbracket R_V \rrbracket^w(p)(b)$ while falsify $\llbracket R_V \rrbracket^w(p)(a)$.

Stepping back, reducibility does not hold for a veridical predicate *V* in the current analysis for the following reason: the truth conditions of

$$(26) [X [x [R_V [\text{Ans}_d Q]]]]$$

is sensitive to the truth-value of propositions of the form $\llbracket R_V \rrbracket^w(p)(x)$ for some $p \in Q$ that is false in *w*. This information cannot be paraphrased with

$$(27) [X [x [R_V [\text{Ans}_d [\text{Id } p]]]]]$$

Since (27) would be undefined whether or not $\llbracket R_V \rrbracket^w(p)(x)$ is true.

Thus, we have seen that reducibility as formulated by George (2011) is not supported in the current analysis. However, the current analysis predicts the following modified version of reducibility:

(28) **Reducibility modulo factivity**

A responsive predicate V is REDUCIBLE MODULO FACTIVITY if, for every two entity-denoting terms a and b ,

- if for every declarative clause p ,
 a **R_VS** *that* p is true iff b **R_VS** *that* p is true
- then for every interrogative clause Q ,
 a V s Q is true iff b V s Q is true.

The only difference between George’s formulation in (4) and this version of reducibility is that R_V instead of V is used in the antecedent of the conditional. The current analysis predicts this property to universally hold of any responsive predicate since the LF representation of x V s Q is (26), and its interpretation is analyzed solely in terms of propositions of the form $\llbracket R_V \rrbracket^w(p)(x)$.

In other words, we predict that the truth conditions of sentences where V embeds an interrogative complement can be reduced to the truth conditions of sentences where V ’s *non-factive counterpart* embeds a declarative complement. For example, to the extent that *believe* is the non-factive counterpart of *know* (that is, disregarding the Gettier-like counterexamples), the interpretation of *know-wh* can be reduced to that of *believe-that*. Another way to describe the claim is the following: reducibility simpliciter as formulated by George is violated due to factivity, an epiphenomenon caused by **Ans_{d/MS}**. However, if we disregard the effect of factivity, reducibility holds across all responsive predicates.

5.5 Summary

In this chapter, I discussed general properties of the current semantics of responsive predicates surrounding the notion of reducibility defined by George (2011). By extending the compositional system to mention-some answers, I argued that George’s (2011) counterexamples to the reducibility of *know* can be captured within the current semantics. Although this shows that the current semantics does not satisfy reducibility simpliciter, it turns out that it satisfies a related property, reducibility modulo factivity. Here, the diagnosis that factivity is the crucial factor that prevents some predicates from satisfying reducibility simpliciter is crucially enabled by the decompositional perspective on factivity introduced in the previous chapter.

Chapter 6

Conclusions

6.1 The resulting picture

In this dissertation, I proposed a compositional semantics of question-embedding sentences that meets the following three challenges concerning the selectional properties of embedding attitude predicates.

- (1) **Complement selection** Why some declarative-embedding attitude predicates (e.g., *know*, *be surprised*, *tell*, *be certain*, *agree*) can embed interrogative complements while other declarative-embedding predicates (e.g., *believe*, *think*) cannot.

Exhaustivity Why cognitive/epistemic predicates like *know* are compatible with an exhaustive interpretation of their complement while emotive predicates like *surprise* select for a non-exhaustive interpretation.

