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RESEARCH ARTICLE

A question of strength: on NPIs in interrogative clauses

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Abstract We observe that the facts pertaining to the acceptability of negative polarity items (henceforth, NPIs) in interrogative environments are more complex than previously noted. Since Klima [Klima, E. (1964). In J. Fodor & J. Katz (Eds.), *The structure of language*. Prentice-Hall], it has been typically assumed that NPIs are grammatical in both matrix and embedded questions, however, on closer scrutiny it turns out that there are differences between root and embedded environments, and between question nucleus and *wh*-restrictor. While NPIs are always licensed in the nucleus of root questions, their acceptability in the restrictor of *wh*-phrases and in the nucleus of any embedded question depends on the logical properties of the linguistic environment: its strength in terms of exhaustivity [Groenendijk, J., & Stokhof, M. (1984). *Studies on the semantics of questions and the pragmatic answers*. Amserdam (NL), Post-Doctoral Dissertation. Heim, I. (1994). In R. Buchalla & A. Mittwoch (Eds.), *Proceedings of the 9th annual IATL conference and of the 1993 IATL workshop on discourse* (pp. 128–144). Akademon, Jerusalem. Beck, S., & Rullmann, H. (1999). *Natural Language Semantics, 7*, 249–298. Sharvit, Y. (2002). *Natural Language Semantics, 10*, 97–123] and its monotonicity

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properties (in the sense of von Fintel [von Fintel, K. (1999). *Journal of Semantics, 16*, 97–148]).

Keywords Negative polarity items · Interrogative clauses

1 Introduction

Ever since Klima (1964), interrogative sentences have been uncontroversially classified together with negative sentences as prototypical linguistic environments licensing negative polarity items (NPIs). Focusing exclusively on occurrences in matrix questions and in the nucleus of constituent questions (where "nucleus" refers to the material that appears after the *wh*-phrase, e.g., *left* in *Which students left*; see von Stechow 1995 among others), Ladusaw (1979) and Heim (1984) further refined Klima's initial empirical generalization, by pointing out that while so-called "weak" NPIs (e.g. *any*, *ever*; cf. Zwarts 1995) are acceptable in genuine information-seeking questions, "minimizer" NPIs (a.k.a. "strong" NPIs, cf. Krifka 1995) induce a negatively biased, if not outright rhetorical, interpretation of their hosting question. Examples of NPIs of this latter variety are *lift a finger*, *budge (an inch), bother, bat an eyelash* etc.; namely, all those NPIs that according to Heim (1984) should be analyzed as containing a silent *even*. A detailed account of why *even* in minimizers triggers negative bias is given in Guerzoni (2001)–(2004) (see also Abels 2003; van Rooy 2003; for a different view see Giannakidou 2007). The sentences in (1) illustrate occurrences of NPIs from the former class in root questions, the examples in (2) illustrate the bias of root questions containing "*even*-NPIs".

(1) a. Did you eat **anything**?
  b. Were you **ever** in Paris?
  c. Who cooked **anything**?
  d. Who was **ever** in Paris?

(2) a. Did John **lift a finger** to help you?
  b. Do you **give a damn** about the elections?
  c. Have you seen Mary **in years**?
  d. Did you **bother** feeding the cat?
  e. Who **lifted a finger** to help you?
  f. Who **gave a damn** about the elections?

Other "presuppositional" NPIs, like *yet* and *anymore*, whose presuppositions generally further constrain their distribution (see Krifka 1995), appear to pattern with "weak" NPIs within this limited set of interrogative environments, as illustrated in (3).

(3) a. Have you written your thesis **yet**?
  b. Do you smoke **anymore**?

c. Who has written his thesis **yet**?
d. Who of you smokes **anymore**?

The questions in (3) do carry the presuppositions introduced by the NPIs in them, as predicted. However, no negative bias follows from these presuppositions.

This paper argues that while the above mentioned Ladusaw–Heim two-way distinction between weak vs. minimizer-NPIs in questions comprehensively characterizes the distribution of NPIs in the nucleus of root questions, the facts pertaining to their acceptability in the restrictor of *wh*-questions and in the nucleus of embedded questions are much more complex than what has so far been assumed.

Only recently van Rooy (2003) extended the Ladusaw/Heim generalization to *wh*-restrictors. He reports that weak NPIs are acceptable in this syntactic context as well.[1]

(4) Who of those who have **ever** been to China climbed the Chinese Wall? (from van Rooy 2003)

The novel facts we present in this paper suggest that this generalization isn't completely correct. Our most surprising finding is that even NPIs of the weak variety, like *any* and *ever*, which are known to be subject to weaker constraints in general, and have been believed to occur freely in genuine information-seeking questions, are not always acceptable in them either.

The first set of cases where we attested previously overlooked contrasts comprises NPIs occurring in the *wh*-restrictor of constituent questions. Here, what we found (contra van Rooy 2003) is that weak NPIs are licensed only if the *wh*-phrase is plural, while they are unacceptable if the *wh*-phrase is singular.

(5) a. Which students who have any interest in polarity attended the seminar?
b. #Which student who has any interest in polarity attended the seminar?

Our first goal, then, is to provide an account for this contrast. The proposal we put forth below derives this contrast from a presuppositional semantics of *wh*-phrases together with the theory of NPI licensing inspired by suggestions in Ladusaw (1979) and Kadmon and Landman (1993), and fully developed in von Fintel (1999). By taking the presuppositions of *wh*-determiners into account, plural *wh*-determiners can be shown to qualify as NPI-licensers in the sense of von Fintel, while singular ones can be shown not to.

The second set of cases where we attested puzzling contrasts is related to the distribution of weak NPIs in the nucleus of embedded questions. Specifically, we observe that when the hosting question is embedded, the acceptability of weak NPIs in its nucleus becomes sensitive to (i) the nature of the embedding

[1] van Rooy explains these occurrences in terms of Ladusaw's theory of NPIs, according to which NPIs are triggered in the scope of expressions denoting Downward Entailing (DE) functions.

predicate, and (ii) the type of question (i.e., yes/no vs. *wh*). The examples in (6)–(8) provide an illustration ("%" indicates cross-speaker variation).

Wonder, ask, want to know, not know, not remember ...

(6)a. Claire **wonders** whether Frank has any books on Negative Polarity. ✓ ***Y/N***

b. Claire **wonders** which students have any books on Negative Polarity. ✓ ***Wh***

Know, *find out*, *remember*, *be certain/positive*, *agree on*

(7)a. Claire **knows** whether Frank has any books on Negative Polarity. ✓ ***Y/N***

b. % Claire **knows** which students have any books on Negative Polarity ***% Wh***

Surprise/realize

(8)a. *It **surprised** Bill which students had ever been to Paris. * ***Wh***

b. *Bill **realized** which students had ever been to Paris.[2] * ***Wh***

While under predicates of the *wonder*-type weak NPIs can be embedded regardless of the type of the question, under *know*-type predicates a contrast is attested between yes/no questions, which always admit weak NPIs, and *wh*-questions, where the judgments are less robust.[3] Furthermore, under *surprise*-type predicates, NPIs are never acceptable, a particularly puzzling fact, in light of the well-known observation that NPIs are licensed under *surprise* when its complement is a declarative clause (e.g., *It surprised Bill that John has any money*, see Baker 1970 and Linebarger 1980, 1987, among others).[4]

Just like the facts regarding NPIs in the *wh*-restrictor, this two-way sensitivity of NPIs in the nucleus of embedded questions has also been largely overlooked in the previous literature on the subject (with the exception of Munsat 1986, who does observe that some embedded *wh*-questions do not admit NPIs).

[2] An anonymous reviewer points out a difference in the status of (8a) and (8b). We return to this issue in Sect. 5.2.

[3] Crucially, this judgment is reported above as unstable not because each individual consultant found the sentence only slightly marginal, but rather because some of our consultants found it fully acceptable and others found it highly marginal or totally unacceptable. We use the diacritic '%' to indicate this cross-speaker variation.

[4] Groenendijk and Stokhof's (1982, 1984) classification of question embedding verbs as either *intensional* or *extensional* might appear to be playing a role here, since *know* and *surprise* are extensional and *wonder* is intensional. However, the difference in licensing potential between *know* and *surprise* clearly indicates that this two way distinction is not sufficiently fine-grained to account for the full range of data.

