Chapter 4

Variations of exhaustivity and sensitivity to false answers

This chapter is partially developed from Xiang (2016, Proceedings of Sinn und Bedeutung 20) and Xiang (2016, talk at the Workshop of Attitudes and Questions, Center for Formal Epistemology, Carnegie Mellon University).

4.1.   Introduction

There have been a plenty of studies on the interpretations of indirect questions, especially on the variations of exhaustivity.[46] Most of the studies take weak exhaustivity as the baseline and generate other forms of exhaustivity (i.e., intermediate exhaustivity and strong exhaustivity) using a strengthening operation, such as employing a strong answerhood-operator or strengthening the root denotation. Nevertheless, to unify mention-some and mention-all readings of questions, we have replaced weak exhaustivity with max-informativity. This move requires us to re-consider the derivational procedures of other forms of exhaustivity.

The main goal of this chapter is to characterize the condition of *false answer (FA)-sensitivity* involved in interpreting indirect questions. For example, for the sentence in (241) to be true, John shall not believe any false answers to *who came*.

(241)   John knows who came.

Previous accounts of FA-sensitivity consider only the case of indirect mention-all questions and treat FA-sensitivity as a result of strengthening weak exhaustivity (Klinedinst & Rothschild 2011, Spector & Egré 2015, Uegaki 2015). George (2011, 2013) observes that, however, FA-sensitivity is also involved in interpreting indirect mention-some questions, which therefore calls

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[46]Representative studies are list in the following: Karttunen (1977), Groenendijk & Stokhof (1982, 1984), Heim (1994), Ginzburg (1995), Dayal (1996, 2016a), Beck & Rullmann (1999), Lahiri (2002), Beck & Sharvit (2002), Sharvit (2002), Guerzoni & Sharvit (2007), George (2011, 2013), Klinedinst & Rothschild (2011), Nicolae (2013), Spector & Egré (2015), Križ (2015), Xiang (2016), Uegaki (2015), Cremers & Chemla (2016), Cremers (2016), Theiler *et al.* (2016).

for a uniform treatment of FA-sensitivity across mention-all and mention-some. Moreover, I observe that the content of FA-sensitivity is richer than what the previous accounts thought: it is concerned with not only potential complete answers, but also the answers that are always partial, such as false disjunctive answers and false denials.

The rest of this chapter is organized as follows. Section 4.2 introduces some basics about question-embedding, including the typology of question-embedding predicates and the forms of exhaustivity involved in interpreting indirect mention-all questions. Section 4.3 discusses two facts that challenge the current dominant view of FA-sensitivity:

(i) Indirect mention-some questions have readings sensitive to false answers (George 2011, 2013);

(ii) FA-sensitivity is also concerned with all types of false answers, not just the answers that are potentially complete.

Section 4.4 reviews and argues against the exhaustification-based account by Klinedinst & Rothschild (2011). Section 4.5 presents my analysis of Completeness and FA-sensitivity. I treat them as two independent conditions. Moreover, I argue that the embedded question should not be flattened into a proposition, otherwise we cannot recover all the relevant answers of the embedded question. Section 4.6 discusses other two puzzling issues:

(i) How is FA-sensitivity interacted with factivity? In particular, why is it that questions embedded under emotive factives (e.g. *surprise*) do not seem to be FA-sensitive?

(ii) Why is it that questions embedded under *agree* (*with/on*) cannot take mention-some readings?

Section 4.7 presents experimental evidence for the claim that FA-sensitivity is concerned with false denials. Moreover, the results of the experiments show asymmetries of false beliefs that vary by question type. I provide a principled explanation to these asymmetries. Section 4.8 summarizes the lines of approaches to strong exhaustivity, and shows how those approaches can be adapted to the proposed framework.

4.2. Background

4.2.1. Interrogative-embedding predicates

There is a rich literature on the interpretations of indirect questions and the semantics of interrogative-embedding predicates. (See footnote 46 for a list of representative studies.) The following tree illustrates the typology of interrogative-embedding predicates, adapted from Lahiri (2002: ch. 6), Spector & Egré (2015), and Uegaki (2015).
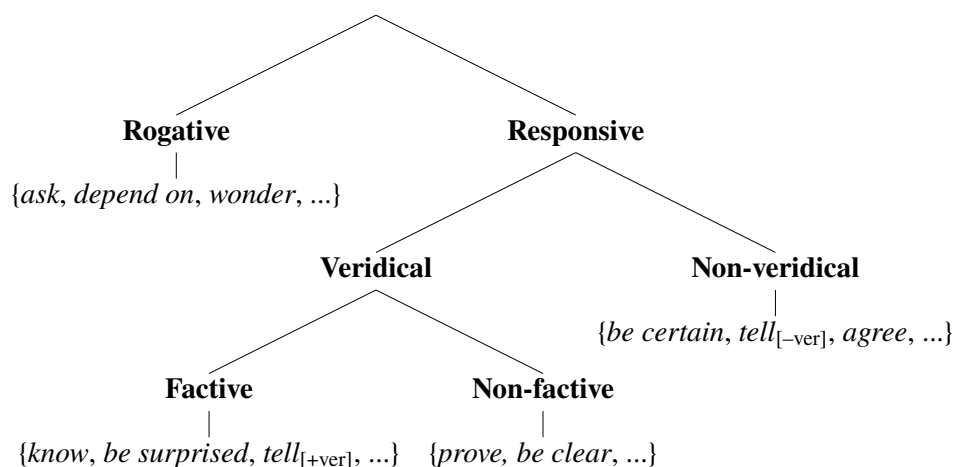
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                              Rogative              Responsive
                                 |
                       {ask, depend on, wonder, ...}
                                        Veridical            Non-veridical
                                                                  |
                                                    {be certain, tell[−ver], agree, ...}
                              Factive              Non-factive
                                 |                     |
                   {know, be surprised, tell[+ver], ...}   {prove, be clear, ...}
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Figure 4.1: The typology of interrogative-embedding predicates

Rogative versus responsive   Following Lahiri (2002: ch. 6), we firstly classify interrogative-embedding predicates into two major classes, namely, *rogative predicates* and *responsive predicates*. Rogative predicates are only compatible with interrogative complements, while responsive predicates are also compatible with declarative complements.

(242) a.   John knows that Mary left.

      b.   * John asked me that Mary left.

Veridicality   We further divide responsive predicates into two groups, based on veridicality with respect to interrogative complements. Compare the following minimal pair:

(243) a. John knows who left.

        ⤳ *For some <u>true</u> answer p as to who left, John knows p.*

      b. John is certain about who left.

        ⤳ *For some <u>possible</u> answer p as to who left, John is certain about p.*

(243a) implies that John knows a complete true answer as to *who left*, while (243b) only suggests that John is sure about the truth of a possible answer as to *who left*. Hence, we say that *know* is veridical, while *be certain* is non-veridical.

Communication verbs as factives   A few more things need to be clarified for *communication verbs* (e.g., *tell*, *predicate*). Karttunen (1977) claims that *tell* is non-veridical with respect to declarative complements, but that it can be veridical with respect to interrogative complements. For instance, (244a) does not imply that what John told us is true (i.e., it does not imply that Mary indeed left), while (244b) intuitively suggests that John told us some true answer as to who left. Based on this contrast, Karttunen concludes that the verb *tell* is non-veridical by itself, and that the veridicality of *tell* in (244b) comes from the interrogative complement. Hence, Karttunen argues that a question denotes a set of true propositions.

(244)   a.   John told us that Mary left.

        ↛ *Mary left.*

    b.   John told us who left.

        ⤳ *For some true answer p as to who came, John told us p.*

Contrary to Karttunen (1977), Spector & Egré (2015) argue that declarative-embedding *tell* does admit a factive/veridical reading. Compare the examples in (245): while the indirect question in (245a) by itself does not necessarily imply the truth of the declarative complement, embedding it under negation or in a polar question strongly suggests the truth of the declarative complement. These facts suggest that the declarative-embedding *tell* also has a factive reading, and that the veridicality of interrogative-embedding *tell* comes from *tell*, not the interrogative complement. Following Spector & Egré, I classify communication verbs that take veridical readings as factives.

(245)   a.   Sue told Jack that Fred is the culprit.   ↛ *Fred is the culprit.*

    b.   Sue didn't tell Jack that Fred is the culprit.   ⤳ *Fred is the culprit.*

    c.   Did Sue tell Jack that Fred is the culprit?   ⤳ *Fred is the culprit.*

A veridical predicate is not necessarily factive (Egré 2008, Uegaki 2015). For instance, *prove* is veridical with respect to both interrogative and declarative complements, but it is not factive. The following examples are taken from Uegaki (2015: ch. 4).

(246)   a.   John proved which academic degree he has.

        ⤳ *For some true answer p as to which academic degree John has, John proved p.*

    b.   John proved that he has a PhD.

        ⤳ *John has a PhD.*

    c.   John didn't prove that he has a PhD.

        ↛ *John has a PhD.*

4.2.2.   Forms of exhaustivity

Earlier works have noticed two forms of exhaustivity involved in interpreting indirect mention-all questions, namely, *weak exhaustivity* (Karttunen 1977) and *strong exhaustivity* (Groenendijk & Stokhof 1982, 1984). Consider the indirect question (247) for illustration. This example is just to illustrate the range of theoretically possible readings. At this point, I am not committed to any empirical claim about the available readings of the sentence in (247).

(247)   John knows who came.

    (*w: Among the three considered individuals, Andy and Billy came, but Cindy didn't.*)

    a.   John knows that a and b came.   **WE**

    b.   John knows that a and b came; and John knows that c did **not** come.   **SE**

    c.   John knows that a and b came; and **not** [John believes that c came].   **IE**

The weakly exhaustive (WE) reading only requires John to know the mention-all answer as to *who came*: for any individual x, if x came, then John knows that x came. While the strongly exhaustive (SE) reading also requires John to know the mention-all answer as to *who didn't come*: for any individual x, if x didn't come, then John knows that x didn't come. Recent works (Klinedinst & Rothschild 2011, Spector & Egré 2015, Uegaki 2015, Cremers & Chemla 2016) start to consider an intermediate form of exhaustivity: stronger than WE but weaker than SE, the *intermediately exhaustive* (IE) reading requires John to know the mention-all answer as to *who came* and to have no false belief as to *who came*. I call this "no false belief" condition "be sensitive to false answers," and abbreviate it as "false answer (FA)-sensitivity" henceforth.

Several different empirical claims have been made as to which embedding predicates license which forms of exhaustivity. For now, I only consider veridical responsive predicates, which can be classified into the following four groups.

(248) **Veridical responsive predicates**

    a. Cognitive factives: *know*, *remember*, *discover*, ...

    b. Emotive factives: *be surprised*, *be pleased*, *be annoyed*, ...

    c. Communication verbs: *tell*, *predict*, ...

    d. Non-factives: *be clear*, *prove*, ...

It is commonly believed that SE readings are licensed by cognitive factives (Groenendijk & Stokhof 1982, 1984) but are difficult for other veridical responsive predicates (Heim 1994, Beck & Rullmann 1999, Guerzoni & Sharvit 2007, Nicolae 2013, Uegaki 2015). Nevertheless, a recent experimental work by Cremers & Chemla (2016) found evidence that supports the availability of SE readings with the communication verb *predict*.

As for the distribution of WE readings, there are basically two positions, different with respect to whether WE readings can be licensed by cognitive factives: one position (Groenendijk & Stokhof 1984, George 2011, Uegaki 2015) believes that WE readings can be licensed by most veridical responsive predicates except cognitive factives; the other position (Karttunen 1977, Heim 1994, Guerzoni & Sharvit 2007, Klinedinst & Rothschild 2011) believes that WE readings are also available under cognitive factives. For instance, Guerzoni & Sharvit (2007) argue that the consistency of (249) would be left unexplained if *know* licenses only SE readings.

(249)   Jack knows who came, but he does not know who did not come.

Nevertheless, for authors taking either position, the readings that they claim to be WE might be actually IE. Lahiri (2002: pp. 149) firstly discusses the possible confusion between WE and IE for *know*. He argues that WE readings are too weak for *know*, based on the following example due to J. Higginbotham. This sentence cannot be true (on any conceivable reading) if John happens to believe that all numbers between 10 and 20 are prime.

(250)   John knows which numbers between 10 and 20 are prime.

Cremers & Chemla (2016) experimentally validate the existence of IE readings for *know* and *predict*. Moreover, they indicate that it is difficult to establish the existence of WE readings for

know at least, because what appears to be WE readings might be actually SE or IE readings with covert domain restrictions. The only "seeming" exceptions with respect to the availability of IE readings are emotive factives. For instance, as shown in (251), a *surprise*-sentence is true as long as the attitude holder is surprised at the WE answer of the embedded question.

(251)   John is surprised at who came.
        (*w: Among the three considered individuals, Andy and Billy came, but Cindy didn't.*)
        a. ⤳ John is surprised that Andy and Billy came.
        b. ↛ John isn't surprised that Cindy came.