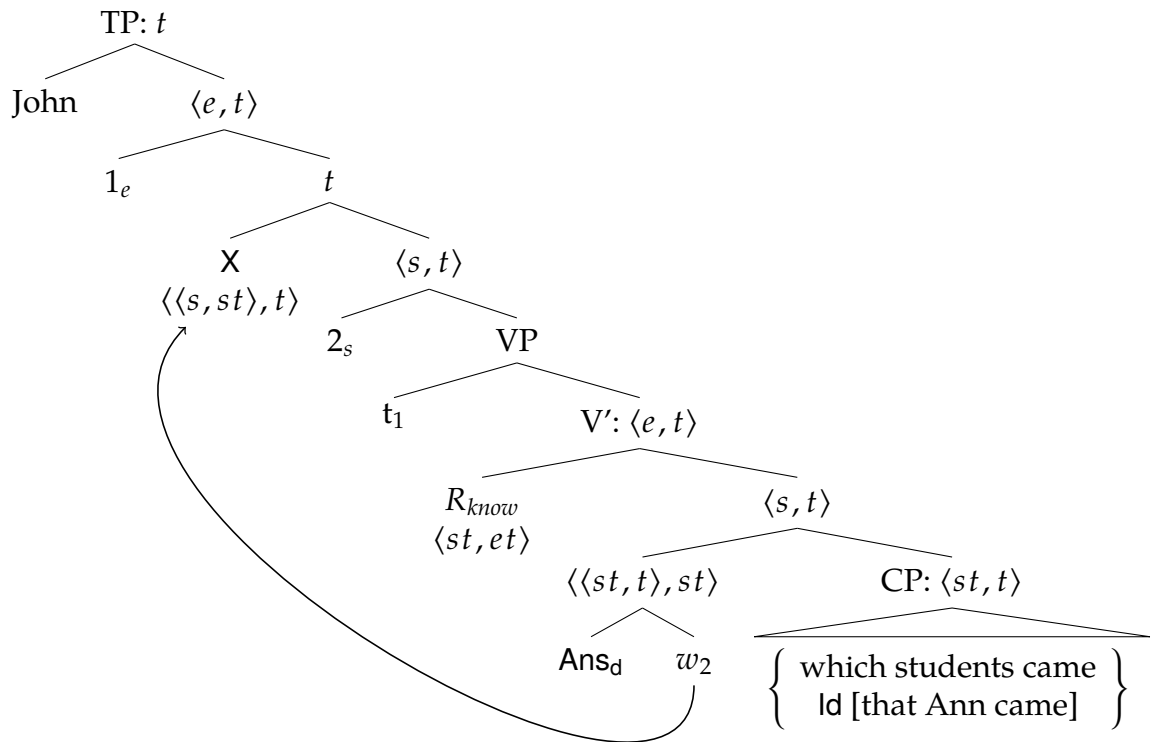
Veridicality Why some predicates (e.g., *know*) select for a veridical interpretation of its complement while other predicates (e.g., *be certain*) select for a non-veridical interpretation.

The proposal is based on the following two main proposals:

1. **Declarative complements as singleton questions** Responsive predicates semantically select for questions, and their declarative complements are analyzed as the limiting (singleton) case of embedded questions.
2. **A unified derivation for exhaustivity** All types of exhaustive interpretations result from the same semantic derivation, one involving so-called matrix exhaustification. The variation in the exhaustive interpretations fall out from this derivation once the lexical semantics of embedding predicates is taken into account.

It is illustrative to look at representative LF structures to see how these two central proposals are fleshed out so that the resulting theory overcomes the above three challenges. Figure 6-1 shows LFs for two representative examples differing in how the world argument of Ans_d is bound. Below, I summarize how the proposals based on these structures meet each of the three challenges one by one.

(a) John knows $\left\{ \begin{array}{l} \text{which students came} \\ \text{that Ann came} \end{array} \right\}$. (Other predicates : *be surprised, decide*
*tell*_[+ver], *agree* etc.)



(b) John is certain $\left\{ \begin{array}{l} \text{which students came} \\ \text{that Ann came} \end{array} \right\}$.
(Other predicates : *tell*_[-ver], *predict*_[-ver]
prove etc.)