Our second goal, then, is to investigate what properties of the above embedding predicates are responsible for this complex pattern. We ultimately suggest that this pattern results from the distinction between "weakly exhaustive" and "strongly exhaustive" question-embedding predicates (see Heim 1994; Beck and Rullmann 1999; Sharvit 2002).

Because the weak/strong exhaustivity distinction cannot be straightforwardly reconnected to a distinction in logical properties typically associated with NPI licensing (e.g., Downward Entailingness), unlike the semantics of *wh*-phrases, which can, we will conclude that the complex distributional pattern of NPIs in interrogative environments calls for a multi-layered approach in which both entailment reversal and strength of exhaustivity of the hosting linguistic environment must play a crucial role.

2 The insufficiency of downward entailing-ness

The literature on NPIs is roughly divided into two camps. One camp, which follows ideas put forth by Fauconnier (1975, 1978) and Ladusaw (1979, 1980), claims that NPIs are licensed in the scope of Downward Entailing (DE) functions. The second camp, which builds on Linebarger's (1980, 1987) objections, challenges the DE-view, mainly because of the observation that many environments that license NPIs are not (or at least do not seem to be) DE. Questions are a well-known example because they do not appear to be DE (for a different view, see Higginbotham 1993, to be discussed in Sect. 6), but do host NPIs.

Since a component of our multi-layered account of NPIs in interrogatives draws from Fauconnier's and Ladusaw's original insight and from subsequent implementations of it, in this section we aim to qualify more carefully Linebarger's original objections by evaluating the DE-theory against the particular pattern of NPI-distribution in questions we observed. Specifically, we address separately the questions of how this theory fairs with the distribution of NPIs in yes/no questions, in the nucleus of *wh*-questions, and in the restrictor of *wh*-questions.

DE functions (e.g., NEGATION, EVERY, etc.) are functions that support the validity of inferences under strengthening of their argument (in the case of EVERY, its first argument). The notion of strength intended here is based on the commonly employed notion of generalized entailment (==>), defined in terms of logical entailment as in (9).

(9) For every p and q $\in D_t$, p ==> q iff p = False or q = True;
For every f and g of type $\langle \alpha, \beta \rangle$: f ==> g iff for all x $\in D_\alpha$, f(x) ==> g(x).

According to (9), for any A and B, if A and B have a truth value, then "A ==> B" amounts to logical entailment; if A and B are predicates, it amounts to inclusion: "A ==> B" iff all the objects that satisfy A also satisfy B. Once the notion of entailment is so generalized, the logical property of DEness amounts to generalized entailment reversal.

(10) A function f ∈ $D_{\langle\alpha,\beta\rangle}$ is DE iff for all x and y ∈ D_α such that x ==> y: f(y) ==> f(x).

Returning to the Ladusaw–Fauconnier generalization, the grammaticality of *No student has any cars* shows that *no student* licenses NPIs. (11) illustrates the DE nature of *no students*: ⟦*red car*⟧ ==> ⟦*car*⟧ and ⟦*have a red car*⟧ ==> ⟦*have a car*⟧ (because for any individual x, ⟦*red car*⟧(x) ==> ⟦*car*⟧(x), and ⟦*has a red car*⟧(x) ==> ⟦*has a car*⟧(x)), and (11a) ==> (11b) (according to (9)).

(11) a. No student has a car.
==> b. No student has a red car.
(More precisely, ⟦*no student*⟧(⟦*has a car*⟧) ==> ⟦*no student*⟧ (⟦*has a red car*⟧)).

⟦*no students*⟧ licenses NPIs because it is DE according to (10): it corresponds to 'f' in (10), while ⟦*has a red car*⟧ corresponds to 'x', and ⟦*has a car*⟧ corresponds to 'y'. Importantly, the ==> relation between (11a) and (11b) reflects an intuitive entailment relation.

When we turn to questions, the DE-theory proves inadequate in a number of ways. First, the theory fails to predict that NPIs are always licensed in yes/no questions, because NPIs in them do not seem to appear in DE contexts (Progovac 1993). The NPI in (12) is in a DE environment only if the original direction of entailment (⟦*have a red car*⟧ ==> ⟦*have a car*⟧) is reversed in the question; thus only if (13a) entails (13b).

(12) Does John have any car?

(13) a. Does John have a car?
=?=> b. Does John have a red car?
(Or: ⟦*whether*⟧(⟦*has a car*⟧(⟦*John*⟧)) =?=> ⟦*whether*⟧ (⟦*has a red car*⟧(⟦*John*⟧)))

Evidently, part of the problem is to establish if and how the notion of logical entailment can be extended to yes/no interrogatives. Moreover, any plausible proposal for such an extension should be independently justified as a notion that accounts for native speakers' intuitions. These intuitions must be about semantic relations between questions that are in some way a natural counterpart of entailment relations between sentences, modulo the difference between these two types of linguistic objects: sentences being devices to provide information (true or false) and questions to seek information. A possible natural extension of this sort that comes to mind is a relation that holds between a question A and a question B if (and only if) asking A automatically leads to asking B (that is to say, if by asking question A we are at the same time soliciting information that one also solicits by asking question B). In this very sense, (13a) clearly fails to entail (13b). So even if it were technically possible to define the meaning of *whether* and the notion of entailment between questions

in such a way that would predict (13a) to entail (13b), this move would not be justified in terms of native speakers' intuitions.[5]

Further support for the claim that the NPI in (12) does not occur in the scope of a DE function comes from the absence of entailment, in the intuitive sense as well as the logical sense, in (14), where the questions in (13) are embedded in a larger structure, making it possible to test for standard logical entailment. Let us assume, somewhat informally, that for any individual x and any question Q, *x wonders Q* means "x wants to know the answer to Q".

(14)a. Bill wonders whether John has a car.
⟦*wonders*⟧(⟦*whether*⟧(⟦*has a car*⟧(⟦*John*⟧)))(⟦*Bill*⟧)
=/=> b. Bill wonders whether John has a red car.
⟦*wonders*⟧(⟦*whether*⟧(⟦*has a red car*⟧(⟦*John*⟧)))(⟦*Bill*⟧)
(Bill can wonder whether John has a car without being interested in the color of the car)

One may object to the relevance of (14) precisely because the question appears in an embedded environment, and NPIs are sometimes licensed in embedded environments, even when DEness is not preserved (for example, *John doesn't know that Mary doesn't like anyone* is good, but *John doesn't know that Mary doesn't have a book* doesn't entail *John doesn't know that Mary doesn't have a semantics book*). But this objection is not valid: NPIs seem to require (in non-interrogative environments) a DE licensor (e.g., negation), and it doesn't matter that the licenser itself may be further embedded. Moreover, further embedding will reverse entailment only if the embedder itself is DE. But the intuitive meaning of *wonder* suggests that it doesn't involve any "negative" attitude (unlike *not know*, *doubt*, and the like).

The second drawback of the DE-theory is that it fails to predict the acceptability of NPIs in the nucleus of *wh*-questions as well (see Progovac 1993).

(15) Who has any cars?

(16)a. Who has a car?
=?=> b. Who has a red car?
(Or: ⟦*who*⟧(⟦*has a car*⟧) =?=> ⟦*who*⟧(⟦*has a red car*⟧))

In this case, too, the original entailment relation (⟦*have a red car*⟧ ==> (⟦*have a car*⟧) does not appear to be reversed (intuitively; and in the absence of an extension of '==>' to questions, also logically). Even if we view (16a) and (16b) as roughly equivalent to asking (17a) and (17b) respectively

[5] No existing proposal for a notion of entailment between questions we know of (Progovac 1993; Groenendijk and Stokhof 1989, some discussion in van Rooy 2003) and for the semantics of *whether*, predicts that (13a) entails (13b). See Sect. 6 for a brief discussion of Higginbotham (1993).

(cf. Higginbotham 1993), there seems to us to be no intuitive sense in which asking (17a) 'entails' asking (17b) (that is to say, soliciting the information solicited by (17a) doesn't automatically lead to soliciting the information solicited by (17b)).

(17)a. For all p ∈ {John has a car, Fred has a car, Jen has a car,…}, is p true?
b. For all p ∈ {John has a red car, Fred has a red car, Jen has a red car,…}, is p true?

In a parallel fashion with (14), there is no entailment between (18a) and (18b) either. This confirms that there is no entailment in (16).

(18)a. Bill wonders which students bought a car
=/=> b. Bill wonders which students bought a red car.
(Bill can wonder who bought a car without being in the least interested in what color the relevant cars come in.)