In section 4.6.1, I will show that the FA-sensitivity condition (i.e., the condition that distinguishes IE from WE) collapses under the strong factive presupposition of *surprise*, which therefore makes IE undistinguishable from WE. If all of these claims are right, then there is no independent WE reading for indirect questions.

I summarize my take on the distributional pattern of each exhaustive reading as follows:

(252)   a. WE is not an independent reading;
        b. IE is widely available;
        c. SE is available at least under cognitive factives and communication verbs.

4.3.   Two facts on FA-sensitivity

4.3.1.   FA-sensitivity under mention-some

George (2011, 2013) observes that indirect mention-some questions also have readings sensitive to false answers, in parallel to the IE readings of indirect mention-all questions. For a concrete example, consider the scenario described in (253): Italian newspapers are available at Newstopia but not PaperWorld; both John and Mary know a true mention-some answer as to *where one can buy an Italian newspaper* (viz., *at Newstopia*), but Mary also believes a false answer, namely, *that one can buy an Italian newspaper at PaperWorld*. Intuitively, there is a prominent reading under which (253a) is true while (253b) is false.

(253)   Scenario:

Italian newspapers are available at ...	*Newstopia?*	*PaperWorld?*
Facts	*Yes*	*No*
John's belief	Yes	?
Mary's belief	Yes	Yes

        a. John knows where one can buy an Italian newspaper.   [Judgment: TRUE]
        b. Mary knows where one can buy an Italian newspaper.   [Judgment: FALSE]

George takes this fact as an argument against the reductive view of interrogative-embedding *know*. On the reductive view, the meaning of a [*x* knows Q] construction can be paraphrased based on *x*'s knowledge of facts or declaratives relevant to Q. The sensitivity to false answers in indirect mention-some questions shows that 'which answers of Q *x* knows' does not suffice to resolve 'whether *x* knows Q.' Klinedinst & Rothschild (2011) and Uegaki (2015) argue that the ordinary value of [*x* knows Q] can still be defined in terms of *x*'s declarative-knowledge relevant to Q, namely, '*x* knows a complete true answer of Q,' and that the FA-sensitivity condition is a logical consequence of exhaustifying this reduced inference. I will review and argue against this exhaustification-based approach in section 4.4.

It remains controversial, however, whether the reading described above for (253a-b) is exhaustive in any sense (see section 4.4.2). To be theory neutral, for both mention-all questions and mention-some questions, I call the readings that are sensitive to false answers "FA-sensitive readings." I divide the truth conditions of an FA-sensitive reading into two parts, namely, *Completeness* and *FA-sensitivity*, roughly described in (254) based on the factive *know*.

(254)   John knows Q.

    a.   John knows a complete true answer of Q.   **Completeness**

    b.   John does not believe any false answers of Q.   **FA-sensitivity**

4.3.2.   FA-sensitivity to partial answers

What types of false answers are involved in the condition of FA-sensitivity? Previous studies consider only answers that are potentially complete and characterize FA-sensitivity accordingly. Nevertheless, as I will show in the following, FA-sensitivity is concerned with all types of false answers, not just those that can be complete. Regardless of how Completeness is defined, the answers in the following example can never be complete:[47]

(255)   Who came?

    a.   Andy or Billy. $\phi_a \vee \phi_b$ Disjunctive partial

    b.   Andy didn't. $\neg \phi_a$ Negative partial

Consider, for example, the sentences in (256) and (257) satisfy the Completeness condition but are intuitively false in the given scenarios. These facts suggest that the FA-sensitivity condition is concerned with **false disjunctive** answers.

(256)   John knows who came.   [Judgment: FALSE]

    Fact: *a* came, while *b* and *c* didn't come.

    John's belief: *a* someone else came, who might be *b* or *c*.

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[47]Under the assumed definition of Completeness, adopted from Fox (2013), a proposition *p* is a potential complete answer of Q only if there is a world *w* such that *p* is a max-informative true answer of Q in *w*. Formally:

  (1)   *p* is a potential complete answer of Q only if $\exists w[p \in \textsc{Ans}(\llbracket Q \rrbracket)(w)]$.

(257)   John knows where we can get gas.   [Judgment: FALSE]

       Fact: *a* sells gas, while *b* and *c* do not.

       John's belief: *a* and somewhere else sell gas, <u>which might be *b* or *c*</u>.

Moreover, interpretations of indirect mention-some questions show that FA-sensitivity is also concerned with **false denials**, which are always partial and are even excluded from any possible Hamblin set. George (2011, 2013) has discussed false answers that are *over-affirming* (OA), namely, overly affirming a possible answer that is false in the evaluation world. For example, Mary incorrectly believes that Italian newspapers are available at store B. Correspondingly, we should also check false answers that are *over-denying* (OD), namely, overly denying a possible answer that is true in the evaluation world. For example, Sue incorrectly believes that Italian newspapers are unavailable at store C.

(258)

Italian newspaper are available at …	*A?*	*B?*	*C?*	FA-type
Facts	*Yes*	*No*	*Yes*	
John's belief	Yes	?	?	
Mary's belief	Yes	**Yes**	?	OA
Sue's belief	Yes	?	**No**	OD

    a. John knows where one can buy an Italian newspaper.   TRUE

    b. Mary knows where one can buy an Italian newspaper.   FALSE

    c. Sue knows where one can buy an Italian newspaper.   TRUE/FALSE?

The truth value of (258c) reflects whether FA-sensitivity is concerned with over-denying: if over-denying is involved in FA-sensitivity, then there should be a reading under which (258a) is true while (258c) is false. It is however a bit hard to judge the truth value of (258c). (See explanations in section 4.7.3.) In section 4.7, I provide experimental evidence to show that over-denying is indeed involved in FA-sensitivity: cases like (258c) received significantly less acceptances than cases like (258a).

It is worthy noting that, based on mention-all questions, we cannot tell whether FA-sensitivity is concerned with over-denying. Consider (259) for illustration, the requirement of avoiding over-denying can be understood in two ways. One way is to treat this requirement as simply a logical consequence of Completeness: if John has no conflicting belief, then (259c) follows (259a). The other way is to treat this requirement as part of FA-sensitivity and group it together with the condition (259b), because both (259b-c) are concerned with false answers.

(259)   John knows who came.

     a. if *x* came, John believes that *x* came.

     b. if *x* didn't come, not [John believes that *x* came].   Avoiding OA

     c. if *x* came, not [John believes that *x* didn't come].   Avoiding OD

Previous accounts of FA-sensitivity (Klinedinst & Rothschild 2011, Uegaki 2015, Roelofsen *et al.* 2016) take the former option. In a mention-some question, however, the requirement of avoiding over-denying is not entailed by Completeness. Hence, to unify the analyses of mention-all and mention-some questions, it is more plausible to take the latter option.

4.4.   The exhaustification-based approach and its problems

4.4.1.   The exhaustification-based approach

Klinedinst & Rothschild (2011) derive IE readings based on exhaustifications. The core idea of their approach is as follows: exhaustifying the Completeness condition (260a) yields an inference entailing the FA-sensitivity condition (260b).[48]

(260)   John knows who came.

      a. If x came, then John knows that x came.   **Completeness**

      b. If x didn't come, then not [John believes that x came].   **FA-sensitivity**

Klinedinst & Rothschild assume that the ordinary value of sentence (260) is its WE inference, and that the IE reading is derived by exhaustifying this WE inference at the matrix level.[49] The LFs for WE and IE readings are thus as follows:

(261)   a. John knows [who came]   **WE**

      b. O [John knows [who came]]   **IE**

The O-operator has a meaning akin to the exclusive particle *only*: it affirms the prejacent proposition and negates all the alternatives of the prejacent that are not entailed by the prejacent. (Chierchia *et al*. 2012, among others)

(262) $O(p) = \lambda w[p(w) = 1 \wedge \forall q \in \textsc{Alt}(p)[p \not\subseteq q \rightarrow q(w) = 0]]$

      (The prejacent p is true, while the alternatives that are not entailed by the p are false.)

    Klinedinst & Rothschild define the denotation of the embedded interrogative Q as a function that maps each possible world to the mention-all answer of Q in that world, as in (263a). The ordinary value of the indirect question is thus the WE inference, namely, that John knows the true mention-all answer to Q, as in (261b). Employing exhaustification globally affirms this WE inference and negates all the propositions of the form "John believes ϕ" where ϕ is a **possible** mention-all answer to Q and is not entailed by the **true** mention-all answer to Q,[50] yielding the following exhaustified inference: among all the possible mention-all answers of Q, John only believes the TRUE mention-all answer of Q.

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[48]Klinedinst & Rothschild (2011) consider only the existence of IE readings for communication verbs like *tell* and *predict*. But Cremers & Chemla (2016) have experimentally validated the existence of IE readings for the cognitive factive *know*. This section uses *know* to demonstrate Klinedinst & Rothschild's idea, so as to avoid confusions from the ambiguity of *tell* on veridicality.

[49]Klinedinst & Rothschild (2011) derive SE readings by placing an O-operator immediately above the embedded interrogative, as illustrated in (1). This implementation requires additional assumptions, because here the prejacent of O-operator denotes a function from possible worlds to propositions (of type $\langle s, st \rangle$), not a proposition. See more details on the derivation of SE in section 4.8.

    (1)   John knows [O [who came]]

[50]Note that the alternatives are of the form "John believes ϕ," not "John knows ϕ." As observed by Spector & Egré (2015), in paraphrasing the FA-sensitivity condition of a question with a cognitive factive, the factive needs to be replaced with its non-factive counterpart. See my explanation in section 4.6.1.

(263) O [$_S$ John knows [$_Q$ who came]]

    a. $[\![Q]\!] = \lambda w \lambda w'.\forall x[\mathsf{came}_w(x) \rightarrow \mathsf{came}_{w'}(x)]$

    b. $[\![S]\!] = \lambda w.\mathsf{know}_w(j, \lambda w'.\forall x[\mathsf{came}_w(x) \rightarrow \mathsf{came}_{w'}(x)])$ **WE**

       (John knows the true mention-all answer to *who came*.)

    c. $\textsc{Alt}(S) = \{q \mid \exists w''[q = \lambda w.\mathsf{bel}_w(j, \lambda w'.\forall x[\mathsf{came}_{w''}(x) \rightarrow \mathsf{came}_{w'}(x)])]\}$

       ($\{q \mid \exists w''[q = $ John believes the mention-all answer to *who came$_{w''}$*]\}.)

    d. $[\![O(S)]\!] = \lambda w[[\![S]\!](w) = 1 \wedge \forall q \in \textsc{Alt}(S)[[\![S]\!] \not\subseteq q \rightarrow q(w) = 0]]$ **IE**

       (John only believes the TRUE mention-all answer to *who came*.)

To adapt this account to the proposed hybrid categorial approach of question semantics developed in Chapter 1, we just need to define the embedded interrogative as a topical property and obtain the WE inference via employing an Ans-operator. A schematized derivation is given in the following. For simplicity, the proposition $\mathsf{came}(x)$ is abbreviated as ϕ_x. For a schematization following Hamblin-Karttunen Semantics, see Uegaki (2015) and Xiang (2016).

(264) O [$_S$ John knows [$_Q$ who came]]

    (*w: Among the three considered individuals, Andy and Billy came, but Cindy didn't.*)

    a. $[\![Q]\!] = \lambda x.\phi_x$

    b. $\textsc{Ans}([\![Q]\!])(w) = \{\phi_x : w \in \phi_x \wedge \forall y[w \in \phi_y \rightarrow \phi_y \not\subseteq \phi_x]\} = \{\phi_{a \oplus b}\}$

    c. $[\![S]\!] = \lambda w.\exists \phi \in \textsc{Ans}([\![Q]\!])(w)[\mathsf{know}_w(j, \phi)] = \mathsf{know}(j, \phi_{a \oplus b})$ **WE**

       (John knows a true complete answer of Q.)

    d. $\textsc{Alt}(S) = \{\lambda w.\exists \phi \in \alpha[\mathsf{bel}_w(j, \phi)] \mid \exists w'[\alpha = \textsc{Ans}([\![Q]\!])(w')]\}$

            $= \{\lambda w.\exists \phi \in \textsc{Ans}([\![Q]\!])(w')[\mathsf{bel}_w(j, \phi)] \mid w' \in W\}$

$$= \left\{ \begin{array}{l} \mathsf{bel}(j, \phi_a), \mathsf{bel}(j, \phi_b), \mathsf{bel}(j, \phi_c), \\ \mathsf{bel}(j, \phi_{a \oplus b}\}, \mathsf{bel}(j, \phi_{b \oplus c}\}, \mathsf{bel}(j, \phi_{a \oplus c}\} \\ \mathsf{bel}(j, \phi_{a \oplus b \oplus c}) \end{array} \right\}$$

       (John believes ϕ, where ϕ is a potential complete answer of Q.)

    e. $[\![O(S)]\!] = \mathsf{know}(j, \phi_{a \oplus b}) \wedge \neg\mathsf{bel}(j, \phi_c)$ **IE**

       (John only believes the TRUE complete answer of Q.)