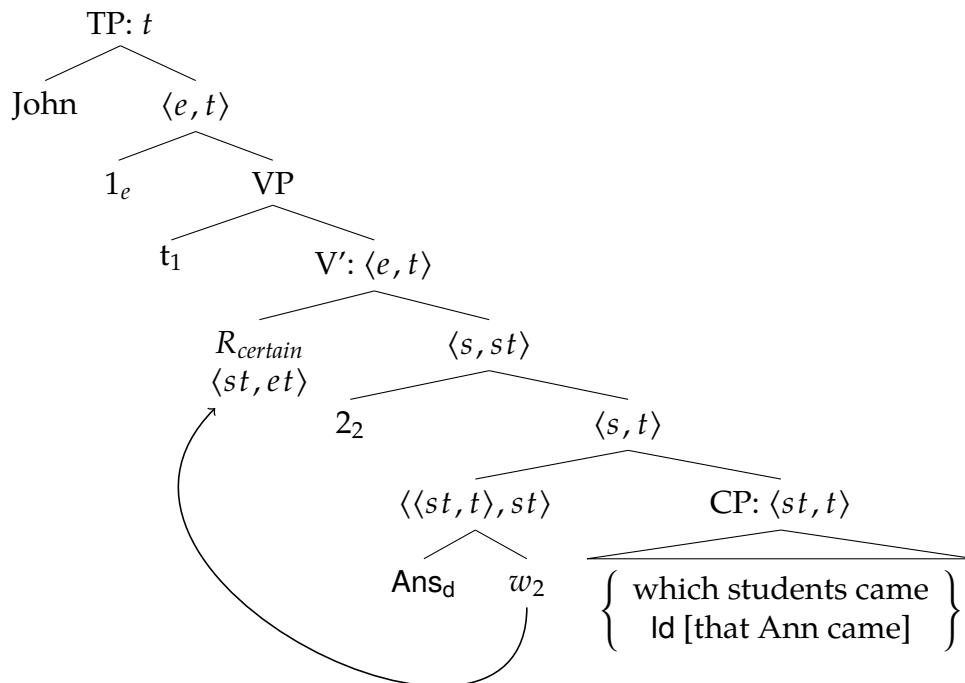


Figure 6-1: Two representative LF structures

6.1.1 Complement selection

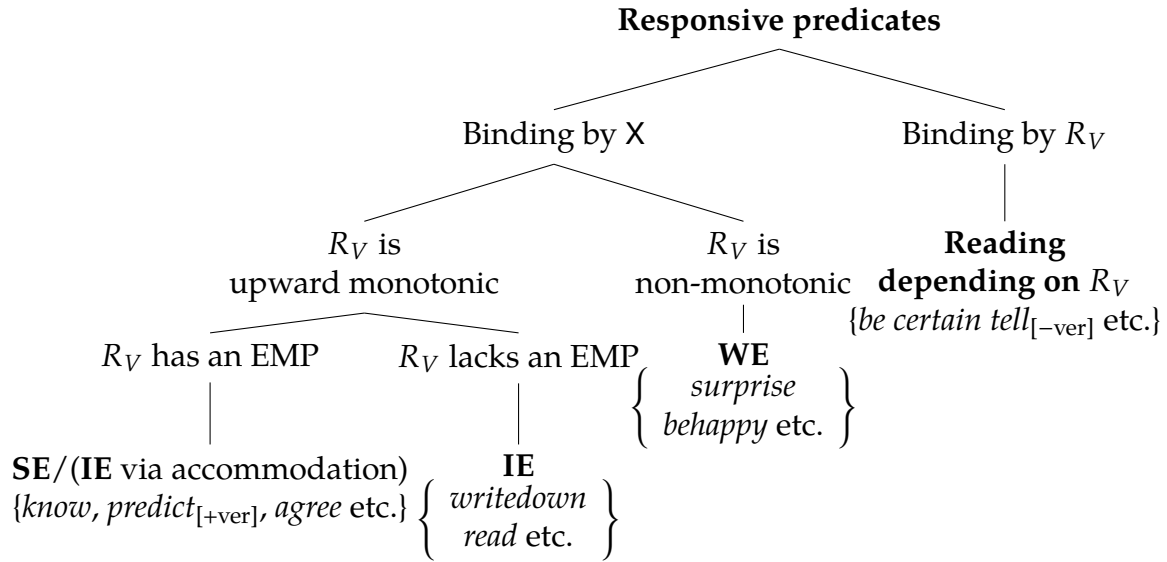
The issue of complement selection posed by the first challenge is accounted for by the first proposal, i.e., the analysis of declarative complements as singleton questions. In the structures in Figure 6-1, this is represented by the fact that the declarative complement *that Ann came* with the type-shifter *Id* is in the complement position of the complex head involving the answerhood operators. Responsive predicates can combine with both declarative and interrogative complements since their decompositional structures involve an answerhood operator selecting for a question, and declarative complements can be coerced into singleton questions with the help of the *Id* type-shifter. The exclusively declarative-embedding predicates, such as *believe*, cannot combine with interrogative complements simply because they semantically select for propositions, and that there is no way to coerce questions into propositions. On the other hand, exclusively interrogative-embedding predicates, such as *wonder*, cannot combine with declarative complements since their lexical semantics comes with the non-triviality requirement, i.e., the requirement that the question they combine with are non-singletons.