Unlike the two contexts just discussed, the case of restrictors of constituent questions appears at first to fall under Ladusaw's generalization. In fact, van Rooy (2003) argues that the acceptability of *any* in (19) is due to the DE nature of the question restrictor (see (20), and footnote 1 above).

(19) Which students who have any books on NPIs are selling them?

(20)a. ⟦*French student*⟧ ==> ⟦*student*⟧
b. Which of the students attended the seminar?
c. Which of the French students attended the seminar?

(20b) entails (20c), in the intuitive sense (at least on its *de re* reading). And indeed, as the reader can easily verify, asking (21a) entails asking (21b), assuming that entailment between questions A and B is defined along the way suggested above, namely, that asking question A automatically leads to asking question B (and assuming that John and Jen are the French students, and that John, Jen, and Fred are the students):

(21) For all p ∈ {John attended, Fred attended, Jen attended}, is p true?
For all p ∈ {John attended, Jen attended}, is p true?

So if the definition of '==>' could be extended to reflect this intuition, the DE view would correctly predict licensing of NPIs in the *wh*-restrictor. Given this, the problem for the DE-view does not seem to be, as far as *wh*-restrictors are concerned, one of under-generation. What the DE-theory fails to predict is that while NPIs are always licensed in the restrictor of plural *wh*-phrases, they are always unacceptable in the restrictor of singular *wh*-phrases, as shown below.

(22) a. Bill wonders which students who have any interest in polarity attended the seminar.
b. #Bill wonders which student who has any interest in polarity attended the seminar.

In sum, the DE-theory faces three problems which we will address in this paper: (i) it fails to predict the acceptability of NPIs in yes/no questions, (ii) it fails to predict their acceptability in the nuclei of *wh*-questions, and (iii) it incorrectly predicts NPIs to be always acceptable in the *wh*-restrictor of a constituent question.

3 Outline of the proposal

We start by addressing the third problem mentioned at the end of the previous section, and argue that in order to solve it, it is sufficient to appeal to a weaker version of the DE-theory; that is the Strawson Downward Entailingness (SDEness, henceforth) view advocated in von Fintel (1999).

We then show that even this weaker version of the DE-view by itself does not suffice to provide a comprehensive account for all the facts, as it proves inadequate to address the first and second problems mentioned at the end of Sect. 2. In fact, as we argue in Sect. 5, the distribution of NPIs in the question nucleus of embedded questions is governed by a semantic property that is distinct from (S)DEness: the property of "strong exhaustivity" in the sense of Groenendijk and Stokhof (1982, 1984). To get an idea of what 'strength' means in this context, consider (23), which provides paraphrases of the weak/strong interpretations of *John knows who left* and *John knows whether Mary left*.

(23) The strong/weak distinction:
a. John knows who left
Weak exhaustivity reading: For every x, if x left, John knows that x left.[6]
Strong exhaustivity reading: For every x, if x left, John knows that x left, and if x didn't leave, John knows that x didn't leave.
b. John knows whether Mary left.
Strong exhaustivity reading: If Mary left, John knows that she left If Mary didn't leave, John knows that she didn't.

[6] There is, of course, the issue of what 'John knows that x left' means. For *a* to know a proposition it doesn't suffice that the proposition is true and *a* believes it, because accidental belief of a true proposition doesn't count as knowledge. The belief has to be justified. We ignore this for simplicity, and assume that knowledge amounts to belief of a true proposition.

Accordingly, when *know* takes a *wh*-question it gives rise to an ambiguity that doesn't arise when it takes a yes/no-question. When *know* takes a yes/no question, it only has a strongly exhaustive reading. One might conjecture that a weakly exhaustive reading of, for example, *John knows whether Mary left* is 'if Mary left, John knows that she left'. But the sentence doesn't have this reading, as illustrated by the fact that the sentence is false if Mary didn't leave and John doesn't know it. The absence of such a weak reading actually follows from the way we define knowing a question in the weak sense (see Karttunen 1977) vs. knowing a question in the strong sense (see Groenendijk and Stokhof 1984; Heim 1994). Assuming that a question is a set of propositions (its possible answers), to know a question Q in the weak sense is to believe the conjunction of its true answers (for example, to know who left in the weak sense is to believe all the actually true propositions of the form 'x left', where x is some individual). To know a question Q in the strong sense is to believe that the conjunction of its true answers is the conjunction of its actually true answers (for example, to know who left in the strong sense is to believe that the actually true propositions of the form 'x left' are the only true propositions of the form 'x left').[7] Since a yes/no question is the two-membered set $\{p, \neg p\}$ (for example, *Did Mary leave* denotes the two-membered set {'that Mary left', 'that Mary didn't leave'}), one cannot know it in the weak sense without knowing it also in the strong sense.[8]

Whether an embedded *wh*-question has a weakly or strongly exhaustive reading depends on the embedding predicate (see Heim 1994; Beck and Rullmann 1999; Sharvit 2002), but yes/no questions are inherently strongly exhaustive. This is why, we argue, NPIs are always acceptable in polar questions, but are sometimes marginal and sometimes outright unacceptable in embedded *wh*-questions. Some verbs (e.g., *know*) support both a weakly and a strongly exhaustive *wh*-question interpretation, but not all verbs are like that (as will be demonstrated below).

Reference to strong exhaustivity, then, provides a unified account of licensing in yes/no questions, the marginal acceptability of NPIs in *wh*-questions under predicates of the *know* class, and their unacceptability under predicates of the *surprise* class, thus solving the puzzle concerning the difference in acceptability between NPIs in declarative complements of *surprise* vs. interrogative ones. In this sense it is preferable over alternative approaches to NPI licensing in questions such as Higginbotham (1993), Progovac (1993), Giannakidou (1997, 2004) and van Rooy (2003), which do not make these distinctions.

[7] It is worth noting that whenever *know* takes a proposition with a false complement (e.g., *John knows that the earth is flat*), the mere falsity of the complement does not suffice to make the whole sentence false. But when *know* takes a constituent question, if the subject believes that a false answer is true, this on its own suffices to make the whole sentence false, on its strong reading (see Groenendijk and Stokhof 1984; Sharvit 2002).

[8] More generally (see Heim 1994), for any question Q and world w, Ans-weak(Q)(w) is the conjunction of those propositions $p \in Q$ such that p is true in w, and Ans-strong(Q)(w) is the proposition $\{w': \text{Ans-weak}(Q)(w') = \text{Ans-weak}(Q)(w)\}$. Thus, the semantics of many question-embedding verbs can be defined in terms of these notions. For example, to know Q in the weak sense is to believe Ans-weak(Q), and to know it in the strong sense is to believe Ans-strong(Q) (cf. (54) and (55) in 5.1).

Because the weak/strong exhaustivity distinction cannot be straightforwardly reconnected to a distinction in logical properties typically associated with NPI licensing (e.g. DEness), unlike the semantics of *wh*-determiners, we conclude that the complex distributional pattern of NPIs in interrogative environments calls for a multi-layered approach in which both entailment reversal and strength of exhaustivity of the hosting linguistic environment must play a crucial role.

An additional fact that might lead one to suspect that the licensing of NPIs in the *wh*-restrictor and their licensing in the question nucleus are accounted for by two different principles is this: only NPIs in the nucleus of an embedded question exhibit the pattern observed in (6)–(8). NPIs occurring in the *wh*-restrictor are always licensed if the restrictor is plural and never if it is singular, regardless of whether the *wh*-question is embedded or not and regardless of the particular choice of the embedding predicate.

(24) a. Kim wonders which students who have any interest in polarity attended the seminar.
b. *Bill wonders which student who has any interest in polarity attended the seminar.

(25) a. Bill knows which students who have any interest in polarity attended the seminar.
b. *Bill knows which student who has any interest in polarity attended the seminar.

(26) a. It surprised Bill which students who have any interest in polarity attended the seminar.
b. *It surprised Bill which student who has any interest in polarity attended the seminar.

(24)–(26) show, then, that the pattern of NPIs in the *wh*-restrictor is entirely different and seemingly immune to strength. This, as well as the other facts, follow from our claim that weak NPIs must be subject to a disjunctive condition: they are licensed in (S)DE ((Strawson) DE) environments or in strongly exhaustive questions. In Sect. 6, however, we will revisit the question of whether DEness and strength of exhaustivity are really two different properties, and explore the possibility of reducing them to one.

