Homogeneity and Quantificational variability with Embedded Questions

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Abstract

Quantificational variability effects (QVE) with questions have been studied extensively since Berman (1991). Lahiri (2002) provided a particularly detailed account of QVE. Beck and Sharvit (2002) showed that this effect could arise with a wider variety of verbs than previously thought. Embedded questions also give rise to homogeneity effects reminiscent of those arising with definite plurals (Fodor, 1970; Löbner, 1985), but these effects have almost never been studied. In this manuscript, I propose an extension of Beck and Sharvit's (2002) theory which will treat QVE and homogeneity as two consequences of questions being inherently pluralities, and predict that these effects could in principle arise with all interrogative-embedding predicates. Finally, I discuss predictions of the theory for a wide variety of predicates.

Embedded questions are known to interact with adverbs of quantity to yield a reading where the adverb seems to quantify over answers to the questions (Berman, 1991). This effect was first related to the Quantificational Variability Effect (henceforth QVE) noticed by Lewis (1975), which descrives the interaction between an indefinite and an adverb of frequency to a reading that has little to do with time or frequency, as illustrated in (1) below.

(1) A quadratic equation usually has two different solutions.
$\leadsto$ Most quadratic equations have two different solutions.

A parallel analysis of QVE with questions and indefinites was appealing since many theories treat questions as some sort of indefinites (this view is supported by morphological similarities between indefinites and *wh*-phrases in many languages, among other things). However, questions which give rise to QVE were independently related to *plural* nouns, and embedded questions to definite descriptions (Dayal, 1996). What we call QVE for questions may have little to do with the effect Lewis discovered with singular indefinites, but the name *QVE* remains. The goal of this paper will be to extend the view of questions as pluralities presented in Beck and Sharvit (2002) to explain another effect arising with plural nouns: homogeneity.

In a first section, we will introduce homogeneity effects as defined in the literature on plural definite descriptions and show that very similar effects arise with embedded questions. As we will see homogeneity, just like QVE, has a deep link with plurality, so in the second section, we will review a few proposals from the rich literature on QVE with questions. The third section will present a new account of QVE which treats homogeneity effects in a very similar way. The last section will explore a wider variety of question-embedding predicates and discuss predictions of the new theory.

1 Homogeneity effects

1.1 Plural definite descriptions and homogeneity effects

The data: As first noticed by Fodor (1970), plural definite descriptions interact with negations in a particular way, which is illustrated in (2). (2a) is usually understood as "John talked with all of the students", while (2b) can be understood as "John talked with none of the students", a reading which is stronger than the mere negation of (2a). This effect has often been dubbed *homogeneity* because it seems that a predicate has to apply uniformly on the definite description: either all individuals must satisfy the predicate or none of them, and any intermediate case is somehow deviant.

(2) a. John talked with the students.
    b. John didn't talk with the students.

Using a bound pronoun and a negative QNP, we can show that the effect cannot simply be explained by having the object DP take scope over the negation. Indeed, (3) is usually understood as meaning that no professor talked with **any** of the students she likes, but the co-reference prevents the object DP from taking scope over the quantifier *No* in subject position.

(3) No professor$_i$ talked with the students she$_i$ likes.

Let me add immediately for later comparisons that, as first noted by Löbner (1985), homogeneity effects disappear in the presence of an overt universal adverb. This is illustrated in (4a,b), where we get a weaker reading which corresponds to the logical negation of a universal quantifier.

(4) a. John didn't talk with all the students.
    b. The students didn't all talk with John.

Theoretical accounts: Several theories have been proposed to explain this homogeneity effect. Schwarzschild (1993), Löbner (2000) and Gajewski (2005) treat it as a form of presupposition. They suggest that $S =$"the students P" has a universal assertive meaning, but that it also introduces a presupposition of the form "all students P or no student P". Depending on the sentence, the presupposition would be satisfied by making the first or the second disjunct true. Magri (2013) proposed that 'the' is basically an existential quantifier, but that 'some' is a scalar alternative to 'the'. Since 'all' is in turn an alternative to 'some', recursive exhaustification of 'the' would lead to the meaning "some students P and it is not the case that some but not all students P", which is equivalent to "all students P". The exhaustification would be blocked in downward entailing environments, just like usual scalar implicatures, explaining why the negative sentence (2b) is understood as the negation of an existential sentence. Finally, supervaluationnist theories (Spector, 2013; Križ and Spector, 2015) treat plurals more like vague items and develop the *Strongest meaning hypothesis* of Krifka (1996). In this view, 'the students' can be seen as a quantifier with a vague quantificational force and the sentence S is *super-true* if both $S_\forall$ = "all students P" and $S_\exists$ = "some students P" are true. It is *super-false* if both $S_\forall$ and $S_\exists$ are false, and corresponds to a truth-value gap in other cases.