The proposal is motivated independently by the interpretation of nominal complements of the relevant predicates, as argued in chapter 2. Furthermore, the proposal is argued to be superior to the standard picture where responsive predicates are proposition-taking. The reason is that the current proposal does away with a purely syntactic selectional restriction (the ‘c-selections’) that blocks *believe*-type predicates from embedding interrogatives although it is necessitated by the standard picture.

6.1.2 Exhaustivity

The second issue concerning exhaustivity is addressed by the second proposal, the proposal for a unified derivation of exhaustivity. In chapter 3, it is argued that all varieties of exhaustive interpretations result from a derivation involving the operator *X* scoping above the embedding predicate. This is the picture illustrated in Figure 6-1(a). Taking into account the structure in Figure 6-1(b) discussed in chapter 4, the proposal can be generalized to the claim that exhaustivity results from a derivation involving a binding of the world argument of *Ans_d* either by *X* scoping over the embedding predicate or by the core embedding predicate itself, such as *R_{certain}*.

In the case where *X* binds the world argument of the answerhood operator, as in Figure 6-1(a), the exhaustivity of the interpretation varies depending on the semantic properties of the core predicate *R_V*, specifically, its monotonicity and the presence/absence of the excluded-middle presupposition. If *R_V* is upward monotonic, as in cognitive predicates, such as *know*, and the veridical version of communication predicates, such as *tell_[+ver]*, the effect of *X* is non-vacuous, and hence the structure derives the intermediately exhaustive (IE) interpretation. This interpretation can be further strengthened into the strongly exhaustive (SE) interpretation by the mechanism of neg-raising if *R_V* comes with the excluded-



(EMP: Excluded-middle presupposition)

Figure 6-2: Summary of the analysis of the variation in exhaustivity

middle presupposition. On the other hand, if R_V is non-monotonic, as in emotive factives, such as *be happy* and *be surprised*, the effect of X is vacuous. Thus, the resulting interpretation in such cases is a weakly exhaustive (WE) one.

In the case where R_V binds the world argument of the answerhood operator, the exhaustivity of the interpretation is directly dependent on the lexical semantics of R_V . For example, the lexical semantics of $R_{certain}$ is specified so that the interpretation is always SE. On the other hand, the existential lexical semantics of $R_{tell[-ver]}$ derives a mention-some interpretation. Together with the excluded-middle presupposition, the latter type of predicates may give rise to an SE interpretation.