4.4.2. Extending the exhaustification-based account to mention-some

In an indirect mention-some question, there are two possible positions to place an O-operator: one of such positions is immediately above the scope part of the existential closure, as in (265a), and the other is above the existential closure, as in (265b).

(265) John knows [$_Q$ where we can get gas].

    a. Local exhaustification

       $\exists \phi$ [ϕ is a true mention-some answer of Q] [O [John knows ϕ]]

    b. Global exhaustification

       O [$\exists \phi$ [ϕ is a true mention-some answer of Q] [John knows ϕ]]

In the paragraphs that follow, I show that neither of the options derives the desired the FA-sensitivity inference.

Local exhaustification is apparently infeasible. If the embedded question Q takes a mention-some reading, this operation yields the following truth conditions: (i) John knows a mention-some answer of Q, and (ii) John doesn't believe any answer that is not entailed by this mention-some answer. The exhaustification condition (ii) is clearly too strong. For example, in case that there are three accessible stations and John knows two of them, the sentence (265) would be predicted to be false, contra fact.

The option of global exhaustification seems to have a better chance of yielding the desired FA-sensitivity inference. As Danny Fox and Alexandre Cremers point out (pers. comm.) to me independently, employing *innocent exclusion* (Fox 2007) globally yields an inference that is very close to the FA-sensitivity condition. As seen in section 3.3, while the regular exhaustifier O negates all the excludable alternatives (i.e., the alternatives that are not entailed by the prejacent of the exhaustifier), the innocently exclusive exhaustifier IE-ExH negates only the "innocently" excludable alternatives. For a proposition p, one of its alternatives q is innocently excludable only if q is included in every maximal set of alternatives such that the exclusion of this set is consistent with p.

(266) **Innocent Exclusion** (Fox 2007)

    a. Innocently excludable alternatives

       $\text{IExcl}(p) = \bigcap\{A : A \text{ is a maximal subset of } \text{Alt}(p) \text{ s.t. } A^{\neg} \cup \{p\} \text{ is consistent}\}$,

                   where $A^{\neg} = \{\neg q : q \in A\}$

       (The intersection of the maximal sets of alternatives of p such that the exclusion of each such set is consistent with p)

    b. Innocently exclusive exhaustifier

       $\text{IE-ExH}(p) = \lambda w[p(w) = 1 \wedge \forall q \in \text{IExcl}(p)[q(w) = 0]]$

       (The prejacent p is true, and the innocently excludable alternatives of p are false.)

Using innocent exclusion avoids negating propositions of the form "John believes ϕ" where ϕ is a true mention-some answer or a disjunctive answer that involves at least one true mention-some answer as a disjunct. Consider (267) for a concrete example. For simplicity, the proposition 'we can get gas from place x' is abbreviated as ϕ_x.

(267) John knows [$_Q$ where we could get gas].

    (*w: Among the considered places abc, only a and b sell gas.*)

    a. IE-ExH [$_S$ $\exists\phi$ [ϕ is a true mention-some answer of Q] [John knows ϕ]]

    b. $[\![S]\!] = \lambda w.\exists\phi \in \text{Ans}([\![Q]\!])(w)[\text{know}_w(j, \phi)]$

       $= \text{know}(j, \phi_a) \vee \text{know}(j, \phi_b)$

    c. $\text{Alt}(S) = \{\lambda w.\exists\phi \in \text{Ans}([\![Q]\!])(w')[\text{bel}_w(j, \phi)] \mid w' \in W\}$

$$= \left\{ \begin{array}{lll} \text{bel}(j, \phi_a), & \text{bel}(j, \phi_a) \vee \text{bel}(j, \phi_b), & \text{bel}(j, \phi_a) \vee \text{bel}(j, \phi_b) \vee \text{bel}(j, \phi_c) \\ \text{bel}(j, \phi_b), & \text{bel}(j, \phi_a) \vee \text{bel}(j, \phi_c), & \\ \text{bel}(j, \phi_c), & \text{bel}(j, \phi_b) \vee \text{bel}(j, \phi_c), & \end{array} \right\}$$

    d. $[\![\text{IE-Exh(S)}]\!] = [\text{know}(j, \phi_a) \vee \text{know}(j, \phi_b)] \wedge \neg\text{bel}(j, \phi_c)$

The basic value of prejacent clause S is the Completeness condition, namely, that John knows a true mention-some answer of Q, as schematized in (267b). Alternatives of S are propositions of the form "John believes some proposition in α" where α is the set of complete true answers of some possible world, as shown in (267c). Among these alternatives, only $\text{bel}(j, \phi_c)$ is innocently excludable.[51] Hence, employing innocent exclusion yields the inference in (267d), which affirms the truth of prejacent clause and negates only the innocently excludable alternative $\text{bel}(j, \phi_c)$. More generally, the final inference can be stated as follows: 'John knows a true mention-some answer of Q, and he doesn't believe any false mention-some answers of Q.'

4.4.3. Problems with the exhaustification-based account

4.4.3.1. FA-sensitivity is concerned with partial answers

So far, the alternative set used by the exhaustification-based account includes only propositions that are based on potential complete answers of the embedded questions. Hence, exhaustifying the Completeness condition only yields the requirement of avoiding false answers that are potential complete answers. This requirement is however insufficient. As seen in section 4.3.2, the FA-sensitivity condition is concerned with all types of false answers, including also those that can never be complete, such as false denials and false disjunctives. This insufficiency applies to not only the interpretation of indirect mention-some questions but also the interpretation of indirect mention-all questions.

    To derive the desired FA-sensitivity inference, an exhaustification-based account would have to assume a very special set of alternatives. For instance, for the indirect mention-some question in (268), the alternative set of S ought to be like (268c). One the one hand, this set includes all the propositions stating that John believes a false answer (including over-affirming (OA), over-denying (OD), and false disjunctive (Disj)). On the other hand, this set must exclude propositions stating that John believes a true mention-all (MA) answer or a mention-intermediate (MI) answer; otherwise, (268) would be predicted to be false in a scenario that John knows multiple accessible gas stations, contra fact. I suspect that there is no theory of exhaustification that would generate an alternative set of this sort.

(268)   John knows where we can get gas.

        (*w* : *Among the four considered places, a and b sell gas; but c and d do not.*)

        a. IE-Exh [$_S$ John knows [$_Q$ where we can get gas]]

        b. $[\![S]\!] = \text{know}(j, \phi_a) \vee \text{know}(j, \phi_b)$

        c. NO WAY TO GENERATE AN ALTERNATIVE SET AS FOLLOWS:

---

[51]For instance, $\text{bel}(j, \phi_a)$ is not innocently excludable, because $[\text{know}(j, \phi_a) \vee \text{know}(j, \phi_b)] \wedge \neg\text{bel}(j, \phi_a)$ entails another excludable alternative $\text{bel}(j, \phi_b)$. In contrast, $\text{bel}(j, \phi_c)$ is innocently excludable, because $[\text{know}(j, \phi_a) \vee \text{know}(j, \phi_b)] \wedge \neg\text{bel}(j, \phi_c)$ does not entail any of the excludable alternatives.

$$\text{ALT(S)} = \left\{ \begin{array}{ll} \text{bel}(j,\phi_c),\text{bel}(j,\phi_d),\, ... & \text{OA} \\ \text{bel}(j,\neg\phi_a),\text{bel}(j,\neg\phi_b),\, ... & \text{OD} \\ \text{bel}(j,\phi_c \vee \phi_d),\, ... & \text{Disj} \\ ... & \\ \cancel{\text{bel}(j,\phi_a \wedge \phi_b),\, \text{bel}(j,\phi_{a\oplus b})} ... & \cancel{\text{MA/MI}} \end{array} \right\}$$

4.4.3.2. FA-sensitivity is not a scalar implicature

Treating FA-sensitivity as a logical consequence of exhaustifying Completeness amounts to saying that FA-sensitivity is a scalar implicature of Completeness. Nevertheless, FA-sensitivity inferences do not behave like scalar implicatures.

First, unlike scalar implicatures, FA-sensitivity inferences are easily generated even in downward-entailing contexts. Consider scalar implicatures first: in (269a), appearing within the antecedent of a conditional, the scalar item *some* does not evoke a scalar implicature unless is stressed (cf. (269b)).

(269)   a. If [Mary invited some of the speakers to the dinner], I will buy her a coffee.
            ⇏ If Mary invited some but **not all** speakers to the dinner, I will buy ....

        b. If [Mary invited SOME of the speakers to the dinner], I will buy her a coffee; but if she invited all of the speakers to the dinner, we would run out of budget.
            ⇝ If Mary invited some but **not all** speakers to the dinner, I will buy ....

This is so because strengthening the antecedent weakens the entire conditional and violates the *Strongest Meaning Hypothesis* (Chierchia *et al.* 2012, Fox & Spector to appear) for exhaustifications: the use of an exhaustifier is marked if it gives rise to a reading that is equivalent to or weaker than what would have resulted in its absence. In other words, it is marked to use an exhaustification in an environment that is downward-entailing or non-monotonic.

(270)   **Strongest Meaning Hypothesis** (Chierchia *et al.*'s 2012 formulation)
        Let S be a sentence of the form [S ..O(X)...]. Let S_0 be the sentence of the form [S_0 ...X...], i.e., the one that is derived from S by replacing O(X) with X, i.e., by eliminating this particular occurrence of O. Then, everything else being equal, S_0 is preferred to S if S_0 is logically stronger than S.

In (271), however, while uttered as the antecedent of a conditional, the indirect question *Mary knows which speakers went to the dinner* still evokes an FA-sensitivity inference.

(271)   (*w*: *Andy and Billy went to the dinner, but Cindy didn't.*)
        If Mary knows which speakers went to the dinner, I will buy her a coffee.
        ⇝ If [Mary knows that Andy and Billy went to the dinner] ∧
                not [Mary believes that Cindy went to the dinner], I will buy her a coffee.

Second, FA-sensitivity inferences are not cancelable. Compare the following conversations. In (272), the scalar implicature 'Mary did not invite all of the speakers to the dinner' can be

easily cancelled, while in (273), the FA-sensitivity inference 'it is not the case that Mary believes that Cindy went to the dinner' cannot be cancelled.

(272) A: "Did Mary invite some of the speakers to the dinner?"
       B: "Yes. Actually she invited all of them."

(273) (*w*: *Andy and Billy went to the dinner, but Cindy didn't.*)
       A: "Does Mary know which speakers went to the dinner?"
       B: "Yes. #Actually also she believes that Cindy went to the dinner."

One might suggest that FA-sensitivity inferences are special species of scalar implicatures which are mandatorily evoked and exceptionally robust. To assess this assumption, let us compare FA-sensitivity inferences with scalar implicatures that are mandatorily evoked in presence of the overt exhaustifier *only*. In (274) and (275), for instance, since the scalar item *some* is associated with *only*, its scalar implicature patterns like FA-sensitivity inferences: this scalar implicature can be generated within the antecedent of a conditional and cannot be cancelled.

(274) If [Mary invited only SOME$_F$ of the speakers to the dinner], I will buy her a coffee.
       ⤳ If Mary invited some but **not all** speakers to the dinner, I will buy her a coffee.

(275) A: "Did Mary invite only SOME$_F$ of the speakers to the dinner?"
       B: "Yes. #Actually she invited all of them."

Nevertheless, a contrast between FA-sensitivity inference and obligatory scalar implicature arises in negative sentences. In (276b), associating *only* with the focused item over negation evokes a positive implicature (i.e., an indirect scalar implicature): as schematized in (276c), *only* negates the negative alternative $\neg\phi_{\text{male}}$, yielding an indirect scalar implicature ϕ_{male}. If FA-sensitivity inferences were mandatory scalar implicatures, we would predict the negated indirect question (277b) to take the analogous LF (277c),[52] negate the excludable alternative $\neg\mathsf{bel}(m,\phi_c)$, and evoke an indirect scalar implicature $\mathsf{bel}(m,\phi_c)$ (i.e., the negation of the FA-sensitivity inference), contra fact.

(276) a. Mary **only** invited some FEMALE$_F$ speakers to the dinner.
           ⤳ Mary did not invite any male speakers to the dinner. $\neg\phi_{\text{male}}$
       b. Mary **only** did <u>not</u> invite any FEMALE$_F$ speakers to the dinner.
           ⤳ Mary did invite some male speaker(s) to the dinner. ϕ_{male}
       c. $O\neg\phi_{\text{female}} = \neg\phi_{\text{female}} \wedge \neg\neg\phi_{\text{male}} = \neg\phi_{\text{female}} \wedge \phi_{\text{male}}$

(277) (*w*: *Andy and Billy went to the dinner, but Cindy didn't.*)
       a. Mary knows which speakers went to the dinner.
           ⤳ not [Mary believes that Cindy went to the dinner. $\neg\mathsf{bel}(m,\phi_c)$
       b. Mary doesn't know which speakers went to the dinner.
           ⤴ Mary believes that Cindy went to the dinner. $\mathsf{bel}(m,\phi_c)$
       c. *O* **not** [Mary knows [$_Q$ which speakers went to the dinner]]

---

[52]Note that here the exhaustifier cannot be placed below negation, due to the Strongest Meaning Hypothesis.