1.2 Homogeneity with embedded questions?

Similar facts: The sentences presented in (5) suggest that embedded *which*-questions behave exactly as plural definite descriptions. To begin with, (5a) suggests that John knows about all students who called, while (5b) suggests that he knows for none of them.

As with definite descriptions, (5c) shows that an account in terms of inverse scope is not possible, and (5d) suggests that the effects disappears in the presence of an adverb.[1]

(5) a. John knows which students called.
  b. John doesn't know which students called.
  c. No professor$_i$ knows which of her$_i$ students called.
  d. John doesn't completely know which students called.

Theoretical accounts: Even though some of the facts described here have already been noticed (e.g., George, 2011, p.109), no theoretical account has been proposed (a few recent exceptions being work by Yimei Xiang or Manuel Križ).

1.3 Summary

Homogeneity effects seem to arise for both definite descriptions and embedded questions. The introspective data presented above are supported by quantitative data from Križ and Chemla (2014) and Xiang (2014)[2] for definite descriptions and embedded questions, respectively. The results from both studies do not reveal any difference between the two cases (although the methodologies are very different). In particular, the observed rates for projection of homogeneity out of negation are similar (about 50%).

[1]Obviously, *completely* affects the meaning of the sentence in a much more complicated way than what I assume here. However, the crucial observation is that (5d) does not give rise to homogeneity effect. A reasonable assumption would be that sentences with *completely* are ambiguous between the QVE reading and a 'degree of knowledge' reading. In affirmative sentences, the QVE reading is equivalent to the meaning of the sentence without any adverb, hence the 'degree of knowledge' reading is more salient. In negative sentences however, the QVE reading becomes more salient. As we will see in further sections, the effect of the adverb in such sentences will be to remove homogeneity effects by forcing a universal quantification on the question, which under negation yields a weaker reading than what we would get without the adverb. Furthermore, it is likely that *completely* will compete with other adverbs of quantity in this case, giving rise to implicatures. The pragmatic QVE reading for (5d) could be paraphrased as "John doesn't know for all student callers that they called, but he knows for some/most of them".

[2]What she calls *projection of completeness* corresponds to what I call *homogeneity*.

The goal of this paper will be to show how current theories of embedded questions on the one hand and of homogeneity on the other hand can be combined to provide an account of the data. We will then evaluate new predictions derived from this proposal.

2 Quantificational variability effects and questions as pluralities

In the discussion of homogeneity effects, we showed that these effects disappear when the sentence contains an overt adverb. Even though the homogeneity effects due to questions have not been studied, the interaction between embedded questions and adverbs of quantity has given rise to an extensive literature. The theory presented in section 3 will provide a unified account of these two things, building mostly on previous theories of *Quantificational variability effects*.

2.1 What is Quantificational variability?

Quantificational variability effects (henceforth QVE), refer to the interaction between an adverb of quantity or frequency and an embedded questions or an indefinite DP respectively. The effect with embedded questions, illustrated in (6), was first described in Berman (1991).[3] The adverb *mostly* can yield the reading (6a), which Lahiri (2002) calls the focus-affected reading, but I will only be interested in the reading (6b), where the adverb seems to quantify over answers to the questions.

(6) John mostly knows which students called.
  a. Most of what John knows is the answer to the question 'which students called'.
  b. For most students who called, John knows that they called.