A crucial syntactic assumption in the current account is that X cannot scope below R_V . That is, its landing site in the structure in Figure 6-1(a) cannot be below R_{know} . Although this remains as a stipulation in the current dissertation, it may very well be the case that the necessity of this syntactic stipulation is a by-product of the technical implementation of X as a syntactically free operator. If X is a part of the lexical semantics of R_V for the relevant predicates, as suggested throughout the course of this dissertation, we would end up with a unified picture where R_V always undergoes a shortest LF-movement out of the argument position of the answerhood operator. The summary of how the different varieties of exhaustive interpretations are derived in the current analysis is illustrated in Figure 6-2.

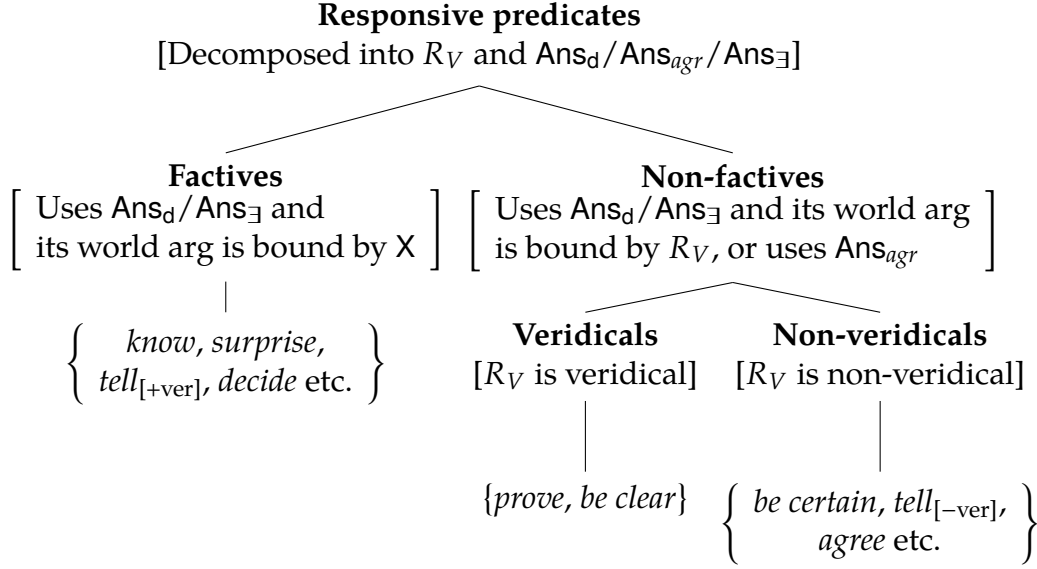


Figure 6-3: Summary of the analysis of the veridicality/factivity

6.1.3 Veridicality

There are two ways for a responsive predicate to be veridical: (i) by virtue of having Ans_d interpreted in the matrix evaluation world, and (ii) by virtue of having a core predicate R_V that is veridical. The former case applies to the predicates participating in the structure in Figure 6-1(a) and the latter case applies to predicates such as *prove* participating in the structure in Figure 6-1(b). In both cases, the predicate is veridical with respect to both declarative and interrogative-embedding since declarative complements are limiting case of question-embedding, as stated in Proposal 1.

In the case (i) above, the predicate is *factive* when it embeds a declarative complement, as the limiting case of the existential presupposition boils down to the presupposition that the unique proposition denoted by the declarative complement is true. On the other hand, the predicate is non-factive in the case (ii) above, provided that the core predicate itself is non-factive. The summary of the analysis of veridicality and factivity is illustrated in Figure 6-3, repeated from chapter 4.

6.2 Future prospects

As concluding remarks, I would like to discuss several future prospects of the analysis presented in the current dissertation. There are a number empirical and theoretical domains in which the current analysis can be extended or refined. These include constraining the derivation of *de re/de dicto* ambiguity and mention-some readings, Quantificational Variability Effect, integration of the current analysis of exhaustivity with the general theories of exhaustive inferences, and the investigation of the constraints on the lexical semantics of attitude predicates.