4.5. Proposal

I propose that Completeness and FA-sensitivity are two independent conditions. Both of them are mandatorily involved in interpreting any indirect question. In particular, completeness is defined based on a complete true answer, while FA-sensitivity is concerned with all relevant answers, recovered from the partition of the embedded question. For indirect questions with veridical predicates, their FA-sensitive readings are uniformly defined as in (278). This analysis accounts for indirect MA questions as well as indirect MS questions.

(278) $[\![x \ V_{[+\text{ver}]} \ Q]\!]^w = \underbrace{\exists\phi \in \text{Ans}([\![Q]\!])(w)[V'_w(x,\phi)]}_{\text{COMPLETENESS}} \wedge \underbrace{\forall\psi \in \text{Rel}([\![Q]\!])[w \notin \psi \rightarrow \neg V'_w(x,\psi)]}_{\text{FA-SENSITIVITY}}$

The core ideas of this proposal are independent from whether a question denotes a topical property or a Hamblin set. To be theory-neutral, I use $[\![Q]\!]$ (where 'Q' is in text mode) for the denotation of Q, and $\text{Ans}([\![Q]\!])(w)$ for the set of max-informative true answers of Q in w. In case that the exact question denotation matters, I use Q (where 'Q' is in math mode) for a Hamblin set, and **P** for a topical property.

4.5.1. Characterizing Completeness

Following Fox (2013), I have defined completeness as max-informativity: a true answer is complete if and only if it is not asymmetrically entailed by any of the true answers. As shown in section 2.5 and 2.6, this definition works for both mention-all and mention-all readings of questions. If a question takes a mention-some reading, it has a unique max-informative true answer, namely, the mention-all answer. If a question takes a mention-some reading, it can have multiple max-informative true answers, each of which is a mention-some answer.

Based on these assumptions, I schematize the Completeness condition of an indirect question of the form '$x \ V \ Q$' uniformly as follows. The letters x, V, and Q stand for an attitude holder, an interrogative-embedding predicate, and an embedded interrogative, respectively.

(279) **Completeness condition**

   a. For '$x \ V_{[+\text{ver}]} \ Q$': $\quad \lambda w.\exists\phi \in \text{Ans}([\![Q]\!])(w)[V'_w(x,\phi)]$
   (There is a proposition ϕ such that ϕ is a max-informative true answer of Q in w and that x Vs ϕ in w.)

   b. For '$x \ V_{[-\text{ver}]} \ Q$': $\quad \lambda w.\exists w'\exists\phi \in \text{Ans}([\![Q]\!])(w')[V'_w(x,\phi)]$
   (There is a proposition ϕ such that ϕ is a potential max-informative answer of Q and that $V'(x,\phi)$ is true in w.)

In the formalizations above, the set of max-informative true answers $\text{Ans}([\![Q]\!])(w)$ serves as the domain restriction of an existential quantification. If the embedding predicate V is veridical (e.g., factives like *know*, *remember*; non-factive veridical predicates like *prove*, *be clear*), the world argument of the Ans-operator would be co-indexed with that of V. By contrast, if V is non-veridical (e.g., *be certain*, *tell*$_{[-\text{ver}]}$), then the world variable of Ans would be existentially

bound at a non-local scopal site, as assumed by Berman (1991), Lahiri (2002), and Spector & Egré (2015).

4.5.2. Characterizing FA-sensitivity

A proper characterization of FA-sensitivity should capture the following two facts:

(i) FA-sensitivity is involved in interpreting both indirect mention-all questions and indirect mention-some questions (George 2011, 2013; see section 4.3.1);

(ii) FA-sensitivity is concerned with all types of false answers, including not only those that are potentially complete, but also those that can never be complete (see section 4.3.2).

The current dominant approach (Klinedinst & Rothschild 2011, Uegaki 2015) characterizes FA-sensitivity as a logical consequence of strengthening or exhaustifying the WE inference. As argued in section 4.4, although this approach can be extended to indirect mention-some questions using innocent exclusion, it cannot capture fact **(ii)**.

I argue that FA-sensitivity is independent from Completeness. Regardless of whether the embedded question takes a mention-some or mention-all reading, the FA-sensitivity condition can be uniformly schematized as in (280). Intuitively, FA-sensitivity is not involved in the interpretation of an indirect question that has a non-veridical interrogative-embedding predicate. To capture this fact, we do not need to make any stipulation as to the distribution of FA-sensitivity, but instead make the evaluation world variable of ϕ existentially bound. Some concrete examples are given in (281).

(280) **FA-sensitivity condition**

    a. For '$x\ V_{[+\text{ver}]}\ Q$':

       $\lambda w.\forall \phi \in \text{Rel}(\llbracket Q \rrbracket)[w \notin \phi \rightarrow \neg V'_w(x,\phi)]$

       (For any Q-relevant proposition ϕ, whenever ϕ is false, $V'(x,\phi)$ is false.)

    b. For '$x\ V_{[-\text{ver}]}\ Q$':

       $\lambda w.\exists w' \forall \phi \in \text{Rel}(\llbracket Q \rrbracket)[w' \notin \phi \rightarrow \neg V'_w(x,\phi)]$

       (For any Q-relevant proposition ϕ, there is a world w' such that $V'(x,\phi)$ is false in w' if ϕ is false in w'.)

(281) a. For 'John knows Q':

       $\lambda w.\forall \phi \in \text{Rel}(\llbracket Q \rrbracket)[w \notin \phi \rightarrow \neg \text{believe}_w(j,\phi)]$

       (John has no Q-relevant false belief.)

    b. For 'John is certain at Q':

       $\lambda w.\exists w' \forall \phi \in \text{Rel}(\llbracket Q \rrbracket)[w' \notin \phi \rightarrow \neg \text{certain}_w(j,\phi)]$

       (There is world such that everything John is certain about Q is true in this world.)

       (= Everything that John is certain about Q is consistent.)

$\text{Rel}(\llbracket Q \rrbracket)$ stands for the set of propositions that are relevant to the embedded interrogative, called "Q-relevant propositions." Formally, a proposition is Q-relevant if and only if it equals to

the union of some partition cells of Q, as schematized in (282). As seen in section 1.3.4, the partition of a question can be derived based on a Hamblin/Karttunen set or a topical property, as defined in (283a) and (283b), respectively.

(282) **Q-relevant propositions**

$\text{REL}(\llbracket Q \rrbracket) = \{\bigcup X : X \subseteq \text{PAR}(\llbracket Q \rrbracket)\}$

(ϕ is Q-relevant if and only if ϕ is the union of some partition cells of Q.)

(283) **Partition cells**

a. If Q denotes a Hamblin set Q:

$\text{PAR}(\llbracket Q \rrbracket) = \{\lambda w[Q_w = Q_{w'}] : w' \in W\}$, where $Q_w = \{p : w \in p \in Q\}$

(The family of world sets such that every world in each world set yields the same true propositional answers)

b. If Q denotes a topical property **P**:

$\text{PAR}(\llbracket Q \rrbracket) = \{\lambda w[\mathbf{P}_w = \mathbf{P}_{w'}] : w' \in W\}$, where $\mathbf{P}_w = \{\alpha : \alpha \in \text{Dom}(\mathbf{P}) \wedge w \in \mathbf{P}(\alpha)\}$

(The family of world sets such that every world in each world set yields the same true short answers)

Consider (284) for a concrete example of deriving the Q-relevant propositions of a mention-all question. Partition 1 and 2 are identical. The former is defined based on an equivalence relation between possible worlds with respect to **true propositional answers**, while the latter is defined based on an equivalence relation between possible worlds with respect to **true short answers**. For instance, the second cell c_2 stands for the set of worlds where only a came, or equivalently, the set of worlds where the Karttunen set Q_w is $\{\phi_a\}$, or equivalently, the set of worlds where the set of true short answers $\mathbf{P}_w$ is $\{a\}$. Q-relevant propositions can be obtained easily from the partition. In particular, the disjunctive answer $\phi_a \vee \phi_b$ is the union of the first three cells, and the negative answer $\neg\phi_a$ is the union of the last two cells.

(284) Who came?

a. $Q = \{\hat{}\,\text{came}(x) : x_e \in \dagger\text{people}_@\}$

b. $\mathbf{P} = \lambda x_e[\dagger\text{people}_@(x) = 1.\hat{}\,\text{came}(x)]$

c. Andy came. $\qquad\qquad\qquad\qquad\qquad\qquad \phi_a = c_1 \cup c_2$

   Andy or Billy came. $\qquad\qquad\qquad\qquad \phi_a \vee \phi_b = c_1 \cup c_2 \cup c_3$

   Andy didn't. $\qquad\qquad\qquad\qquad\qquad\qquad \neg\phi_a = c_3 \cup c_4$

w: $Q_w = \{\phi_a, \phi_b, \phi_{ab}\}$		c_1	w: only ab came$_w$		w: $\mathbf{P}_w = \{a, b, a \oplus b\}$
w: $Q_w = \{\phi_a\}$	$=$	c_2	w: only a came$_w$	$=$	w: $\mathbf{P}_w = \{a\}$
w: $Q_w = \{\phi_b\}$		c_3	w: only b came$_w$		w: $\mathbf{P}_w = \{b\}$
w: $Q_w = \varnothing$		c_4	w: nobody came$_w$		w: $\mathbf{P}_w = \varnothing$

Partition 1 $\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad$ Partition 2

For a question that takes a mention-some reading, its Q-relevant propositions are derived analogously, as exemplified below:

(285) Where can we get gas? (mention-some)

    a. $Q = \{{}^{\wedge}\Diamond\pi(\lambda x.O[f(x)]) : \pi_{\langle et,t\rangle} \in \dagger\mathsf{places}_@\}$

    b. $\mathbf{P} = \lambda\pi_{\langle et,t\rangle}[\dagger\mathsf{places}_@(\pi) = 1.{}^{\wedge}\Diamond\pi(\lambda x.O[f(x)])]$

    c. Station A. $\phi_a = c_1 \cup c_2$

        Station A or B, (I don't know which). $\phi_a \vee \phi_b = c_1 \cup c_2 \cup c_3$

        Not station A. $\neg\phi_a = c_3 \cup c_4$

$w: Q_w = \{\Diamond\phi_a, \Diamond\phi_b, \Diamond\phi_{a\,\bar{\vee}\,b}\}$		c_1	w: only ab sell$_w$ gas		$w: \mathbf{P}_w = \{a, b, a\,\bar{\vee}\,b\}$
$w: Q_w = \{\Diamond\phi_a, \Diamond\phi_{a\,\bar{\vee}\,b}\}$		c_2	w: only a sells$_w$ gas		$w: \mathbf{P}_w = \{a, a\,\bar{\vee}\,b\}$
$w: Q_w = \{\Diamond\phi_b, \Diamond\phi_{a\,\bar{\vee}\,b}\}$	$=$	c_3	w: only b sells$_w$ gas	$=$	$w: \mathbf{P}_w = \{b, a\,\bar{\vee}\,b\}$
$w: Q_w = \varnothing$		c_4	w: nowhere sells$_w$ gas		$w: \mathbf{P}_w = \varnothing$

           Partition 1   Partition 2

Although the proposed hybrid categorial approach does not assume the syntactic presence of an Ans-operator, I would like to discuss some consequences with respect to FA-sensitivity if Ans is syntactically present in the LF. Consider the following LFs:

(286)   a. John knows [Ans$_w$ [$_Q$ who came]]

        b. John knows [λw [Ans$_w$ [$_Q$ who came]]]

In (286a), depending on the assumption of answerhood, the complement of *know* denotes a max-informative true answer or a set of max-informative true answers of the embedded question. Since here the Ans-operator has already introduced truth, we cannot form a partition from the complement of *know*, let alone retrieve all the Q-relevant propositions.

In (286b), the complement of *know* denotes a function that maps a possible world to the (set of) max-informative true answers of Q in this world. The index w is later saturated by the embedding-predicate (*à la* Groenendijk & Stokhof 1984). With this structure, since the world variable of Ans is alive, we can obtain the partition of Q based on equations with respect to the max-informative true answers of this question, as schematized in the following:

(287)   Par($[\![Q]\!]$) $= \{\lambda w[\text{Ans}([\![Q]\!])(w) = \text{Ans}([\![Q]\!])(w')] : w' \in W\}$

      (The family of world sets such that every world in each world set yields the same max-informative true answers)

For example, in (288), cell c_2 can be defined as the set of worlds where Q has a unique max-informative true answer ϕ_a.