QVE with questions involve adverbs of quantity (e.g., *mostly*, *in part*) and these adverbs usually take as a restrictor something which has the structure of a plurality (similar to Link's 1983 starred predicates). Because of this, recent accounts of QVE treat questions with a plural *which*-phrase as pluralities of some kind (an idea that goes back to Dayal, 1996).[4] Since QVE has been studied extensively and gave rise to many theories which treat questions as pluralities, it makes a lot of sense to try to account for homogeneity and QVE together.

The rest of this section will consist in a quick presentation of the theories of questions I will build on to add an account of homogeneity: Lahiri (2002) and Beck and Sharvit (2002).

2.2 Lahiri (2002)

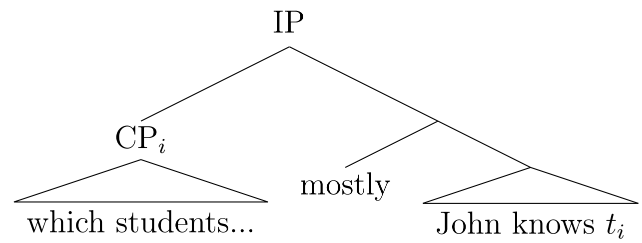
Lahiri (2002) derives QVE for *responsive* verbs (verbs such as *know* or *agree* which can receive interrogative as well as declarative complements). The main idea is that these verbs take arguments of type $<s,t>$, propositions, while questions are of a higher type (usually $<st,t>$, sets of propositions). Because of this type mismatch, the question in (6) has to move

[3] Some speakers find the sentence with *mostly* odd. They usually find the sentence better if *mostly* is replaced with *for the most part*. I will stick to *mostly* for simplicity, but the reader should feel free to replace every occurrence with the adverb s/he prefers, since I will not make any distinction between the two.

[4] Another phenomenon noticed by Lahiri (2002), cumulative (or semi-distributive) readings, provides yet another argument for analyzing questions as pluralities. I will not discuss this phenomenon here.

to the restrictor position of the adverb *mostly*, leaving a trace of type *st*. This movement is dubbed *interrogative raising* (henceforth IR). This leads to the structure sketched in (7), because Lahiri assumes that adverbs combine with their nuclear scope before combining with their restrictor.

(7) Lahiri's (2002) structure for (6b):



Before combining with the adverb, the set of propositions denoted by the question must be restricted, and the restriction is dependent on the embedding verb. For instance, veridical predicates like *know* only relate the agent to the true answers, while a non-veridical verb like *be certain* relates the agent to a different set of answers (the answers that the agent considers possible, according to Lahiri). Lahiri (2002) argues that this restriction cannot simply be accommodation of the verb's presupposition, contra Lahiri (1991). He suggests that each verb comes with a lexical restrictor which combines with the question. Section 4 presents arguments for this approach and further characterization of the restrictors.

Lahiri (2002) also makes use of a type-shifting operator, which takes a question and returns a single proposition. Among other things, this allows questions to be interpreted *in-situ* under responsive verbs, when no overt adverb is present. We will come back to this in section 3.1, where we introduce a similar operator.

2.3 Beck and Sharvit (2002)

Lahiri's theory only derives QVE for responsive verbs. However, Beck and Sharvit (2002) observed that rogative verbs (which can receive interrogative but not declarative complements), also give rise to QVE readings in some cases. As an example, (8) below has the reading (8a), which could be dubbed 'degree of dependence', but also has the reading (8b), which seems very similar to (6b). Nevertheless, the predicate *depend on* does not embed propositions. When one adds *exclusively*, (8b) even becomes the only available reading for the sentence.[5]

(8) Who will be admitted depends for the most part (exclusively) on this committee.
  a. This committee is an important factor in deciding who will be admitted.
  b. For most candidates, it depends (exclusively) on this committee whether they will be admitted.

[5]Lahiri (2002, 224–230) argues that although *depend on* can combine with adverbs of quantity, this is not an instance of QVE. Instead, he proposes that the adverbs combine with *depend on* to provide a new meaning postulate, which inherits its 'degree of dependency' from the force of the adverb. However, the version of (8) with the adverb *exclusively* provides an argument against this analysis. Indeed, assuming that *exclusively* affects the degree of dependency is probably the right analysis, but it does not explain how the resulting meaning can still combine with *for the most part*.