4 NPIs in the *wh*-restrictor and the SDE-view

In this section we consider the licensing properties of the restrictor of *wh*-questions. Specifically, we address the contrast between singular and plural *wh*-phrases. The relevant facts are repeated below:

(27) a. Which students who have any books on NPIs are selling them?
b. *Which student who has any books on NPIs is selling them?

(28) a. Mary knows/ wonders which students who have any books on NPIs are selling them.
b. *Bill knows /wonders which student who has any books on NPIs is selling them.

We start by observing that this contrast is reminiscent of a contrast involving NPIs in the restrictor of definite descriptions:

(29) a. The students who have any books on NPIs are selling them.
b. *The student who has any books on NPIs is selling them.

Drawing on Lahiri's (1998) analysis of the facts in (29), we suggest that the contrast in (29) can be understood under a weaker DE-theory stating that the notion of entailment that is relevant for NPIs licensing is weaker than logical entailment in that it only checks for truth preservation "under the assumption that all conventional implicatures and presuppositions of premises and conclusion are satisfied" (von Fintel 1999). This is essentially a generalized version of the weak notion of validity Strawson discusses in relation to his view of presuppositional quantification in natural language (Strawson 1952, p. 176).[9] Concretely put, when checking this weaker form of entailment between P1 and P2, we assume that the presuppositions of P2 are satisfied. We follow von Fintel in referring to this entailment as "Strawson-entailment".

One case von Fintel discusses involves the adversative proposition embedding predicate *surprise*, which licenses NPIs in its complement clause (see (30)), but can be shown not to be DE in the strong sense of Ladusaw's (as shown in (31) below).

(30) John is surprised that we have any food left.

(31) a. John is surprised that we have a car.
=/=> b. John is surprised that we have a red car.
(John can be surprised that we have a car without knowing that our car is red)

Examples such as (30), which led some authors (e.g., Linebarger) to reject the DE-hypothesis altogether, have led von Fintel to slightly amend this hypothesis as follows: the necessary semantic condition for a (weak) NPI to be acceptable is that it occurs in the scope of a Strawson-DE (SDE- henceforth) function, where SDE-ness is defined on Strawson-entailment as follows:

[9] A weaker theory of this sort was already hinted at in Ladusaw (1979) and Kadmon and Landman (1993).

(32) A function f ∈ $D_{\langle\alpha,\beta\rangle}$ is SDE iff for all x and y ∈ D_{α} such that x ==> y and f(x) is defined: f(y) ==> f(x)

Returning to the example involving *surprise*, (33) gives the suggested factive semantics for proposition embedding *surprise* (p-*surprise*), and (34) shows that p-*surprise* is indeed SDE:[10]

(33) $[\![$p-*surprise*$]\!]^{w}$(p)(x) is defined only if w ∈ p and x believes p in w. When defined, $[\![$p-*surprise*$]\!]^{w}$(p)(x) = True iff for all worlds w′ compatible with x's past expectations in w, w′ ∉ p.

(34) a. John is surprised that we have a car.
b. John knows that we have a red car. (factive presupposition of (34c))
(34a) & (34b) ==> c. John is surprised that we have a red car.

Importantly, SDEness in the weaker theory is a semantic necessary condition for NPI licensing, not a sufficient one. Thus, it is plausible to find SDE contexts where NPIs are not licensed. One such context, first discussed in Lahiri (1998), is a context that is both DE in the weak sense and upward entailing (i.e., entailment preserving), also in the weak sense (see also Cable 2002). Lahiri shows that plural definite descriptions are unidirectionally SDE in their restrictor, while singular definite descriptions are also Strawson Upward Entailing (SUE) and attributes to this difference the difference in acceptability of NPIs in the two types of restrictors (see (29)).

The semantics of definite descriptions involves universal quantification where their restrictor provides the restriction to such a quantifier. In addition, definite descriptions carry an existence and a uniqueness presupposition as shown below:

(35) a. The students came late.
Assertion: Every student came late
Presupposition: There is a unique salient group of students.
b. The student came late.
Assertion: Every student came late.
Presupposition: There is a unique salient student.

[10] Sentences such as *It surprised Bill that Mary bought a car, but it didn't surprise him that she bought a red one* seem to be at odds with the claim that p-*surprise* is DE or SDE. The reader is referred to Ladusaw (1979), Linebarger (1987), Kadmon and Landman (1993), and von Fintel for discussion of why such sentences are not genuine counter-examples, once context-dependency is taken into account.

As a consequence, the restrictor of plural definites is a SDE environment, while the restrictor of singular definites is both a SDE and a SUE environment, and this makes the latter unsuitable for NPIs:[11]

(36) a. The students came late.
b. There is a unique salient group of French students.
(presupposition of (36c))
(36a) & (36b) ==> c. The French students came late.

(37) a. The French students came late.
b. There is a unique salient group of students.
(presupposition of (37c))
(37a) & (37b) =/=> c. The students came late

(38) a. The student came late
b. There is a unique salient French student
(presupposition of (38c))
(38a) & (38b) ==> c. The French student came late

(39) a. The French student came late.
b. There is a unique salient student.
(presupposition of (39c))
(39a) & (39b) ==> c. The student came late.

That NPIs are not licensed in SDE contexts that are also SUE is confirmed by their unacceptability in *it*-clefts (and in the restrictor of *both*; cf. Cable 2002).

(40) *It was John who has ever been to Paris.

The generalization that emerges in the weak theory is that a weak NPI is licensed when it occurs in the scope of a function that is SDE but not SUE.

Let us now see how this accounts for the contrast we started out with. *Wh*-questions have often been suggested to carry an existential presupposition of the kind illustrated in (41):

(41) a. I wonder which students bought a red car.
b. Presupposition: I believe that some student(s) bought a red car.

When this presupposition is assumed to be satisfied for the consequent, it is easy to show that entailment is preserved under strengthening in the restrictor

[11] If definites denote individuals (that is to say, if *the* is of type $\langle\langle e,t\rangle,e\rangle$), we should rewrite (9) as follows: "… f ==> g iff for all $x \in D_\alpha$, (i) f(x) ==> g(x) or (ii) $g(x) \leq f(x)$, whichever is relevant". This makes *the* SDE on its restrictor, and non-SUE when applied to a plural restrictor.

but not in the question nucleus (whether the question is interpreted *de re* or *de dicto*):[12]

(42) a. I wonder which students bought a car.
b. I believe that some students bought a red car.
(presupposition of (42c))
(42a) & (42b) =/=> c. I wonder which students bought a red car.

(43) a. I wonder which students came to the party.
b. I believe that some French student(s) came to the party.
(presupposition of (43c))
(43a) & (43b) ==> c. I wonder which French students came to the party.
d. I wonder which French students came to the party.
e. I believe that some student(s) came to the party.
(presupposition of (43f))
(43d) & (43e) =/=> f. I wonder which students came to the party.

Therefore, while *who/which* is not SDE on its nucleus in constituent questions as shown by (42) (see discussion in Sect. 2, and footnote 16 below), *which* is unidirectionally SDE on its restrictor, when the latter is plural. When the restrictor is singular, *which* is SDE on it as well (as shown in (44)), but not unidirectionally so (see (45)).

(44) a. I wonder which student came to the party.
b. I believe that exactly one French student(s) came to the party.
(44a) & (44b) ==> c. I wonder which French student came to the party.

(45) a. I wonder which French student came to the party.
b. I believe that exactly one student came to the party.
(45a) & (45b) ==> c. I wonder which student came to the party.

In this sense *wh*-phrases behave like definite noun phrases (for discussion of further similarities between *wh*-questions and definite noun phrases, see Dayal (1996), Rullmann and Beck (1998), among others), and the contrast in the licensing potential between singular and plural *wh* follows from the same difference in entailment properties observed in singular vs. plural definites. Notice that under standard assumptions, the denotation of *Which French students left* (e.g., {that Mary left, that Fred left}) is a subset of the denotation of *Which*

[12] If the *wh*-phrase is understood *de dicto*, (43a) does not entail, but does Strawson entail (43b) because *to wonder which students came* (*de dicto*) presupposes *to believe that some of the students are French and that some of the French students came*. Given this, the weaker theory, unlike the original DE theory, makes the desirable prediction that the occurrence of an NPI in the *wh*-restrictor does not eliminate the *de dicto/de re* ambiguity.

students left (= {that Mary left, that Fred left, that Sally left}) and the former entails the latter, according to (9). However, to account for the parallelism between *which*-phrases and definites illustrated above, we need a more fine-grained theory of questions, one according to which *Which French students left* denotes the singleton set {that Mary and Fred left} and *Which students left* denotes the singleton set {that Mary, Fred and Sally left}, and the latter entails the former (the reader is referred to the works cited above, as well as Lahiri 2002, for concrete proposals). The idea would be, then, that a *which*-phrase contains a hidden, cross-categorial, *the* (which means that the restrictor of *which* is in the scope of *the*). This view is consistent with our suggestion that a question Q1 entails a question Q2 iff asking Q1 amounts to asking Q2.