(288)   Who came?

c_1	w: only $a \oplus b$ came$_w$		w: Ans($[\![Q]\!]$)(w) = $\{\phi_{a\oplus b}\}$
c_2	w: only a came$_w$		w: Ans($[\![Q]\!]$)(w) = $\{\phi_a\}$
c_3	w: only b came$_w$	$=$	w: Ans($[\![Q]\!]$)(w) = $\{\phi_b\}$
c_4	w: nobody came$_w$		w: Ans($[\![Q]\!]$)(w) = $\varnothing$

4.6.   Other issues

This section will discuss the following puzzling issues on interpreting indirect questions:

- How does FA-sensitivity interact with factivity? Why is it that indirect questions with emotional factives (cf. cognitive factives) do not seem to be FA-sensitive?

- Why it is that mention-some readings are not licensed by *agree*?

4.6.1.   FA-sensitivity and factivity

This section discusses some puzzling issues related to the FA-sensitivity condition in cases where the interrogative-embedding predicate is a factive. As seen below, factives are veridical responsive predicates that trigger factivity effects. When embedding a declarative, a factive presupposes the truth of the embedded declarative. When embedding an interrogative, a factive expresses a relation between the attitude holder and some TRUE answer of the embedded interrogative.
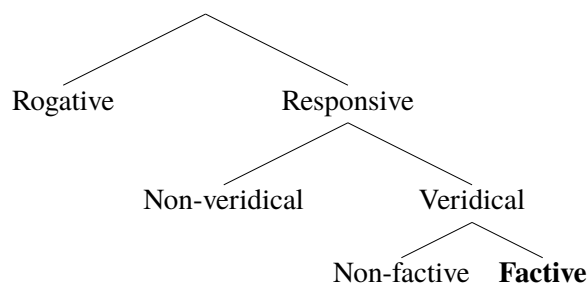

Figure 4.2: The typology of interrogative-embedding predicates

Factives are classified into the three groups. In particular, following Spector & Egré (2015), I treat communication verbs with veridical readings as factives (see section 4.2.1).

(289)   **Types of factives**
  a. Cognitive factives: *know*, *remember*, *discover*, ...
  b. Emotive factives: *be surprised*, *be pleased*, ...
  c. Communication verbs: *tell*[+fac], *predict*[+fac], ...

In what follows, I will first explain the the following two puzzling facts. **Fact 1**: in paraphrasing the FA-sensitivity condition of a question with a cognitive factive, the cognitive factive needs to be replaced with its non-factive counterpart (Spector & Egré 2015). For instance, in (290a), where the embedding predicate is the factive *know*, the FA-sensitivity inference needs to be paraphrased using the non-factive *believe*. **Fact 2**: indirect questions with emotive factives do not seem to be FA-sensitive. For instance, the meaning of the *surprise*-sentence in (290b) can be sufficiently defined in terms of the attitude of John with respect to a true answer of the embedded question. In other words, its interpretation is not concerned with the relation between the agent and the false answers of the embedded question.

(290)   (*w: Among the three considered individuals, Andy and Billy came, but Cindy didn't.*)

   a.   John knows who came.

        ↛ John doesn't **know** that c came.

        ↝ John doesn't **believe** that c came.

   b.   John is surprised at who came.

        ⇔ $\exists\phi$ [ϕ is a true answer as to *who came*] [John is surprised at ϕ]

        ↛ John isn't surprised that c came.

To explain **Fact 1**, let us first consider the consequences if the FA-sensitivity condition of (290a) were paraphrased with the factive *know*. The factive presupposition of *know* would have to be accommodated (notated by '$w \in \phi$'), globally or locally relative to negation, as shown in (291a) and (291b), respectively. Both ways of accommodating the factive presupposition yield an unwelcome consequence: global exhaustification causes a presupposition failure (i.e., a contradiction between the assertion and the presupposition); local accommodation makes the FA-sensitivity condition tautologous. To avoid these consequences, it is better to "deactivate" the factive presupposition of *know*, which yields the desired condition, as seen in (291c).[53]

(291)   FA-sensitivity condition for 'John knows Q':

   a.   GLOBAL ACCOMMODATION ✗

        $\lambda w.\forall\phi \in \text{REL}(\llbracket Q \rrbracket)[w \notin \phi \rightarrow [w \in \phi \wedge \neg\mathsf{believe}_w(j,\phi)]]$ **Contradiction**

        (For any Q-relevant proposition ϕ, whenever ϕ is false, ϕ is true and it is not the case that John believe ϕ.)

   b.   LOCAL ACCOMMODATION ✗

        $\lambda w.\forall\phi \in \text{REL}(\llbracket Q \rrbracket)[w \notin \phi \rightarrow \neg[w \in \phi \wedge \mathsf{believe}_w(j,\phi)]]$ **Tautology**

        (For any Q-relevant proposition ϕ, whenever ϕ is false, then it is not the case that [ϕ is true and John believes ϕ].)

   c.   DEACTIVATING FACTIVITY √

        $\lambda w.\forall\phi \in \text{REL}(\llbracket Q \rrbracket)[w \notin \phi \rightarrow \neg\mathsf{believe}_w(j,\phi)]$

        (For any Q-relevant proposition ϕ, if ϕ is false, then John doesn't believe ϕ.)

As for **Fact 2**, I assume that tautologies are more tolerated than contradictions. Hence, in paraphrasing the FA-sensitivity condition, the factive presupposition of an emotive factive is

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[53]Benjamin Spector (pers. comm.) points out to me a deficiency of this explanation: if the factive presupposition of *know* can be freely deactivated, we would expect that *know* never suffers presupposition failure, contra fact. For instance, in a scenario that Andy actually didn't arrive, (1a-i) and (1b-i) suffer presupposition failure, while (1a-ii) and (1b-ii) do not. I don't have a good answer to this problem.

(1)   (*w: Andy didn't arrive.*)

   a.   i.   # John knows that Andy arrived.

        ii.   John believes that Andy arrived.

   b.   i.   # Perhaps John knows that Andy arrived.

        ii.   Perhaps John believes that Andy arrived.

locally accommodated, so as to rescue presupposition failure. Consider (292) for illustration. The inference in (292a) holds as long as the factive presupposition ϕ_c is accommodated under negation. In contrast, the inference in (292b) is not implied, because global accommodation causes presupposition failure.

(292)   John is surprised at who came.
        (*w: Among the three considered individuals, Andy and Billy came, but Cindy didn't.*)
        a. ⤳ it isn't the case that John is surprised that *c* came. $\neg[\mathsf{surprise}(j, \phi_c) \wedge \phi_c]$
        b. ↛ John isn't surprised that *c* came. $\neg\mathsf{surprise}(j, \phi_c) \wedge \phi_c$

Broadly speaking, locally accommodating the factive presupposition of an emotive factive turns the FA-sensitivity condition into a tautology, as schematized in (293). Or, equivalently, the FA-sensitivity inference collapses under the factive presupposition. This undesired consequence explains why emotive factives "seemingly" cannot license FA-sensitive readings.

(293)   FA-sensitivity condition for 'John is surprised at Q':
        $\lambda w. \forall \phi \in \mathrm{REL}(\llbracket Q \rrbracket)[w \notin \phi \rightarrow \neg[w \in \phi \wedge \mathsf{surprise}_w(j, \phi)]]$ **Tautology**
        (For any Q-relevant proposition, whenever ϕ is false, it is not the case that [ϕ is true and John is surprised at ϕ].)

Here arises a question: in paraphrasing FA-sensitivity conditions, why is it that the factive presupposition of *be surprised* is accommodated locally, while that the factive presupposition of *know* is deactivated? This contrast correlates with the general distinction between emotive factives and cognitive factives as presupposition triggers, as exemplified in (477a): the factive presupposition triggered by the cognitive factive *discover* is defeasible, while that triggered by the emotive factive *regret* is not.

(294)   a. If someone **regrets** that I was mistaken, I will admit that I was wrong.
            ⤳ *The speaker was mistaken.*
        b. If someone **discovers** that I was mistaken, I will admit that I was wrong.
            ↛ *The speaker was mistaken.*

Earlier works have argued that emotive factives are **strong** presupposition triggers, while cognitive factives are **weak** presupposition triggers (Karttunen 1971, Stalnaker 1977). Recent theoretical and experimental works (Romoli 2012, 2015; Romoli & Schwarz 2015) argue that the presuppositions of soft triggers are actually scalar implicatures. The contrast between hard and soft triggers is far beyond the scope of this dissertation, but whatever accounting for this contrast should also explain the contrast between (292) and (291) with respect to FA-sensitivity.

Factive communication predicates are also weak presupposition triggers. Hence, in paraphrasing FA-sensitivity, they pattern like cognitive factives and need to be replaced with their non-factive/non-veridical counterparts, as exemplified in the following:

(295)   FA-sensitivity condition of 'John told$_{[+ver]}$ Mary Q':
        $\lambda w. \forall \phi \in \mathrm{REL}(\llbracket Q \rrbracket)[w \notin \phi \rightarrow \neg\mathsf{told}_{[-ver], w}(j, m, \phi)]$
        (For any Q-relevant proposition, if ϕ is false, then John didn't tell$_{[-ver]}$ Mary ϕ.)

To sum up this section, the FA-sensitivity condition of an indirect question with a factive interrogative-embedding predicate is schematized as one of the following forms, varying depending on whether the embedding factive is a strong or a weak presupposition trigger:

(296) FA-sensitivity condition of '$x\ V_{[+\text{fac}]}$ Q':

    a. If $V_{[+\text{fac}]}$ is a weak factive presupposition trigger:

      $\lambda w.\forall \phi \in \text{R}_{\text{EL}}(\llbracket Q \rrbracket)[w \notin \phi \to \neg V'_{[-\text{fac}],w}(x,\phi)]$

    b. If $V_{[+\text{fac}]}$ is a strong factive presupposition trigger:

      $\lambda w.\forall \phi \in \text{R}_{\text{EL}}(\llbracket Q \rrbracket)[w \notin \phi \to \neg[V'_w(x,\phi) \wedge w \in \phi]]$

4.6.2. Collapsing of mention-some under *agree*: Opinionatedness

The non-veridical responsive predicate *agree* also licenses FA-sensitive readings. For instance, for the following sentences to be true, if Mary has a negative belief that *Cindy didn't come*, John cannot have the contrary positive belief that *Cindy came*.

(297) a. John agrees with Mary on who came.

    b. John and Mary agree on who came.

It remains controversial what precisely the truth conditions of (297a-b) are. Lahiri (1999, 2002) takes *agree with* sentences as basic and *agree on* sentences as their symmetric counterparts.[54] Different empirical claims have been made by Beck & Rullmann (1999), Spector & Egré (2007, 2015), Uegaki (2015: ch. 4), and so on.[55]

(298) **Semantics of** *agree with/on* **(Lahiri 2002)**

    a. '*A* agrees with *B* on Q' is true if and only if

      for all *p* in the Hamblin set of Q, if *B* believes *p*, then *A* believes *p*;

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[54]Unexpected to Lahiri (2002), the experimental results of Chemla & George (2016) did not show any significant differences between *agree with* and *agree on*. The results suggest that both (297a-b) should take the following truth conditions, interpreted as 'John and Mary have the same positive belief as to *who came*.'

(1) a. $\forall x$ [Mary believes that x came $\to$ John believes that x came]

    b. $\forall x$ [**not** [Mary believes that x did came] $\to$ **not** [John believes that x came]]

  $\Rightarrow$ $\forall x$ [Mary believes that x came $\leftrightarrow$ John believes that x came]

    (John and Mary have the same positive belief as to *who came*.)

Alexandre Cremers points out (pers. comm.) to me that there is probably no need to draw strong interpretations from the lack of difference between *agree with* and *agree on* in the results. The lack of difference might be simply due to experimental artifact.

[55]Beck & Rullmann (1999) discuss only *agree on* sentences. They argue that the truth conditions of *agree on* sentences are also concerned with negative beliefs. They assume that the truth conditions of *agree on* sentences involve both (1a-b). Chemla & George (2016) experimentally validated condition (1a), but showed that (1b) is too strong.

(1) '*A* and *B* agree on Q' is true if and only if for all *p* in the Hamblin set of Q,

    a. *A* believes *p* if and only if *B* believes *p*;

    b. *A* believes $\neg p$ if and only if *B* believes $\neg p$;

   b. '*A* and *B* agree on Q' is true if and only if

      for all p in the Hamblin set of Q, *A* believes p if and only if *B* believes p.

The semantics given by Lahiri does not capture the condition of FA-sensitivity involved in interpreting *agree*-sentences. Consider the scenario described in the following table. Intuitively, if Mary has a negative belief that *c didn't come*, John shall not have the corresponding affirmative belief that *c came*. More generally, John shall not have any belief that contradicts Mary's belief as to *who came*. In comparison, if Mary is ignorant as to whether *d* came, it does not matter whether John believes, doubts, or is ignorant as to whether *d* came.