They propose a theory which shares many features with Lahiri's (2002), but has quantity adverbs quantify on subquestions rather than answers to the question. I will not present the details of this analysis here to avoid redundancy, since the theory I present in section 3 below draws heavily on the proposal of Beck and Sharvit (2002). Rather, I will point the differences when my account diverges significantly from theirs.

3 A unified theory of plural embedded questions

In this section, I will present a theory of questions which accounts uniformly for QVE and the homogeneity effects discussed in section 1, and discuss a few new predictions. Following Beck and Sharvit (2002), the theory derives these effects with both responsive and rogative verbs. However, the theory presented here will not derive the strong exhaustive reading (nor the *intermediate* exhaustive reading, Spector, 2005). Implementing a derivation of these readings would be possible by extending the proposal of Klinedinst and Rothschild (2011), but this would make the current proposal very technical and blur the main message: QVE and homogeneity can be unified under a view of embedded questions as pluralities.

3.1 Ingredients of the theory

Denotation of questions and operators: Following Hamblin (1973), I will assume that questions denote sets of propositions. More precisely, a question such as (9) will denote all propositions of the form "x called" with x in the denotation of *students*. Following Dayal (1996), I will assume that the question inherits the plural morphology of *students*, translated with Link's (1983) star (*) operator. Formally, this will yield the denotation in (10).[6]

(9) $\mathcal{Q}$ = Which students called?

(10) $[\![\mathcal{Q}]\!] = Q = \lambda p_{st}.\, \exists x \in [\![{}^\star\text{student}]\!] \colon [p = \lambda w. [\![\text{called}]\!]^w(x)]$
$Q = \{C(p), C(m), C(p \oplus m), \dots\}$ (with $C = [\![\text{called}]\!]$ and p, m denoting some students)

I will define a few operators on these question denotations. Following most previous authors, I will define a supremum operator σ, as in (11). Because it is based on the definite description operator ι, σ will have a *uniqueness* presupposition, implying that σQ is only defined if Q has a unique maximal element. Questions such as (9), which are schematically of the form: "which A's are B" (with A a count noun and B a distributive predicate), will always have a maximal element because the set of propositions they denote is closed under conjunction.[7]

(11) $\sigma = \lambda Q_{<st,t>}.\, \iota p.\, \big[p \in Q \wedge \forall q \in Q, (q \subseteq p) \rightarrow (q = p)\big]$

Secondly, I will define an operator At, which will return all the minimal elements in the denotation of the question (the *atoms*).

(12) $At = \lambda Q_{<st,t>}.\, \lambda p_{st}.\, \big[p \in Q \wedge \forall p' \in Q, [(p \subseteq p') \rightarrow (p = p')]\big]$

[6] I will not discuss the question of *de re*/*de dicto* readings. With minor modifications, this could be implemented as an ambiguity regarding which world fills the w argument in $[\![\text{student}]\!]^w$. For further discussion, see Sharvit (2002).

[7] This is the case because *A is closed by sum and B satisfies: $B(a \oplus b) \equiv B(a) \wedge B(b)$.

I will define an operator *Sub* which applies to a question denotation and returns a set of subquestions which corresponds to a *division* of the question, in the sense of Beck and Sharvit (2002).[8] Concretely, *Sub* will return all *whether*-questions formed on the atoms of Q, hence the denotation in (13). Since answering all the questions in $Sub(Q)$ provides a complete answer to Q, $Sub(Q)$ is indeed a division of Q in the sense of Beck and Sharvit (2002).

(13) $Sub = \lambda Q_{<st,t>}.\lambda q_{<st,t>}.\,\exists p \in At(Q)\colon q = whether\text{-}p$ $\qquad$ ($whether\text{-}p = \{p, \neg p\}$)
$Sub([\![(9)]\!]) = \{[\![\text{whether Peter called}]\!], [\![\text{whether Mary called}]\!], ...\}$
Note that: $[\![\text{whether Peter}\oplus\text{Mary called}]\!] \notin Sub([\![(9)]\!])$

As defined here, $Sub(Q)$ corresponds to the strong version of Beck and Sharvit's (2002) $Part(Q)$. This is so because our denotation for questions is not restricted to true answers, therefore $Sub(Q)$ contains *all* questions of the form "whether x called". In particular, if Bill is a student who did not call, $[\![\text{whether Bill called}]\!]$ will be part of $Sub(Q)$, so answering all the questions in $Sub(Q)$ will require affirming that Bill did not call. Nevertheless, we will see in the next paragraph that *Sub* will not usually apply directly to Q, and we will often see weak exhaustive answers.