6.2.1 Other kinds of variability: *de re/de dicto* and mention-some

I started the dissertation by pointing out that existing theories of question-embedding generally are not constrained to make fine-grained predictions about variability in complement selection, exhaustivity and veridicality. I developed an analysis that aims to achieve the fine-grained predictions, but have simply posited optionality for other kinds of variability in the interpretation of embedded questions, i.e., the *de re/de dicto* ambiguity and mention-some readings. That is, I have simply taken the strategy of ‘generalizing to the worst case’ in treating the *de re/de dicto* ambiguity and the possibility of mention-some readings in the current dissertation. However, an ultimate analysis of question-embedding should address the problem of how the *de re/de dicto* ambiguity and mention-some readings are constrained, both empirically and theoretically.

It has been claimed in the literature that these two types of variability are empirically constrained. Specifically, [Groenendijk and Stokhof \(1984\)](#) and [Sharvit \(2002\)](#) claim that there is a correlation between strong exhaustivity and *de dicto* readings. Also, [George \(2011\)](#) and [Fox \(2013\)](#) claim that mention-some readings require weak modals or existential quantification in the interrogative complement. One of our future tasks is to empirically examine these empirical claims, and see if the empirically attested constraints on the interpretations can be captured by refining the current analysis of question-embedding.

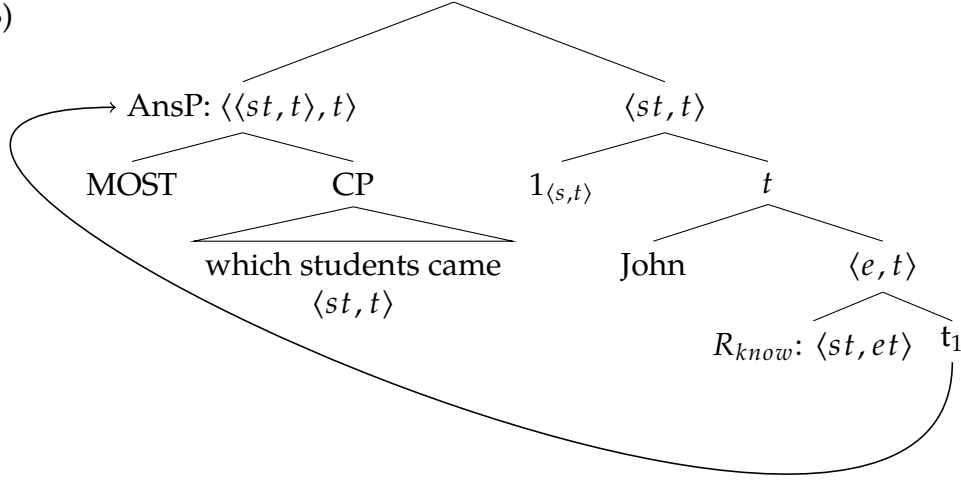
6.2.2 Quantificational variability effect (QVE)

Another domain in which the current analysis can be extended is the Quantificational Variability Effect (QVE) ([Berman 1991](#)), as exemplified in the following example with the paraphrase.

- (2) John knows, for the most part, which students came.
‘For most of the students who came, John knows that they came.’

One possibility of such an extension would be to make Q(uantificational)-adverbs in complementary distribution with the complex head consisting of Ans_d and X , and assume that the Q-adverb+CP undergoes QR, following [Lahiri’s \(2002\)](#) analysis in terms of Interrogative Raising. The LF for (2) would look like the following under such an analysis, assuming the denotation for MOST in (4).

(3)



$$(4) \quad \llbracket \text{MOST} \rrbracket^w = \lambda Q_{\langle st, t \rangle} \lambda Q'_{\langle st, t \rangle} \cdot |\text{At}(Q) \cap \text{True}(w) \cap \text{At}(Q')| > \frac{1}{2} |\text{At}(Q) \cap \text{True}(w)|$$

- **At** is a function that maps sets of propositions to the set of its atomic members.
- **True**(w) is a set of propositions that are true in w .