(299)   John agrees with Mary on who came.

Did ... came?	*a*	*b*	*c*	*d*
Mary's belief	Yes	Yes	No	?
John's belief can be	Yes	Yes	No/?	Yes/No/?

I schematize the truth conditions of *agree with* sentences as follows. Compared with sentences with a veridical predicate, the Completeness condition in an *agree*-sentence is not concerned with the true answers of the embedded interrogative Q, but rather the answers of Q that Mary believes, written as '$\mathcal{B}_w^m(\llbracket Q \rrbracket)$.' Likewise, the FA-sensitivity condition is to avoid contradictions to *Mary's belief* relevant to Q, not to avoid contradictions to the *facts* relevant to Q.

(300) $\mathcal{B}_w^m(\llbracket Q \rrbracket) = Q \cap \{p : \mathrm{DOX}_w^m \subseteq p\}$, where Q is the Hamblin set of Q.
     (The set of possible answers of Q that Mary believes in w)

(301)   John agrees with Mary on Q.
   a. $\lambda w. \exists \phi \in \mathrm{MaxI}(\mathcal{B}_w^m(\llbracket Q \rrbracket))[\mathsf{believe}_w(j, \phi)]$ **Completeness**
     ($\lambda w.$ John believes$_w$ a max-informative proposition in $\mathcal{B}_w^m(\llbracket Q \rrbracket)$)
   b. $\lambda w. \forall \phi \in \mathrm{Rel}(\llbracket Q \rrbracket)[\mathsf{believe}_w(m, \neg\phi) \rightarrow \neg\mathsf{believe}_w(j, \phi)]$ **FA-sensitivity**
     (For any Q-relevant proposition ϕ, if ϕ contradicts to Mary's belief, John doesn't believe ϕ.)

A more uniform way to characterize the truth conditions is as follows. Take FA-sensitivity for example: 'ϕ contradicts the facts in w' can be viewed as 'the intersection between the intension of ϕ and $\{w\}$ is empty'; likewise, 'ϕ contradicts Mary's belief' can be viewed as 'the intersection between the intension of ϕ and DOX_w^m is empty.'

(302)   For 'John knows Q':
   a. $\lambda w. \exists \phi \in \mathrm{MaxI}(Q \cap \{p : \{w\} \subseteq p\})[\mathsf{believe}_w(x, \phi)]$ **Completeness**
   b. $\lambda w. \forall \phi \in \mathrm{Rel}(\llbracket Q \rrbracket)[[\phi \cap \{w\} = \varnothing] \rightarrow \neg\mathsf{believe}_w(j, \phi)]$ **FA-sensitivity**

(303)   For 'John agrees with Mary on Q':
   a. $\lambda w. \exists \phi \in \mathrm{MaxI}(Q \cap \{p : \mathrm{DOX}_w^m \subseteq p\})[\mathsf{believe}_w(x, \phi)]$ **Completeness**
   b. $\lambda w. \forall \phi \in \mathrm{Rel}(\llbracket Q \rrbracket)[[\phi \cap \mathrm{DOX}_w^m = \varnothing] \rightarrow \neg\mathsf{believe}_w(j, \phi)]$ **FA-sensitivity**

What strikes me the most is that $\diamond$-questions embedded under *agree* do not seem to admit mention-some readings. For example, for the *agree*-sentence in (304) to be true, John needs to share **all** the affirmative beliefs that Mary has as to the embedded question, even though this embedded question is a typical mention-some question.

(304)   John agrees with Mary on who can chair the committee.

To be more concrete, compare the scenarios described in the following two tables. Intuitively, (304) is false in both scenarios. The conditions characterized in (301) correctly predict (304) to be false in Scenario 1 due to the violation of FA-sensitivity: John's belief that *b cannot chair* contradicts Mary's belief that *b can chair*. Nevertheless, so far, is remains puzzling why (304) is false also in Scenario 2, where John is ignorant as to whether *b* can chair: (i) John agrees with Mary that *a can chair*, and hence Completeness is satisfied; (ii) John has no belief that contradicts Mary's belief, and hence FA-sensitivity is satisfied.

Can ... chair?	a	b	c	d
Mary's belief	Yes	Yes	No	?
John's belief	Yes	**No**	No	?

Table 4.1: Scenario 1   [FALSE]

Can ... chair?	a	b	c	d
Mary's belief	Yes	Yes	No	?
John's belief	Yes	**?**	No	?

Table 4.2: Scenario 2   [FALSE]

I propose that *agree* also evokes a condition of *Opinionatedness*, defined as follows:

(305)   Opinionatedness condition of 'John agrees with Mary on Q':
$\lambda w. \forall \phi \in \text{MaxI}(\mathcal{B}_w^m(\llbracket Q \rrbracket))[\text{believe}_w(j, \phi) \vee \text{believe}_w(j, \neg\phi)]$
(For any max-informative belief of Mary on Q, John either believes it or doubts it.)

As seen below, FA-sensitivity together with Opinionatedness entails a universal inference, which happens to be equivalent to a mention-all inference. Hence, the *agree*-sentence in (304) cannot take a mention-some reading because the mention-some inference collapses under the universal inference derived from FA-sensitivity and Opinionatedness.

(306)   a. $\lambda w. \forall \phi \in \text{MaxI}(\mathcal{B}_w^m(\llbracket Q \rrbracket))[\neg\text{believe}_w(j, \neg\phi)]$ **Entailed by FA-sensitivity**
(John does not doubt any of Mary's max-informative beliefs on Q.)

   b. $\lambda w. \forall \phi \in \text{MaxI}(\mathcal{B}_w^m(\llbracket Q \rrbracket))[\text{believe}_w(j, \phi) \vee \text{believe}_w(j, \neg\phi)]$ **Opinionatedness**
(For any max-informative belief of Mary on Q, John either believes it or doubts it.)

   $\Rightarrow$ $\lambda w. \forall \phi \in \text{MaxI}(\mathcal{B}_w^m(\llbracket Q \rrbracket))[\text{believe}_w(j, \phi)]$
(For any max-informative belief of Mary on Q, John believes it.)

4.7.   Over-denying and asymmetries of FA-sensitivity: Experimental evidence

4.7.1.   Design

The primary goal of the following experiments is to identify whether over-denying is involved in the condition of FA-sensitivity. "Exp-MA" stands for reanalyzing Klinedinst & Rothschild's (2011) survey on indirect mention-all questions. "Exp-MS" stands for an analogous experiment on indirect mention-some questions.

Exp-MA   Klinedinst & Rothschild (2011) conducted a survey to establish the existence of IE readings.[56] They stipulated that four individuals *abcd* tried out for the swimming team, and that only *a* and *d* made the team. Four sets of predictions (A1-A4 in Table 4.3) were made as to whether each individual made the team. For instance, A1 means that the agent predicted that *d* but not *a* nor *c* made the swimming team and that the agent was uncertain whether *b* made it. Next, they asked the participants to judge whether or not each prediction *correctly predicted who made the swimming team*. Each combination of responses corresponds to a reading of the indirect mention-all question *x predicted who made the swimming team*. For instance, the participants who chose an IE reading would ideally accept A3 and reject the rest responses, while the participants who chose an SE reading would ideally reject all the responses.

Did ... make the swimming team?	*a*	*b*	*c*	*d*	Answer type
Fact	*Yes*	*No*	*No*	*Yes*	
A1	**No**	?	No	Yes	OD
A2	?	No	No	Yes	MS
A3	Yes	?	No	Yes	MA
A4	Yes	**Yes**	?	Yes	OA

Table 4.3: Design of Exp-MA (Klinedinst & Rothschild 2011)

Klinedinst & Rothschild were not particularly interested in over-denying. They removed the participants who accepted A1/A2 (i.e., the participants who were tolerant of incompleteness) from their data analysis. But this survey is also helpful for studying FA-sensitivity. A1 and A4 represent answers with over-denying and answers with over-affirming, respectively: A1 incorrectly predicted that *a* did not make the team, and A4 incorrectly predicted that *b* made the team. A2 and A3 have no false prediction, but A2 violates Completeness. I renamed A1-A4 as OD/MS/MA/OA and re-analyzed the raw data.[57]

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[56]See Cremers & Chelma (2016) for an extensive experimental investigation on intermediate exhaustivity.

[57]See here (`http://users.ox.ac.uk/~sfop0300/questionsurvey/`) for the raw data of Klinedinst & Rothschild's survey. This survey had no fillers. Thus, I excluded only participants who were (i) non-native speakers, (ii) rejected by Amazon Mechanical Turk (MTurk), or (iii) with missing responses. 107 participants (out of 193) were kept in my data analysis. Participants were not chosen based on their responses.

Exp-MS Next, I conducted a similar experiment for indirect mention-some questions on MTurk, henceforth called "Exp-MS":[58] among the four liquor stores *abcd* at Central Square, only *a* and *d* sell red wine; Susan asked her local friends *where she could buy a bottle of red wine at Central Square* and received four responses (A1-A4 in Table 4.4). Participants were asked to identify whether each response correctly answered Susan's question. Note here that A2 satisfies the condition of Completeness, contrary to the case in Exp-MA.

Could Susan buy a bottle of red wine at ...?	*a*	*b*	*c*	*d*	Answer type
Fact	*Yes*	*No*	*No*	*Yes*	
A1	**No**	?	No	Yes	OD
A2	?	No	No	Yes	MS
A3	Yes	?	No	Yes	MA
A4	Yes	**Yes**	?	Yes	OA

Table 4.4: Design of Exp-MS

4.7.2. Results and discussions

The proportions of acceptances by ANSWER are summarized in the Figure 4.3 and 4.4. *N* stands for the number of participants who satisfied all the filtering criteria.[59]
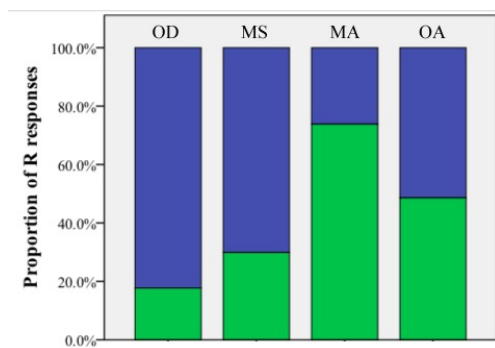
Figure 4.3: Proportion of acceptances by ANSWER in Exp-MA (*N* = 107)
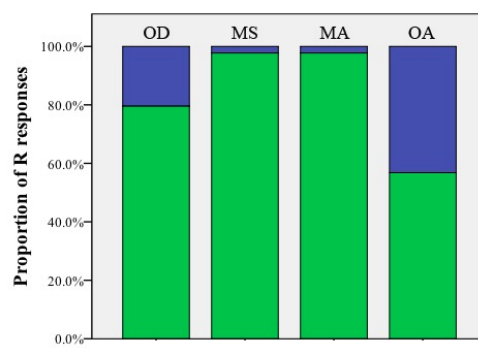
Figure 4.4: Proportion of acceptances by ANSWER in Exp-MS (*N* = 88)

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[58]In Exp-MS, the four target items (A1-A4) and two fillers were randomized into 10 lists. I recruited 100 participants on MTurk. All the participants were required to have completed 90 HITs with the number of HITs approved no less than 50. All IP address were tied to the U.S. Based on the filler accuracy (100%), native language (English), and the completion rate (fully completed exactly one HIT), I kept 88 participants out of 100. The randomization process were done using the *turktools* software (Erlewine & Kotek 2016).

[59]In Exp-MA, A1 to A4 received 88, 75, 28, and 55 acceptances (out of 107), respectively. Note that the results might be noisy because the subjects/responses could not be removed based on filler accuracy. In Exp-MS, A1 to A4 received 70, 86, 86, and 50 acceptances (out of 88), respectively.

FA-sensitivity For every two answers in each experiment, I fitted a logistic mixed effects model predicting responses by ANSWER.[60] All the models, except the one for MS versus MA in Exp-MS, reported a significant effect. These significant effects, especially the ones for OD versus MS/MA in Exp-MS, show that FA-sensitivity is concerned with both over-affirming and over-denying (viz., false denials).

Asymmetry of FA-sensitivity Compared with OD, OA received significantly more acceptances in Exp-MA ($\hat{\beta} = 1.0952$, $p<.001$) but significantly less acceptances in Exp-MS ($\hat{\beta} = -0.7324$, $p<.005$). These results suggest the following asymmetry:

(307) **Asymmetry of FA-sensitivity**
    Compared with over-denying, over-affirming is more tolerated in mention-all questions, but less tolerated in mention-some questions.

What causes this asymmetry? One might suggest that over-denying is less tolerated than over-affirming in mention-all questions simply because over-denying even does not satisfy the Completeness condition. This suggestion yields the following prediction: if a participant was tolerant of incompleteness, then his or her responses would not show any asymmetry with respect to FA-sensitivity. To evaluate this prediction, consider the participants in Exp-MA who were tolerant of incompleteness (i.e., the participants who accepted both MS and MA, $N = 28$). The distribution of each possible combination of responses given by these subjects is summarized in Table 4.5.