Another point about *Sub* that we will discuss in 3.3.3 is that this operator does not distinguish singular and plural questions (since they only differ on their non-atomic propositions).

Lexical restrictors: Each responsive verb V will be assumed to come with a restrictor C. For veridical responsive verbs, such as *know*, C is simply the set of propositions which are true in the context. More generally, I will make the following assumptions:

(14) a. C is closed under conjunction.
b. If q is a set of propositions, a structure "Vq" can be interpreted as $V(\sigma(q \cap C))$.
c. If a question embedded under V undergoes IR, a copy of C projects with the question.

As mentioned above, $Sub(Q)$ corresponds to the strong version of Beck and Sharvit's (2002) $Part(Q)$, but $Sub(Q \cap C)$ corresponds to the weak version of $Part(Q)$. To see this, let us come back to our previous example with Bill, a student who did not actually call, and imagine that C is the set of true propositions. The atomic answer "that Bill called" is in Q but not in C, since it is false. Therefore, the question denoted by "whether Bill called" will not be part of $Sub(Q \cap C)$. As a matter of fact, only questions about students who actually called will be part of $Sub(Q \cap C)$. Therefore, answering all these questions will only provide Karttunen's weak exhaustive answer.

As a consequence, the theory only derives weak exhaustive readings for responsive verbs, although it still derives strong exhaustive readings for rogative verbs (which do not introduce a restrictor).

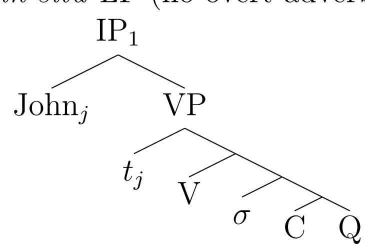
[8] Beck and Sharvit (2002) proposed that the division of the question be determined from the context. I will favor a more rigid approach here: each question is associated to a unique division, which is fully determined by the operator *Sub*.

One could imagine making the rule (14c) optional. This would lead to a theory which can derive Heim's (1994) weak and strong exhaustive readings (including in QV sentences). Nevertheless, deriving the intermediate exhaustive readings (Klinedinst and Rothschild, 2011; Spector and Egré, 2015; Cremers and Chemla, 2014) would require more than simple parameters tweaking, and results from Cremers and Chemla (2014) suggest that this reading is the most salient exhaustive reading. Another argument for not making the rule (14c) optional is that the strong exhaustive reading it would predict for QV sentences is intuitively wrong: all previous literature agrees on the fact that QVE is quantification on the *true* answers, and a strong exhaustive QVE reading should add an independent constraint on the false answers, but not affect the domain of quantification. In the following, I leave the issue of exhaustivity aside since it is mostly orthogonal to the questions discussed in this manuscript and would require sophisticated adjustments to be fully addressed.

Possible structures: When the sentence contains an overt adverb, the question must undergo IR to fill the restrictor position of the adverb. When the sentence does not contain any overt adverb, the question can be interpreted *in situ* or undergo IR to the restrictor position of a silent adverb, which I will write $\mathcal{H}$. The two resulting structures for responsive verbs are presented in (15). Rogative verbs involve similar structures, except they do not introduce a lexical restrictor nor σ-operator.

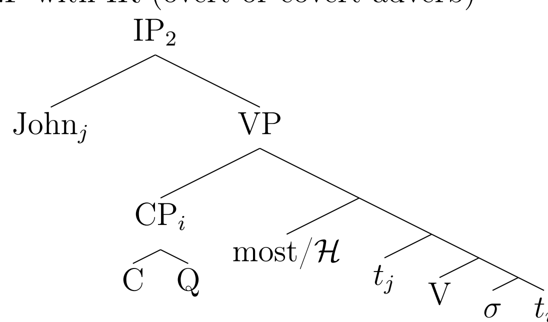
(15) Possible structures for "John $(Adv) V Q$" with V a responsive verb and Q a question.

a. *in situ* LF (no overt adverb)



$[\![\text{IP}_1]\!] = V'(j)(\sigma(C \cap Q))$

b. LF with IR (overt or covert adverb)



$[\![\text{IP}_2]\!] = \text{Adv}'(Sub(C \cap Q))(\lambda q.V'(j)(\sigma(C \cap q)))$

Note that we need a rule like Rule AB (Lahiri, 2002, p85) to get the right LF in (15b).