Like definite descriptions, which are SDE on their restrictor only, *wh*-phrases are SDE only on their restrictor, and not on their nucleus (as shown in (42)). Therefore the acceptability of NPIs in the nucleus of both *wh* and yes/no root questions and under (some) embedding predicates still needs to be explained. We turn to these cases in the next section.

5 Exhaustivity and NPI licensing

The proposal summarized in Sect. 3 is that NPIs are licensed in questions only if their hosting environment is strongly exhaustive or SDE. Given this, we make the following desirable predictions. Since yes/no questions are inherently strong, NPIs are always acceptable in them regardless of the monotonicity properties of the embedding predicate. The data in (46) repeated from Sect. 1, confirm this prediction.

(46) a. Does Frank have any books on Negative Polarity?
b. Claire **wonders** whether Frank has any books on Negative Polarity.
c. Claire **knows** whether Frank has any books on Negative Polarity.

As for *wh*-questions, those that are interpreted as strongly exhaustive admit NPIs; those that are not, do not (unless, of course, the embedding predicate is itself SDE; e.g., *ignore/not know*)). In Sect. 1 we saw that embedding predicates can be grouped into three classes with respect to their licensing properties: the *wonder*-class (whose behavior is exemplified by (6), repeated below as (47)), the *know*-class (whose behavior is exemplified by (7), repeated below as (48)), and the *surprise*-class (whose behavior is exemplified by (8), repeated below as (49)).

(47) Claire **wonders** which students have any books on Negative Polarity.

(48) %Claire **knows** which students have any books on Negative Polarity

(49) *It **surprised** Bill which students had ever been to Paris.

Our task in this section is twofold: (a) to show that *know* and *wonder* can be strongly exhaustive while *surprise* is necessarily weakly exhaustive; and (b) to show that while *wonder* is univocally strongly exhaustive, *know* allows both weakly and strongly exhaustive readings. The prediction, then, is that *surprise* never licenses NPIs in question complements, *wonder* always does, and *know* sometimes does (i.e., when intended as strong). The remainder of this section discusses each verb class in turn.

5.1 The *know* class

As we saw above, question embedding *know* (Q-*know* henceforth), unlike proposition embedding *know* (p-*know*), can sometimes license NPIs.

(50) a. *John knows that we have any food left.
b. *John knows that Bill has ever been to Paris.

(51) a. Claire knows whether Frank has any books on Negative Polarity. ✓ ***Y/N***
b. % Claire knows which students have any books on Negative Polarity ***% Wh***

Groenendijk and Stokhof (1984) have argued that questions embedded under *know* support strongly exhaustive inferences like the following.

(52) a. John knows who left.
b. Mary left.
c. Sally didn't leave.
(52a) & (52b) & (52c) ==> d. John knows that Mary left and that Sally didn't leave.

In other words, knowing who left amounts to knowing for each individual whether they left or not, at least under one of its possible interpretations. Furthermore, one can felicitously deny that John knows who left if John has the right beliefs regarding all the leavers, but the wrong beliefs concerning some non-leaver (for example, *John doesn't know which students left, at least not completely, because Bill didn't leave but John thinks he did*).

It is in virtue of this strong exhaustive semantics that Q-*know* sometimes licenses NPIs. What needs to be explained is why it does not always do so. If *know* was unambiguously strongly exhaustive, the acceptability judgment in (51) should be more solid than it is in actuality.

In fact, Beck and Rullmann (1999) and Sharvit (2002) claim that questions embedded under *know* can also be understood as only weakly exhaustive and present independent evidence supporting this claim, of the sort illustrated in (53).

(53) a. John knows which of his students were admitted, but he has no idea which of his students weren't.
b. Weak reading of *John knows which students were admitted*: For all x such that x is a student of John's, if x was admitted John believes that x was admitted (compatible with *but he has no idea which of his students weren't*).
c. Strong reading of *John knows which of his students were admitted*: For all x such that x is a student of John's, John believes that x was admitted if x was admitted, and John believes that x wasn't admitted if x wasn't admitted (incompatible with *but he has no idea which of his students weren't*).

(53c) shows that if *know* lacked a weakly exhaustive reading then (53a) should be contradictory. Since (53a) is not perceived as a contradiction, Q-*know* must be ambiguous between a strongly and a weakly exhaustive interpretation. For our purposes, one can encode the ambiguity by assuming two lexical items, *know-weak* and *know-strong*.[13] Assuming that a question denotes a set of propositions (the set of possible answers, true or false), as it is customary within the Hamblin/Karttunen tradition (Hamblin 1971; Karttunen 1977), the two lexical entries for *know-weak* and *know-strong* can be defined as in (54) and (55), respectively (see Footnote 8).[14] These definitions presuppose that a question is a (possibly non-singleton) set of possible answers.

(54) For any world w, question Q and individual x, whenever defined, $[\![\text{Q-}know\text{-}weak]\!]^w(Q)(x)$ = True iff for every $p \in Q$ such that $w \in p$, x believes p in w (i.e., for all worlds w' compatible with what x believes in w, $w' \in p$).[15]

(55) For any world w, question Q and individual x, whenever defined, $[\![\text{Q-}know\text{-}strong]\!]^w(Q)(x)$ = True iff for every $p \in Q$ such that $w \in p$, x believes p in w, and for every $p \in Q$ such that $w \notin p$, x believes NOT-p in w (i.e., for all worlds w' compatible with what x believes in w, $w' \notin p$).

[13] One could conceivably adopt a pragmatic approach to strong exhaustivity. However, if strong exhaustivity was merely a pragmatic inference, one would expect it to be in principle derivable in all cases of embedded questions. Because some predicates (e.g., *surprise*) never exhibit strong readings and it is hard to conceive what independent pragmatic factors might be blocking a strengthening inference in all their uses, we tend to believe that the weak vs. strong distinction can only follow from a lexical ambiguity (cf. Sharvit 2002's additional arguments for a lexical ambiguity approach).

[14] For simplicity, we disregard here *de dicto/ de re* ambiguities and concentrate only on *de re* readings. This allows us to consider questions in their extension only. Therefore Q is a set of propositions rather than an intension thereof.

[15] And if no $p \in Q$ is true, x believes this.

For example, if ⟦*who left*⟧ = {p ∈ $D_{\langle s,t\rangle}$: there is an individual x such that p = {w′ ∈ D_s: x left in w′}} (= {that Bill left, that Sally left, that Fred left,…}), then *John knows who left* can have either of the two following readings:

(56) ⟦*John* Q-*knows-weak who left*⟧^{w} = True iff for all x who left in w, John knows in w that x left.

(57) ⟦*John* Q-*knows-strong who left*⟧^{w} = True iff for all x, John knows in w whether x left.

Intuitively speaking, we can think of the strong reading as a relation between the subject and set of yes/no questions—these are inherently strong and as such, license NPIs. The weak reading, on the other hand, would license NPIs only if the semantics of the embedding predicate supported downward inferences. However, Q-*know-weak* does not create a (S)DE environment, as shown in (58) (even if we assume that this verb comes with the presupposition that the subject believes that at least one of the possible answers is true):

(58) a. John knows (weak) who owns a cat.
(i.e., for all x who own a cat, John knows that x owns a cat)
b. John believes that someone owns a white cat.
(possibly a presupposition of (58c))
c. John knows (weak) who owns a white cat.
(i.e., for all x who owns a white cat, John knows that x owns a white cat)

The conjunction of (58a) and (58b) clearly doesn't entail (58c):[16] John can know that Sally owns a cat, but he may believe incorrectly that her cat is black and not white. In this sense Q-*know-weak* is just like p-*know*, which also fails to support entailment under strengthening of its argument:

(59) a. John knows that we have a cat.
b. We have a white cat. (presupposition of (59c))
(59a) & (59b) =/=> c. John knows that we have a white cat.