The syntactic position that **MOST** occupies in (2) is the position that would be occupied by the answerhood operator and **X** if **Q**-adverb does not appear in the sentence. In other words, the answerhood operator + **X** is the ‘default’ **Q**-adverb, in the sense that it shows up whenever there is no explicit **Q**-adverb as in (2).

This, of course, is a very crude analysis at this point. For example, it cannot be generalized to QVE with *agree* and with predicates that involves intensional predicates, such as *be certain*. Examples of such QVE sentences are given below (Lahiri 2002; Beck and Sharvit 2002).

- (5) a. John is certain, for the most part, which students came.
 b. For the most part, John agrees with Mary on which students came.

Part of the problem is that **MOST** in (4) already encodes the fact that the quantification is restricted to *true* answers in the evaluation world, but the data in (5) suggest that it should be generalizable to answers in other worlds and other restrictors, such as Mary’s beliefs, in the case of (5b). At the surface, the problem is similar to how the role of the answerhood operator is generalized to non-factive predicates and *agree* in chapter 4. I have to leave this issue for future research. See Cremers (2015) for a recent approach to QVE employing a generalized notion of the answerhood operator that is aimed to account for cases like (5).

6.2.3 Integration with the general theories of exhaustification

Another future prospect would be to investigate how the exhaustivity of embedded questions can or cannot be integrated with the general theory of exhaustive inferences. The current analysis of exhaustivity in embedded questions makes use

of the exhaustivity operator X , whose function is similar to that of the Maxim of Quantity in Grice (1975) and to the grammatical exhaustivity operator in Chierchia et al. (2012). Thus, it would make sense to consider how the analysis in terms of X can be integrated with the general theories of exhaustive inferences, whether they are Gricean theories or grammatical theories. In this connection, Cremers et al.'s (2015) recent experimental work is also informative as it shows that children exhibit the same behavioral pattern with scalar implicatures and exhaustivity of embedded questions: they are more tolerant to the weaker non-exhaustified readings than the adults. However, as I discussed in chapter 3, there are several challenges for an integration of a theory of general exhaustive inferences and that of exhaustivity in embedded questions. The first is the fixed scope of X , and the other is the fact that the alternatives for X , i.e., those based on the set of possible WE answers, do not seem to be reducible to the general assumptions about alternatives.

6.2.4 Constraints on the lexical semantics of attitude predicates

Finally, the compositional analysis of responsive predicates presented in the current dissertation brings up questions that have not been extensively investigated in the literature, i.e., the questions concerning the constraints on the lexical semantics of attitude predicates. That is, what are possible building blocks and their possible combinations for the lexical semantics of attitude predicates. While there are well-known constraints on quantifier meanings (e.g., Barwise and Cooper 1981), there are relatively few known constraints on the meanings of attitude predicates. This said, the field has also seen new results concerning this general issue in the series of research by conducted by Kratzer (2006); Moulton (2008) and Bogal-Allbritten (2015) on the inner lexical semantics of proposition-taking attitude predicates.

I touched on the issue of constraints on lexical semantics in the analysis of factivity in chapter 4. If the answerhood operator is the only source of factivity of a clause-embedding predicate, then there would be no factive proposition-taking predicates. Yet, other questions regarding the constraints on the lexical semantics of responsive predicates are left open. For example, the following questions are yet to be investigated: What is the possible inventory of the core proposition-taking predicates that participate in the decomposition of responsive predicates? And, what are the possible combinations of those core predicates and the different kinds of answerhood operators, i.e., Ans_d , Ans_{agr} and Ans_\exists ? Needless to say, in order to address such issues, we would have to embark on through cross-linguistic empirical investigations with much wider empirical coverage than that of the current dissertation.

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