Homogeneity: Instead of $\mathcal{H}$, Lahiri (2002) proposes a null adverb in (15b), which is resolved as either universal closure (yielding an exhaustive reading) or existential closure (yielding a *mention-some* reading), depending on context. The present theory will depart from this view and treat the silent adverb as the source of homogeneity effects.

We will adapt the theory of homogeneity proposed in Spector (2013), building on Krifka's (1996) *Strongest Meaning Hypothesis* (SMH). The idea is rather simple: we assume, following Lahiri (2002) that $\mathcal{H}$ is somehow ambiguous between a universal and an existential closure. However, instead of assuming an ambiguity resolved by context, we will apply a supervaluationist version of the SMH: the sentence will be true only if it would be true under both an existential and a universal closure, false if it would be false under both. In any other case, the sentence will be a truth value gap. This idea can be reflected in the entry for $\mathcal{H}$ presented in (16).

(16) Interpretation rule for $\mathcal{H}$:

$$[\![\mathcal{H}]\!](A)(B) = \begin{vmatrix} 1 \text{ iff} & \forall q.[A(q) \to B(q)] & \wedge & \exists q.[A(q) \wedge B(q)] \\ 0 \text{ iff} & \neg\forall q.[A(q) \to B(q)] & \wedge & \neg\exists q.[A(q) \wedge B(q)] \\ \# & \text{otherwise} & & \end{vmatrix}$$

Note that, assuming A is not empty, one of the conjuncts is always entailed by the other. In fact, the only contribution of the existential conjunct to the truth-conditions is to force the existence of at least one A-element. The same point can be made about the contribution of the universal conjunct to the falsity-conditions. A sentence with $\mathcal{H}$ will therefore always be a truth-value gap if the restrictor is empty.

We refer to Križ and Spector, 2015 for details regarding the projection of this truth value gap in quantified sentences, but for the simple cases we are interested in (mostly embedding under negation), we can simply use Kleene's strong logic (K_3).

3.2 Application to simple cases

We will now see how the theory introduced above fares on simple sentences where a *which*-question is embedded under *know*, possibly with sentential negation or an adverb of quantity.

3.2.1 Simple affirmative sentence with *know*

(5a) John knows which students called.

Since the sentence contains no overt adverb, it is ambiguous between the LF (15a), where the question is interpreted *in situ*, and (15b) where it undergoes IR to the restrictor of $\mathcal{H}$.

***In situ* interpretation:** The LF is presented in (17). In the case of *know* (and other veridical responsive verbs) C restricts Q to only the true answers, and σ returns the strongest of these. Since the set $C \cap Q$ is closed under conjunction, its strongest element is simply the conjunction of all, hence $\sigma(C \cap Q)$ will return the conjunction of all true answers, i.e. Karttunen's true complete answer.[9] The meaning can be paraphrased as "John is in the *know*-relation with the conjunction of all true answers to the question", which corresponds to the usual weakly exhaustive reading of (5a).

(17)
$$[\![(5a)]\!] = \text{know}'(j)(\sigma(C \cap Q)))$$
$$[\![(5a)]\!] = \text{know}'(j)\left(\lambda w. \bigwedge_{x \in \text{student}' \cap \text{called}'} [\![\text{called}]\!]^w(x)\right)$$

[9]In cases where there is no true answer (no student called), this would just return a presupposition failure. I see two possible solutions to this problem, which I will not implement. The first one would be to modify the definition of σ so that it returns a stronger proposition in such cases (following Karttunen, 1977 or Heim, 1994). Another one would be to assume that in such cases, pragmatics favors a strongly exhaustive reading of the sentence because the other readings are too weak.