[16] Strictly speaking, we cannot show that ⟦Q-*know-weak*⟧^{w}, as it is defined in (54), is non-(S)DE on Q (see discussion in Sect. 2), but we can show that ⟦Q-*know-weak*^{which}⟧^{w}(⟦*which*⟧^{w})(P1)(x) is non-(S)DE on P2 according to (i) below, and that ⟦Q-*know*^{whether}⟧^{w}(⟦*whether*⟧^{w})(x) is non-(S)DE on P1 according to (ii) (assuming that *who* and *what* are shorthand for *which person(s)* and *which thing(s)* respectively). P1 and P2 correspond to properties such as *students* and *have a car,* respectively, as in *Which students have a car*.

(i) Whenever defined, ⟦Q-*know-weak*^{which}⟧^{w}(⟦*which*⟧^{w})(P1)(x)(P2) = True iff for every p ∈ ⟦*which*⟧^{w}(P1)(P2) such that w ∈ p, x believes p in w (where for any properties P and P′, ⟦*which*⟧^{w}(P)(P′) = {p: there is a y such that P(w)(y) = True and p = {w′: P′(w′)(y) = True}}).

(ii) Whenever defined, ⟦Q-*know*^{whether}⟧^{w}(⟦*whether*⟧^{w})(x)(p) = True iff for every q ∈ ⟦*whether*⟧^{w}(p) such that w ∈ q, x believes q in w (where for any proposition p, ⟦*whether*⟧^{w}(p) = {q: q = p or q = {w′: w′ ∉ p}}).

Given this, it follows from our proposal that NPIs should be ruled out in all *wh*-questions embedded under Q-*know-weak* and allowed in all other cases. We can test this prediction by investigating the status of a weak NPI under Q-*know* in linguistic contexts that force its weakly exhaustive reading. The following example provides such a context.

(60) (John knows who his students are.) John knows which of his students have ever cheated, but he doesn't know which of his students haven't.

Consultants find the above sentence either contradictory or ungrammatical. When a strongly exhaustive reading is chosen, the sentence is predicted to be contradictory (see (53c) above). This leaves only a weakly exhaustive interpretation, which does not admit NPIs and therefore is ungrammatical. On the other hand (and as noted by Beck and Rullmann 1999; Sharvit 2002), *John knows which of his student have cheated, but he has no idea which haven't*, is judged to be perfectly fine (cf. (53a)). This, too, is expected, because once we remove the NPI the (non-contradictory) weakly exhaustive reading is unproblematic.

Going back to the facts discussed in Sect. 1 and repeated below in (61), notice that even though speakers invariably reject (60), some of them find (61b) acceptable. We think that the variability of the consultants' reactions to (7b) ((61b) below) comes from the difficulty some speakers have accessing the strong reading of Q-*know* (at least out of the blue).

(61) a. Claire **knows** whether Frank has any books on Negative Polarity.
b. %Claire **knows** which students have any books on Negative Polarity.

NPIs should be fine only if the embedded question is strong, namely when this question is a yes/no question or when Q-*know-strong* is involved. Speakers who have trouble accessing Q-*know-strong* out of the blue, will not "benefit" from the presence of the NPI (that is to say, it will not help them judge the sentence as acceptable).

Other predicates in this class, like *find out, discover, get to know* and *agree on* have these same two properties: a non-SDE semantics and a lexical ambiguity between a weak and a strong interpretation. For example, *agree on* doesn't easily admit NPIs as shown in (61), is not SDE (as shown in (63)), and like *know* it has a weak and a strong reading as shown in (64a) and (64b), respectively (from Sharvit 2002).

(62) %Bill and John agree on which students read any articles on NPIs.

(63) a. Bill and John agree on who has a cat.
b. Bill and John believe that someone has a white cat.
(presupposition of (63c))
=/=> c. Bill and John agree on who has a white cat.

(64) a. Bill and Mary agree on who has a cat but don't agree on who doesn't.
b. Bill and Mary do not (fully) agree on who has a cat, because Bill thinks that John doesn't have a cat but Mary has no opinion about John.

A weakly exhaustive semantics for *agree on* requires merely that Bill and Mary have the same opinion on which answers to the embedded question ('x has a cat', for some x) are true. This is compatible with Bill and Mary in fact disagreeing on which answers are false (or, equivalently, on which negative answers, 'x doesn't have a cat', for some x, are true). A strongly exhaustive incarnation of *agree on*, on the other hand, requires that Mary and Bill have the same opinion on both which answers are true and which are false. Only from this stronger condition can it follow that lack of agreement would suffice to deny that Bill and Mary agree on who has a cat. This is why we take (64b) to indicate that *agree on* can also be strongly exhaustive. Notice that if *agree on* was only strongly exhaustive, (64a) should be perceived as a contradiction. The fact that (64a) is not a contradiction indicates that the verb does indeed have a weakly exhaustive semantics.

5.2 The *surprise* class

Moving on to question-embedding *surprise* (Q-*surprise*), we show that it is both weak and, unlike proposition-embedding *surprise* (p-*surprise*), non-SDE. As a result, it never licenses NPIs in its indirect question complements.

We claim with Sharvit (2002) and Sharvit and Guerzoni (2003) that *surprise*, unlike *know*, is inherently weak. Intuitively, the idea is this. The weak version of Q-*know*—Q-*know-weak*—places constraints on the true propositions in the question complement, and the strong version of Q-*know*—Q-*know-strong*—places constraints on all the propositions in the question complement, including the false ones. Likewise, a weak version of Q-*surprise* (question-taking *surprise*)—if there is one—should place constraints on true propositions in the question complement, and a strong version—if there is one—on propositions in the question-complement, true or false.

To see why Q-*surprise* has only a weak incarnation, we must first illustrate another property that makes it different from Q-*know*, namely, its non-distributivity with respect to its question-argument (see Lahiri 1991, 2002). This is best shown by looking at a specific example such as the following:

(65) It surprised John who came to the party.

Lahiri observes that in a situation where Bill and Mary came to the party (and the other people didn't), in order for (65) to be true John needn't be surprised by Bill's coming, nor need he be surprised by Mary's coming. The sentence, rather, asserts that he is surprised by the combination of Bill and Mary coming.

In other words, (65) asserts that a world compatible with John's past expectations is one where: (i) Mary doesn't come and Bill does, or (ii) Mary comes and Bill doesn't; or (iii) neither Mary nor Bill comes. So, unlike Q-*know-weak*, which universally quantifies over the true members of the question complement, weak Q-*surprise*, that is to say, the *surprise* that "talks about" true members of the question-complement, is not a universal quantifier over the true members of the question complement. Following is the suggested semantics of this verb (along the lines of Lahiri 1991, 2002):

(66) $[\![$Q-*surprise-weak*$]\!]^w$(Q)(x) is defined only if:
(i) {p: p ∈ Q and w ∈ p} ≠ ∅; and
(ii) for every q ∈ {p: p ∈ Q and w ∈ p}, x currently believes q in w.
When defined, $[\![$Q-*surprise-weak*$]\!]^w$(Q)(x) = True iff for all worlds w′ compatible with x's past expectations in w, there is at least one q ∈ {p: p ∈ Q and w ∈ p} such that w′ ∉ q.

Let us now return to (65). In a context where the set of true members of *Who came to the party* is {'that Bill came to the party', 'that Mary came to the party'}, the truth conditions in (66) amount to the requirement that for every world w′ compatible with John's past expectations in the actual world, there is at least one member in this set which is false in w′.

Now, by analogy with Q-*know-strong*, the strong version of Q-*surprise*—if there is one—should be able to assert that the subject's wrong expectation concern the members of the question complement, true or false. Such semantics would look like this:

(67) $[\![$Q-*surprise-strong*$]\!]^w$(Q)(x) is defined only if for every p ∈ Q, if w ∈ p, x currently believes p in w, and if w ∉ p, x currently believes NOT p in w.
When defined, $[\![$Q-*surprise-strong*$]\!]^w$(Q)(x) = True iff for all worlds w′ compatible with x's past expectations in w, there is at least one p ∈ Q such that: (i) if w ∈ p, w′ ∉ p; and (ii) if w ∉ p, w′ ∈ p.

Evidence showing that Q-*surprise-strong* doesn't exist in the lexicon of English comes from Heim (1994), where it is observed that examples like (68) are judged to be very odd (or simply false).