A1	A2	A3	A4	N
×	√	√	×	11
√	√	√	×	1
×	√	√	√	8
√	√	√	√	8

Table 4.5: Responses in Exp-MA (based on subjects accepting partial answers)

Contrary to the prediction above, however, these participants also rejected OD significantly more than OA (binomial test: 89%, $p<.05$). In other words, over-denying is consistently less tolerated than over-affirming in mention-all questions, regardless of whether Completeness is concerned. In conclusion, the asymmetry of FA-sensitivity varies by question-type (viz., mention-all versus mention-some), not results from a violation of Completeness.

4.7.3. Asymmetries of FA-sensitivity

Experiments above found an asymmetry with respect to FA-sensitivity (at least for indirect questions with communication verbs): over-affirming is more tolerated than over-denying in

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[60]A1 and A4 were coded as −1 and 1, respectively. Fomula: glmer(Choice ~ Item + (1|WorkerId), data = mydata, family = binomial (link="logit"), verbose = TRUE)

mention-all questions, but less tolerated than over-denying in mention-some questions. In other words, mention-all questions are more sensitive to over-denying, while mention-some questions are more sensitive to over-affirming. Moreover, I have shown that this asymmetry holds even if the Completeness condition is ignored.

Why it is that false answers are not equally bad? I propose that a false answer is tolerated if it is not misleading. Each response brings an update to the answer space, such as removing the incompatible answers or adding the entailed answers. If the questioner accepts this response, he would take one of the max-informative answers of the updated answer space as a resolution and make decisions accordingly. If a response updates the answer space in a way such that none of the max-informative answers leads to an improper decision, this response could be tolerated, even if it contains false information. For instance, in Exp-MS, is was assumed that red wine is only available in store A and store D. If someone told Susan that she could get red wine from A but not from store D, she would still go to a right place for red wine (i.e., store A). For this reason, overly denying the possibility of getting red wine from store D is tolerated. In contrast, if someone told Susan that she could get red wine from both Store A and store B, she might end up going to a wrong place for red wine (i.e., store B). For this reason, overly affirming the possibility of getting red wine from store B is not tolerated. Hence, OD received more acceptances than OA in Exp-MS.

Could Susan buy red wine at ...?	*a*	*b*	*c*	*d*
Fact	*Yes*	*No*	*No*	*Yes*
OD	**No**	?	No	Yes
OA	Yes	**Yes**	?	Yes

Table 4.6: Scenario of Exp-MS

More generally, for a max-informative answer not leading to an improper decision, it has to provide enough information that a good answer would do. Whether an answer counts as a "good answer" is determined by both linguistic factors (i.e., whether this answer is a max-informative true answer) and non-linguistic factors (i.e., whether this answer is sufficient for the conversational goal). In a context-neutral case, a max-informative true answer counts as a good answer. Hence, I propose that a false answer is tolerated if it satisfies the *Principle of Tolerance*. This principle relates FA-sensitivity to max-informativity.

(308) **Principle of Tolerance**

Assume that a question has a set of true answers Q_w. An answer of this question is tolerated if and only if this answer updates Q_w into A such that every max-informative member of A entails a max-informative member of Q_w.

In the paragraphs that follow, I elaborate how this principle captures the asymmetry of FA-sensitivity in each type of questions.

FA-sensitivity in Exp-MA: Figure 4.5 illustrates the asymmetry of FA-sensitivity observed in Exp-MA. Arrows indicate entailments. Shading marks the answers that entail the bottom-left

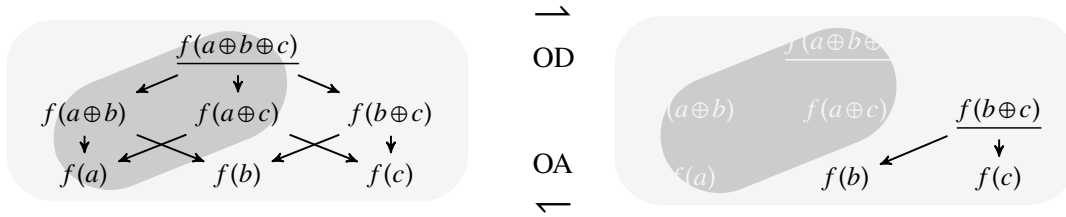answer $f(a)$. Underlining marks the max-informative propositions in each answer space.

Figure 4.5: OA and OD in "who made the swimming team?"
$f = [\![$made the swimming team$]\!]$, *abc* are relevant individuals

- **Over-affirming is tolerated.**   Assume that only the unshaded answers are true, then the question has a unique max-informative true answer $f(b\oplus c)$. Due to the entailment relation among the answers, overly affirming $f(a)$ brings in all the shaded answers. The unique max-informative member of the updated answer space, namely, $f(a\oplus b\oplus c)$, entails the unique max-informative true answer $f(b\oplus c)$.

- **Over-denying is not tolerated.**   Assume that all the present answers are true, then the question has a unique max-informative true answer $f(a\oplus b\oplus c)$. Due to the entailment relation among the answers, overly denying $f(a)$ subsequently excludes all the shaded answers. The max-informative member of the updated answer space, namely, $f(b\oplus c)$, does not entail the unique max-informative true answer $f(a\oplus b\oplus c)$.

FA-sensitivity in Exp-MS: Figure 4.6 illustrates the asymmetry of FA-sensitivity observed in Exp-MS. For simplicity, here I only consider individual answers.[61] Due to the non-monotonicity of the embedded O-operator (see section 2.6.1), all the individual answers are semantically independent; hence, the bottom-left answer is only entailed by itself (shaded).
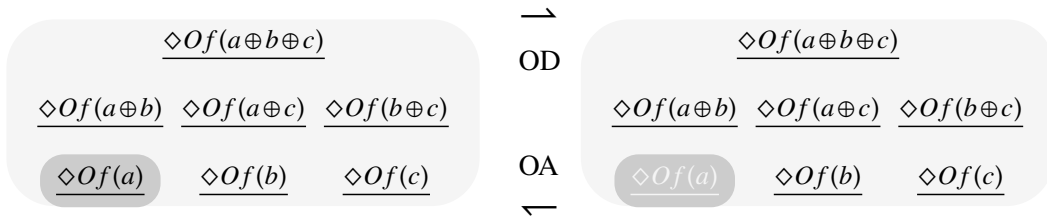
Figure 4.6: OA and OD in "where could Susan get a bottle of red wine?"
$f = [\![$Susan gets a bottle of red wine from$]\!]$, *abc* are relevant places

- **Over-affirming is not tolerated**.   Assume that only the unshaded answers are true, then all of the unshaded answers are max-informative true answers. Overly affirming $\diamond Of(a)$ only adds $\diamond Of(a)$ itself to the answer space. $\diamond Of(a)$ is a max-informative

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[61]As seen in Figure 2.1, if a question takes a mention-some reading, its answer space consists of individual answers, disjunctive answers, and conjunctive answers. Only individual answers are potentially max-informative.

member in the updated answer space, but it does not entail any max-informative true answers.

- **Over-denying is tolerated**.   If all the present answers are true, then all of them are max-informative true answers. Overly denying $\Diamond Of(a)$ only removes $\Diamond Of(a)$ itself from the answer space. All the remaining answers are max-informative members of the updated answer space, and each of them entails a max-informative true answer, namely, itself.

4.8.   Lines of approaches to the WE/SE distinction

There are, quite generally, three lines of approaches to the WE/SE distinction, which I call "answerhood-based approaches," "strengthener-based approaches" and "neg-raising-based approach." This section does not attempt to take a position from the three lines, but just to show how each line of approaches can be adapted or extended to the proposed account of Completeness and FA-sensitivity.

4.8.1.   The answerhood-based approaches

The WE/SE distinction is a result of employing different answerhood-operators (Heim 1994, Dayal 1996, Beck & Rullmann 1999). The root denotation of a question unambiguously denotes a Hamlin set, but it can enter into different answerhood operations. In particular, employing $\textsc{Ans}_{\textsc{we}}$ and $\textsc{Ans}_{\textsc{se}}$ yield WE and SE readings, respectively.

We have seen several $\textsc{Ans}_{\textsc{we}}$-operators, as collected in (309). On Heim's and Dayal's accounts, employing the $\textsc{Ans}_{\textsc{we}}$-operator returns the strongest true answer, which is therefore the WE answer. On Fox's account, employing the $\textsc{Ans}_{\textsc{we}}$-operator returns a set of max-informative true answers; if the underlying question takes a mention-all reading, this set is a singleton set and it consists of only the WE answer.

(309)   a. $\textsc{Ans}_{Heim.\textsc{we}}(Q)(w) = \bigcap\{p : w \in p \in Q\}$ (Heim 1994)

b. $\textsc{Ans}_{Dayal.\textsc{we}}(Q)(w) = \exists p[w \in p \in Q \wedge \forall q[w \in q \in Q \to p \subseteq q]].$ (Dayal 1996)
$\qquad\qquad \iota p[w \in p \in Q \wedge \forall q[w \in q \in Q \to p \subseteq q]]$

c. $\textsc{Ans}_{Fox.\textsc{we}}(Q)(w) = \{p : w \in p \in Q \wedge \forall q[w \in q \in Q \to q \not\subseteq p]\}$ (Fox 2013)

Based on whichever $\textsc{Ans}_{\textsc{we}}$-operator in (309), we can obtain an $\textsc{Ans}_{\textsc{se}}$-operator via the rule in (310): $\textsc{Ans}_{\textsc{se}}(Q)(w)$ returns the set of worlds w' such that the underlying question has the same complete true answer(s) in w and w'.

(310) $\textsc{Ans}_{\textsc{se}}(Q)(w) = \lambda w'[\textsc{Ans}_{\textsc{we}}(Q)(w) = \textsc{Ans}_{\textsc{we}}(Q)(w')]$ (Heim 1994)

Adapting this line of approaches to the proposed account of Completeness and FA-sensitivity, we can treat the WE/SE distinction as a variation with respect to the Completeness condition, as exemplified in (311a-b). Note that $\textsc{Ans}_{\textsc{we}}(\llbracket Q \rrbracket)(w)$ denotes a set of propositions and needs to be existentially bound, while $\textsc{Ans}_{\textsc{se}}(\llbracket Q \rrbracket)(w)$ denotes a proposition. The FA-sensitivity condition

is asymmetrically entailed by the Completeness condition for SE; hence, FA-sensitivity collapses under strong exhaustivity.

(311) John knows Q.

    a. $\lambda w.\exists \phi \in \text{Ans}_{\text{WE}}(\llbracket Q \rrbracket)(w)[\text{know}_w(j, \phi)]$ **Completeness for WE**
      (there is a proposition ϕ such that ϕ is a max-informative true answer of Q and that John knows ϕ.)

    b. $\lambda w.\text{know}_w(j, \text{Ans}_{\text{SE}}(\llbracket Q \rrbracket)(w))$ **Completeness for SE**
      (John knows the SE inference of Q.)

    c. $\lambda w.\forall \phi \in \text{Rel}(\llbracket Q \rrbracket)[\text{know}_w(j, \phi) \rightarrow w \in \phi]$ **FA-sensitivity**
      (Everything that John knows relevant to Q is true.)

4.8.2. The strengthener-based approaches

A number of recent works attribute the WE/SE contrast to the absence/presence of a strengthening operator. The strengthening operator, depending on the actual approach, can be applied to the question root (George 2011, Klinedinst & Rothschild 2011) or used within the question nucleus (Nicolae 2013). The following summarizes the basic idea of each representative analysis:

George (2011: ch. 2) assumes an **X**-operator which can be present between the lambda abstract *Abs* and the question-formation operator **Q**. An answerhood-operator unambiguously takes an existential quantification force. Primarily, **Q**(*Abs*) returns a Hamlin set, yielding mention-some;[62] when the **X**-operator is present, **Q**[**X**(*Abs*)] returns a set of exhaustified propositions, yielding SE. (See more details in section 2.4.2.)

Klinedinst & Rothschild (2011) assume that a question primarily denotes a WE inference, and hence that the ordinary value of an indirect question is its WE reading. The SE reading arises when a generalized exhaustivity-operator is applied to the embedded question. Note here that the exhaustivity-operator is not used in sense of the grammatical view of exhaustifications, because it does not operate on a proposition but instead a function from worlds to proposition sets (of type $\langle s, st \rangle$). (See section 4.4.1.)