(68) Although John correctly expected Sam and Fred—the ones who left—to leave, it still surprised him who left, because he had also expected Bill, who didn't leave, to leave.

If Q-*surprise-strong* existed in the lexicon of English, the oddity of (68) would be a mystery. This is because in the situation described in (68), for all worlds w′ compatible with John's past expectations there is a proposition (namely, 'that Bill didn't leave') which meets the requirements: it is true in w and false in w′. If English has only Q-*surprise-weak*—which says nothing about the subject's

expectations regarding the false propositions in Q—then it is guaranteed that *It surprised John who left* can only be uttered to express the idea that John is surprised by the leavers, not that he is surprised by the leavers or the non-leavers.

Having established that: (a) Q-*surprise* is non-distributive with respect to its question-complement; and (b) its semantics is inherently weak, the task ahead of us is to determine its monotonicity properties. Is Q-*surprise-weak* SDE on its question argument? The reader should recall that if it is, our analysis predicts that it can still license NPIs, but if it isn't—it cannot. It is also worth recalling that the question of whether Q-*surprise-weak* is SDE or not is especially interesting in view of the fact that p-*surprise* (proposition-taking *surprise*) is SDE and in virtue of this it does license NPIs (see examples (30) and (34) in Sect. 4).

Like p-*surprise*, Q-*surprise-weak* is not DE. In a scenario where John, Susan and Mary bought cars, in spite of John's expectations, but none bought a red car, (69a) is true but (69b) is not.

(69) a. It surprised Bill who bought a car.
=/=> b. It surprised Bill who bought a red car.

Unlike p-*surprise*, Q-*surprise-weak* is not SDE either.[17] This is shown below, where the presuppositions of *It surprised Bill who bought a red car* are added.

(70) a. It surprised Bill who bought a car.
(i.e., for every world w′ compatible with Bill's actual expectations, at least one z ∈ {y: y actually bought a car} didn't buy a car in w′)
b. Someone bought a red car and Bill now knows who bought a red car. (presupposed by (70c))
(70a) & (70b) =/=> c. It surprised Bill who bought a red car.
(i.e., for every world w′ compatible with Bill's actual expectations, at least one z ∈ {y: y actually bought a car} didn't by a red car in w′)

Adding the presuppositions of Q-*surprise-weak* (that red cars were bought, and that Bill believes all the true answers to (70b) at the time of his surprise) won't help make the entailment go through. This is so because Q-*surprise-weak* doesn't distribute over the members of its question-complement, as discussed

[17] Again (see footnote 16), strictly speaking, we cannot show that $[\![$Q-*surprise-weak*$]\!]^w$, as it is defined in (66), is non-(S)DE on Q, but we can show that $[\![$Q-*surprise-weak*$]\!]^w([\![$*which*$]\!]^w)$(P1)(x) is non-(S)DE on P2 according to (i) below.

(i) $[\![$Q-*surprise-weak*$]\!]^w([\![$*which*$]\!]^w)$(P1)(x)(P2) is defined only if at least one q ∈ $[\![$*which*$]\!]^w$(P1)(P2) is such that w ∈ q, and for every q ∈ $[\![$*which*$]\!]^w$(P1)(P2) such that w ∈ q, x currently believes q in w.
Whenever defined, $[\![$Q-*surprise-weak*$]\!]^w([\![$*which*$]\!]^w)$(P1)(x)(P2) = True iff for all worlds w′ compatible with x's past expectations in w, there is a least one q ∈ $[\![$*which*$]\!]^w$(P1)(P2) such that w ∈ q and w′ ∉ q.

above. Here is a natural situation which would verify (70a) (and possibly (70b)) and falsify (70c): suppose John, Mary and Susan are siblings and each of them bought a car. In addition, let's suppose that Mary and Susan each bought a red one. Knowing the financial status of their family, Bill's expectation was that the three of them could not afford to buy a car each. This was sufficient to surprise him when he heard they all did, and therefore it makes (70a) true. However, he had never excluded the possibility that two of them would buy cars. In addition, he knew that Mary and Susan's favorite color is red. Given this, the possibility of both Mary and Susan buying a red car is compatible with his past expectations. Therefore he was not surprised that they did, and this renders (70c) false.

Since Q-*surprise-weak* doesn't have either of the properties that allow licensing of NPIs—it is neither SDE nor can it be strongly exhaustive—the prediction regarding Q-*surprise*, then, is that it never licenses NPIs.

Another verb that seems to behave like Q-*surprise* with respect to NPI licensing is question-embedding *realize* (Q-*realize*). Q-*surprise* and Q-*realize* have a shared semantic core: both are "factive" in two ways in that both require at the time the attitude holds: (i) "speaker-factivity"—that the speaker knows the complete true answer to the embedded question, and (ii) "subject-factivity"—that the attitude holder believes the complete true answer to the embedded question. In other words, the speaker's grounds for implying that the attitude holder knows the true answer to the question are that she (the speaker) believes the same answer to be true. In addition, both predicates require that the attitude holder failed to believe the true answer at some past time relative to the time when the attitude holds. The difference between Q-*surprise* and Q-*realize* seems to be that the former alone requires a mistaken past belief, whereas the latter does not. (71a), for example, can only be true if at some time preceding the attitude time John believed the complete true answer to *Who came to the party* to be false, whereas (71b) does not seem to require this degree of certainty on John's side:

(71) a. It surprised John who came to the party.
b. John realized who came to the party.

This difference notwithstanding, Q-*realize* patterns with Q-*surprise* also in the two respects that are most relevant for the purposes of our discussion: the oddity of (72) indicates that it is unambiguously a weakly exhaustive predicate (i.e., Q-*realize* "talks about" only the true propositions in the question-complement), and (73) shows that it is non-SDE:

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

(73) a. John realized who had a car.
b. Somebody has a red car. (presupposed by (73d))
c. John believes someone has a red car. (presupposed by (73d))

(73a) & (73b) & (73c) =/=> d. John realized who has a red car.
(John can know that someone has a red car, and mistakenly believe that Sally, who in effect has a blue car, has a red car)

These considerations lead us to conclude that Q-*realize*, unlike the seemingly equivalent predicates Q-*find out* or Q-*get to know* discussed in the previous section, belongs to the same class of predicates as Q-*surprise*. That Q-*realize* should pattern with Q-*surprise*, rather than with Q-*find out* or Q-*get to know* might at first appear implausible due to the semantic similarity of its proposition embedding incarnation (p-*realize*) with p-*find out* or p-*get to know*.

(74) a. John realized that Mary had arrived.
b. John found out that Mary arrived.
c. John got to know/know that Mary had arrived.

When one turns to their question embedding incarnations, however, one finds that Q-*realize* is closer to Q-*surprise* than to Q-*find out* or Q-*get to know*. Specifically the latter two verbs fail to exhibit what we called "speaker-factivity" (see 75), a feature that, we saw above, Q-*realize* shares with Q-*surprise*.

(75) John just had a phone call from Mary. I am sure that…
a. he found out/got to know who was at the party. Tomorrow, when we meet I will learn that too.
b. #he realized who was at the party. Tomorrow, when we meet I will learn that too.

What the examples above suggest is that question embedding *find out/get to know* are factive only in the second sense ("subject-factivity"): by using these predicates the speaker conveys that the attitude holder knows the complete true answer to the question, but that she does not necessarily know the answer herself. Her grounds for her claim can be different from her direct knowledge of the answer.

In connection with this, an anonymous reviewer reports that some speakers find the following example not impeccable, but not completely unacceptable either:

(76) Sherlock just realized who/which suspect(s) had anything to gain from Mrs. Boddy's death.

Our intuition regarding this example is that here the typical "subject-factive" presupposition of this predicate is suspended and the resulting meaning becomes essentially equivalent to *find out* or *get to know*, which can be strongly exhaustive and therefore, in this particular case, it is predicted to sometimes license NPIs.

As of now, we have no account as to why some speakers can suspend the factive presupposition of Q-*realize* easier than others and in some examples

more than in others, and as to why such a presupposition should block strong exhaustivity. But we still maintain that Q-*realize* in its typical speaker-factive interpretation patterns with *surprise*, as argued in this section.

5.3 The *wonder* class

Verbs such as *wonder* allow NPIs in their question complement in all cases. According to our theory this is possible only if they either completely lack a weakly exhaustive interpretation or their weakly exhaustive interpretation is SDE. In this section we will discuss *wonder* as a paradigmatic example of this class and conclude that the acceptability of NPIs under *wonder* is due to an unambiguously strongly exhaustive semantics of the kind illustrated below.

(77) ⟦*John wonders-strong who left*⟧ = True iff for every p ∈ ⟦*who left*⟧ (i.e.,{that Bill left, that Mary left, that Sally left,…}), John wants to know whether p is true or false (i.e., iff for every x, John wants to know whether x left).

Unlike the case of *know,* there is very little discussion in the literature on whether *wonder* is weakly exhaustive (i.e., regarding merely the true propositions in the question-complement) or strongly exhaustive (i.e., regarding all propositions, true or false, in the question-complement).

Some considerations about what kind of attitude *wonder* expresses might shed some light on this question. The assumption that *wonder* is always strongly exhaustive becomes very plausible if one adopts the view that *x wonders Q* is the report of an ''internal/mental'' questioning act of x's, which, when external (i.e., when Q is uttered as matrix question) pragmatically triggers strong exhaustivity (Groenendijk and Stokhof 1984).

(78) Question: Who left?
Answer: Bill did
(Exhaustive implicature: Nobody else left)

Further support for this view of *wonder* as an 'internal'-speech act report, rather than some other type of attitude report comes from languages different from English where the only equivalent to *x wonders Q,* is literally *x asks oneself Q* (e.g. French *se demander*, Italian *chiedersi/domandarsi* etc.).[18]

On the basis of these considerations we suggest the following meaning for *wonder*:

[18] We thank an anonymous reviewer for pointing out the relevance of these cross-linguistic considerations.

(79) $[\![$*wonder-strong*$]\!]^w(Q)(x)$ is defined only if it is not the case that for all $p \in Q$ s.t. $w \in p$, x believes p in w.
When defined, $[\![$*wonder-strong*$]\!]^w(Q)(x)$ = True iff for every p in Q, x wants in w to know whether p is true or not.

According to the view we are defending in this paper, the prediction regarding *wonder* (and other verbs in this class such as *inquire* and *investigate*) is that it licenses NPIs both in its yes/no and *wh*-questions complements.

6 Why strength?

The distribution of NPIs in embedded questions led us to conclude that strong exhaustivity of the hosting environment is a sufficient, though not necessary, condition for NPI licensing in questions, as these items are always acceptable in embedded polar questions and in *wh*-questions featuring as the argument of strongly exhaustive predicates.

The question arises as to why one should observe such a contrast between weakly and strongly exhaustive questions. In the spirit of the ideas pursued in this paper, i.e. that downward entailment plays a crucial role in NPI licensing in questions as well, addressing this question boils down to understanding whether strong exhaustivity can be directly related (or perhaps reduced) to (S)DEness.

There is one previous approach to the problem of NPIs in interrogatives that is worth discussing precisely in connection with this question, namely Higginbotham (1993). On the one hand, this approach has a general drawback, in that it hinges on the assumption that all questions are strongly exhaustive and therefore it cannot, in principle, predict the kind of variability we are concerned with in this paper. On the other hand, Higginbotham's claim is that in all questions NPIs can be shown to occur in a DE context. This, together with the fact that Higginbotham limits his attention to strongly exhaustive questions might appear to boil down to the claim that all strongly exhaustive questions provide a DE context to NPIs. This would definitely shed some light on the connection we are interested in here. The question that emerges at this point is whether the source of strong exhaustivity and the source of DE-ness coincide or are related in Higginbotham's analysis. What we are about to show is that this, unfortunately, is not the case.

Higginbotham's idea is that NPIs are licensed in yes/no questions and in the nucleus of *wh*-questions because they actually occur in the restrictor of a special universal quantifier. The idea is that both yes/no-questions and *wh*-questions always involve *whether* (i.e. wh + *either*),[19] which, in turn, is analyzed as a universal determiner (and since a *wh*-question is viewed, in this theory, as a collection of yes/no questions, the problem is reduced to analyzing yes/no questions). The restrictor of *whether* is a two-membered set containing the

[19] See Higginbotham (1991) for a treatment of *either* as a universal quantifier in the relevant contexts.

proposition in the question nucleus and its negation (for example, the two-membered set {that John left, that John didn't leave}). The second argument of *whether* is instead a yes/no question on a propositional variable obtained by combining a question morpheme "?" with its propositional argument. Thus, 'Did John leave' is roughly analyzed as 'For all p∈ {'that John left', 'that John didn't leave}, is p or not p true?', and 'Which students have a car' is roughly analyzed as 'For every student x, for every p∈{'that x has a car', 'that x doesn't have a car}, is p or not p true?'.

Details aside, it is important to note that while according to this analysis the source of DEness is the universal determiner *whether*, which is DE on its restrictor, the presence of this determiner is not necessary to make the question strongly exhaustive, since "?" already makes the nuclear scope *is p true or false* strongly exhaustive (that is to say, DEness is not derived from strong exhaustivity, nor is strong exhaustivity derived from DEness). Thus, contrary to what might appear, Higginbotham's system doesn't provide a way to reduce DEness to strong exhaustivity (or the other way around). This leads us to conclude that as of now there seems to be no clear way to state the condition on NPI licensing without a disjunction.

In fact, if the empirical generalization presented in this paper (that strength of exhaustivity is a semantic sufficient licensing condition for NPIs) is correct, one can show that it is impossible to find a direct connection between acceptable NPIs in questions and DE-ness or strengthening. The reason is that strongly exhaustive environments can simply be shown not to be DE, or SDE, once a notion of entailment between questions is adopted that at least does some independent work in capturing relevant speakers intuitions (namely, the one we have adopted in this paper). According to this notion of entailment one can show, instead, that all strongly exhaustive environments share a weaker but related logical property: they are all non-Upward Entailing and non Strawson Upward Entailing.

(80) a. Who bought a red car?
b. Who bought a car?
(asking (80a) does not automatically lead to asking (80b)).

(81) a. Bill $\text{knows}_{\text{strong}}$ who bought a red car
=/=> b. Bill $\text{knows}_{\text{strong}}$ who bought a car
Scenario: *Bill knows that Susan and John and no one else bought a red car. Still, he believes that Fred bought a car, while in fact he bought a motorbike.*

However, this property, which is reminiscent of Progovac semantic condition for NPI licensing, is not uniquely characteristic of strongly exhaustive environments (as shown by (82) below), and therefore fails, by itself, to be empirically significant for NPI licensing in questions, in light of the facts presented in this paper.

(82) a. Bill knows$_{weak}$ who bought a red car
=/=> b. Bill knows$_{weak}$ who bought a car
Scenario: *Bill knows that Susan and John bought a red car. He also incorrectly believes that Mary did . He also believes that Fred didn't buy a car, while he in fact bought a green one.*

We therefore conclude that at this point it is impossible to reduce our disjunctive condition on NPI-licensing to the mono-clausal condition: "NPIs are licensed in a DE environment" (or even: "NPIs are licensed in a non-UE environment).

7 Summary and some open questions

In this paper we have shown that the distribution of NPIs in interrogative clauses is more complex then previously assumed and cannot be captured without taking into account the semantic properties of question embedding predicates, question restrictors and question nuclei. In particular, we identified two relevant properties: strong exhaustivity and SDEness.

As we pointed out above, it still remains an open question why strongly exhaustive environments are inherent licensors of NPIs. More important, perhaps, is why and how strength is related to (S)DEness. Still, we believe that no progress can be made in the study of NPIs in interrogative clauses without recognizing that these two (perhaps related) properties play a role in NPI licensing—even if we still don't understand them completely.

Another question we leave for further research regards the case of *even*-NPIs. The acceptability of these items in embedded questions appears to be even more restricted than what we observed for *any* and *ever* (see (83) below)).

(83) a. Mary wonders whether you lifted a finger to help me.
(Mary is biased towards a negative answer)
b. #Mary knows who lifted a finger to help.
c. #It surprised Mary who lifted a finger to help:

Although we leave an account of (83) for further research, we believe that restriction in this case must be related to the negative bias these NPIs trigger in questions and its compatibility with the implications of the semantics of the embedding predicate.

The final, perhaps most crucial question that remains to be answered concerns NPIs in root questions. One could conceivably make the case that, pragmatically, root questions are always strongly exhaustive (when we ask *Who left* we expect an answer that would at least allow us to infer the strongly exhaustive answer), and as such, they are inherent licensors of NPIs. While we think this is plausible, we still haven't investigated this issue in sufficient depth.

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