(312) a. John knows [who came].   **WE**
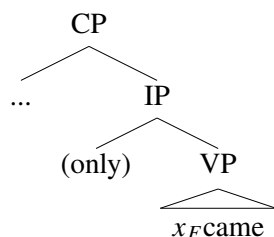   b. John knows [*O* [who came]].   **SE**

Nicolae (2013) takes insights from the negative polarity item (NPI)-licensing effects in *wh*-questions, and correlates these effects with the distributional pattern of SE readings. Compare the sentences in (313) for instance. An emotive factive like *surprise* does not license SE, and the weak NPI *any* cannot be licensed when appearing in a *wh*-question embedded under *surprise*. In contrast, a cognitive factive like *know* licenses SE, and the weak NPI *any* can be licensed when appearing in a *wh*-question embedded under *know*.

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[62]George (2011) does not take WE as an independent reading, but a special case of mention-some.

(313) a. * It **surprised** Angela which boys brought her any gifts.

 b. Angela wants to **know** which boys brought her any gifts.

Given the similar distributional patterns of SE and weak NPIs, Nicolae proposes that an SE reading arises when a covert *only* appears within the question nucleus and is associated with the *wh*-trace.[63] For instance, under the WE reading, the root denotation of (314) is a set of propositions of the form '*x* came', and under the SE reading, it is a set of propositions of the form 'only *x* came'.

(314) Who came?

```
              CP
            /    \
         ...      IP
                /    \
            (only)    VP
                     /  \
                 x_F came
```

(315) $[\![only]\!](p) = \lambda w[p(w) = 1.\forall q \in \text{ALT}(p)[q(w) = 1 \to p \subseteq q]]$

The presence of a covert *only* has two consequences. First, it makes all the answers exhaustified and mutually exclusive, which therefore yields SE. Second, it create an NPI-licensing environment, just like the overt *only* would do.

On the strengthener-based line of approaches, the WE/SE distinction is an ambiguity within the root denotation of the embedded question. Hence, these approaches predict that the WE/SE distinction is independent from how we characterize the Completeness condition and the FA-sensitivity condition.

For my interests in mention-some questions, an advantage of Nicolae's approach is that it predicts that SE readings cannot be derived directly from mention-some readings. This prediction captures the fact that mention-some questions hardly can take SE readings unless mention-some readings are contextually blocked. Consider (316) for a concrete example. Each square represents an answer space. The shaded answers are the true answers. (316a) illustrates the answer space for the mention-some reading. Crucially, when each of the answers is exhaustified, as in (316a′), the

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[63]This covert *only* assumed by Nicolae (2013) is slightly different from the covert *O*-operator assumed by the grammatical view (Chierchia et al. 2012). The overt exclusive particle *only* licenses an NPI in its scope, while a covert exhaustification does not.

 (1) a. Only JOHN$_F$ read any books.
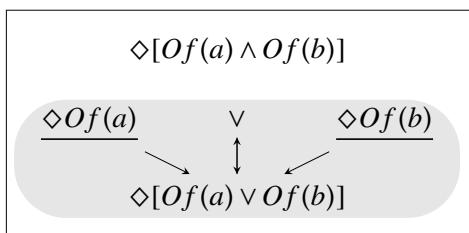
 b. * *O* [JOHN$_F$ read any books].

Gajewski (2011) proposes that the licensing of a weak NPI is only concerned with the asserted component of the embedding environment, not the presupposed or the implicated components. This proposal easily captures the contrast in (1): *only* asserts an exhaustivity inference and presupposes the truth of the prejacent (Horn 1969), while *O* asserts both; therefore, the asserted component of *only* is downward-entailing with respect to the weak NPI *any*, while that of the covert *O*-operator is non-monotonic with respect to the weak NPI *any*. For Nicolae to make use of the NPI-licensing effect of *only*, she needs an exhaustifier that asserts only the exhaustivity inference. Moreover, she has to assume that the prejacent presupposition of the covert *only* is mandatorily locally accommodated.

answer space would have no true answer, which violates the presupposition of the Ans-operator. By contrast, SE readings can be derived from mention-all readings via exhaustifications: in (316b′)/(316c′), the conjunctive/disjunctive mention-all answer is the unique true answer and therefore the SE answer.
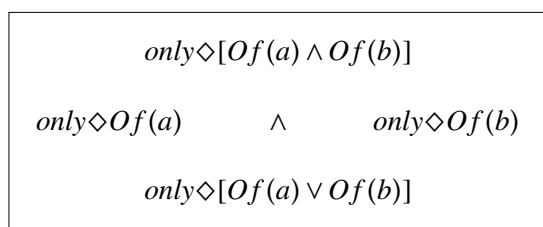
(316)   Who can chair the committee?
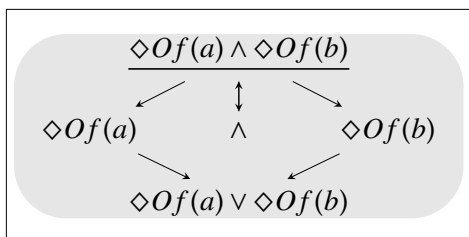   *(w: only Andy and Billy can chair the committee; single-chair only.)*
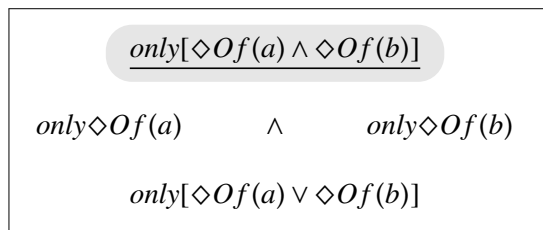
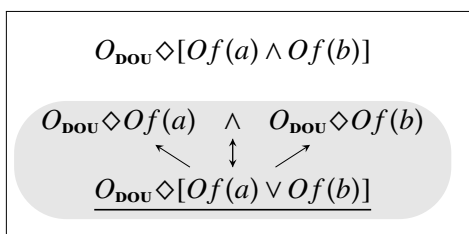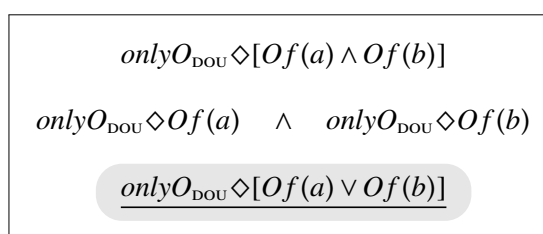   a. mention-some   a′. adding *only* to a

$$\diamond[Of(a) \wedge Of(b)]$$
$$\diamond Of(a) \quad \vee \quad \diamond Of(b)$$
$$\diamond[Of(a) \vee Of(b)]$$

$$only\diamond[Of(a) \wedge Of(b)]$$
$$only\diamond Of(a) \quad \wedge \quad only\diamond Of(b)$$
$$only\diamond[Of(a) \vee Of(b)]$$

       b. mention-all   b′. adding *only* to b

$$\diamond Of(a) \wedge \diamond Of(b)$$
$$\diamond Of(a) \quad \wedge \quad \diamond Of(b)$$
$$\diamond Of(a) \vee \diamond Of(b)$$

$$only[\diamond Of(a) \wedge \diamond Of(b)]$$
$$only\diamond Of(a) \quad \wedge \quad only\diamond Of(b)$$
$$only[\diamond Of(a) \vee \diamond Of(b)]$$

       c. disjunctive mention-all   c′. adding *only* to c

$$O_{\textbf{DOU}}\diamond[Of(a) \wedge Of(b)]$$
$$O_{\textbf{DOU}}\diamond Of(a) \quad \wedge \quad O_{\textbf{DOU}}\diamond Of(b)$$
$$O_{\textbf{DOU}}\diamond[Of(a) \vee Of(b)]$$

$$onlyO_{\textbf{DOU}}\diamond[Of(a) \wedge Of(b)]$$
$$onlyO_{\textbf{DOU}}\diamond Of(a) \quad \wedge \quad onlyO_{\textbf{DOU}}\diamond Of(b)$$
$$onlyO_{\textbf{DOU}}\diamond[Of(a) \vee Of(b)]$$

On the negative side, however, Nicolae's approach predicts that a question cannot license NPIs if it takes a mention-some reading. This prediction is incompatible with the following examples.

(317)   a.   Where can we get any$_{\text{NPI}}$ coffee?
        b.   Who can give me any$_{\text{NPI}}$ help?

4.8.3.   The neg-raising based approach

Uegaki (2015: ch. 3) makes use of a matrix exhaustification to derive IE readings (*à la* Klinedinst & Rothschild 2011, see section 4.4.1) and further derives SE from IE based on neg-raising.

Consider (318) for a concrete example. **First**, an exhaustivity-operator X mandatorily presents in the matrix clause; it affirms the prejacent and negates all the alternatives that are strictly stronger than the prejacent clause, yielding an IE inference, as in (318c). **Second**, *know* evokes an excluded middle (EM) inference (318c), namely, that the attitude holder is opinionated at every potential complete answer of the embedded question. In the considered sentence, the EM inference says that John is opinionated as to whether *abc* all came, whether *ab* both came. Last, (318c-d) together entail the SE inference, as in (318e).

(318)   John knows who came.

(*w: Among the three considered individuals, Andy and Billy came, but Cindy didn't.*)

a. X [$_S$ John knows who came]

b. $[\![S]\!] = \mathsf{know}(j, \phi_{a \oplus b})$

c. $[\![X(S)]\!] = \mathsf{know}(j, \phi_{a \oplus b}) \wedge \neg\mathsf{believe}(j, \phi_{a \oplus b \oplus c})$ **IE**

d. $[\mathsf{bel}(j, \phi_{a \oplus b}) \vee \mathsf{bel}(j, \neg\phi_{a \oplus b})] \wedge [\mathsf{bel}(j, \phi_{a \oplus b \oplus c}) \vee \mathsf{bel}(j, \neg\phi_{a \oplus b \oplus c})]$ **EM**

e. (c)&(d) $= \mathsf{know}(j, \phi_{a \oplus b}) \wedge \mathsf{believe}(j, \phi_a \wedge \neg\phi_{a \oplus b \oplus c})$ **SE**
   $= \mathsf{know}(j, \phi_{a \oplus b}) \wedge \mathsf{believe}(j, \neg\phi_c)$

Adapting this idea to the proposed account, we can derive SE by strengthening the FA-sensitivity condition with an excluded middle inference. The definition of excluded middle is slightly different from what Uegaki assumes: like the FA-sensitivity condition, the excluded middle inference is concerned with every Q-relevant proposition, not just those that are potentially complete. As seen in (319), the inferences in (319b-c) together yield a strengthened (S)-FA-sensitivity condition (319d); then the S-FA-sensitivity condition together with the Completeness condition yields the desired SE inference.

(319)   John knows Q.

a. $\lambda w.\exists\phi \in \textsc{Ans}([\![Q]\!])(w)[\mathsf{know}_w(j, \phi)]$ **Completeness**
   (There is a max-informative true answer ϕ such that John knows ϕ.)

b. $\lambda w.\forall\phi \in \textsc{Rel}([\![Q]\!])[w \notin \phi \to \neg\mathsf{believe}_w(j, \phi)]$ **FA-sensitivity**
   (Every Q-relevant proposition that John believes is true.)

c. $\lambda w.\forall\phi \in \textsc{Rel}([\![Q]\!])[\mathsf{believe}_w(j, \phi) \vee \mathsf{believe}_w(j, \neg\phi)]$ **EM**
   (John is opinionated at every Q-relevant proposition.)

d. (a)&(b)
   $\Rightarrow \lambda w.\forall\phi \in \textsc{Rel}([\![Q]\!])[w \notin \phi \to \mathsf{believe}_w(j, \neg\phi)]$ **S-FA-sensitivity**
   (John doubts at every false Q-relevant proposition.)

4.9. Summary

This chapter started from two understudied facts on FA-sensitivity: (i) FA-sensitivity is observed with indirect mention-some questions (George 2011, 2013), and (ii) FA-sensitivity is concerned with all types of false answers, not just not that are potentially complete. Those facts challenge

the current dominant account by Klinedinst & Rothschild (2011), which derives FA-sensitivity as a logical consequence of exhaustifying Completeness.

I proposed to treat Completeness and FA-sensitivity as two independent conditions, both of which are mandatorily involved in interpreting an indirect question. In the case of a veridical interrogative-embedding predicate, Completeness is concerned with a true max-informative answer of the embedded question, and FA-sensitivity is concerned with all the false propositions that are relevant to the embedded question. This account works uniformly for both mention-some and mention-all questions.

I have also explained some seemingly exceptional behaviors of emotive factives and the non-veridical predicate *agree*. In the case of an emotive factive, the FA-sensitivity condition collapses under the indefeasible factive presupposition and is therefore, not detectable. In the case of *agree*, FA-sensitivity and Opinionatedness together entail a mention-all inference, and hence *agree* does not license mention-some readings.

Experimental results from Exp-MA and Exp-MS suggested an asymmetry with respect to FA-sensitivity: over-affirming is more tolerated than over-denying in mention-all questions, but less tolerated than over-denying in mention-some questions. I proposed a Principle of Tolerance to explain this asymmetry. This principle relates FA-sensitivity to Completeness/max-informativity.