Interrogative raising: If the question undergoes IR to the restrictor position of $\mathcal{H}$, homogeneity comes into play (i.e. application of rule 16). As shown in (18), the sentence receives truth-conditions equivalent to the previous LF (the usual weakly exhaustive reading). Nevertheless, the falsity-conditions are more demanding than the mere negation of this: for the sentence to be plain false, John has to be ignorant about all students who called. Any intermediate case (in which John knows about some of the student callers but not all) leads to a truth-value gap.

(18) $[\![(5a)]\!] = [\![\mathcal{H}]\!](Sub(C \cap Q))(\lambda q.\text{know}'(j)(\sigma(C \cap q)))$
$[\![(5a)]\!] = 1 \leftrightarrow \big(\forall x \in \text{student}' \cap \text{called}', \text{know}'(j)(\lambda w.[\![\text{called}]\!]^w(x))\big)$
$[\![(5a)]\!] = 0 \leftrightarrow \big(\neg\exists x \in \text{student}' \cap \text{called}', \text{know}'(j)(\lambda w.[\![\text{called}]\!]^w(x))\big)$

3.2.2 Simple negative sentence with *know*

(5b) John doesn't know which students called.

Again, the sentence is ambiguous between two LFs, depending on whether the question remains *in situ* or undergoes movement.

***In situ* interpretation:** In this case, we simply obtain the logical negation of (5a), which means that for at least one student caller, John does not know that she called.

Interrogative raising: We will assume that negation interacts with trivalence following the rules of Kleene's K_3 logic, in (19). The situation is symmetric compared to (5a): as shown in (20) the falsity conditions are as usually predicted, but the truth conditions are stronger. The sentence is true only if John knows nothing about the students who called. Note that the scope of the negation has no effect here. If $\mathcal{H}$ was to take scope over negation, we would retrieve the same truth- and falsity-conditions by exchanging the roles of the "∀. . ." and "∃. . ." conjuncts.

(19) Truth table of the negation in K_3:

p	$\neg p$
1	0
#	#
0	1

(20) $[\![(5b)]\!] = \neg[\![\mathcal{H}]\!](Sub(C \cap Q))(\lambda q.\text{know}'(j)(\sigma(C \cap q)))$
$[\![(5b)]\!] = 1 \leftrightarrow \neg\big(\exists x \in \text{student}' \cap \text{called}', \text{know}'(j)(\lambda w.[\![\text{called}]\!]^w(x))\big)$
$[\![(5b)]\!] = 0 \leftrightarrow \neg\big(\neg\forall x \in \text{student}' \cap \text{called}', \text{know}'(j)(\lambda w.[\![\text{called}]\!]^w(x))\big)$

3.2.3 Sentence with an adverb of quantity with *know*

(6) John mostly knows which students called.

If the adverb is overt, for instance *mostly*, the question must undergo IR to fill the restrictor position of the adverb. In this case, the theory derives the usual QV reading. The sentence (6) is predicted to be true if and only if for most students who actually called, John knows that they did. The equivalence is shown in (21).[10]

(21) $[\![(6)]\!] = \text{mostly}'(Sub(C \cap Q))(\lambda q.\text{know}'(j)(\sigma(C \cap q)))$
$[\![(6)]\!] = \text{mostly}'(\lambda q.\exists p \in At(C \cap Q) : q = ?p)(\lambda q.\text{know}'(j)(\sigma(C \cap q)))$
$[\![(6)]\!] \equiv most_{st}\, p \in At(C \cap Q), \text{know}'(j)(p)$
$[\![(6)]\!] \equiv most_e{}'\, x \in \text{student}' \cap \text{called}', \text{know}'(j)(\lambda w.[\![\text{called}]\!]^w(x))$

Summary: The theory predicts the correct reading for simple QVE sentences such as (6), and an ambiguity in the case of sentences which embed questions without an overt adverb of quantity, such as (5a,b). If the question is interpreted *in situ*, the sentence receives the usual weakly exhaustive reading and no homogeneity. If the question undergoes IR to the restrictor position of a silent adverb $\mathcal{H}$, homogeneity effects come into play. In the case of (5a) the difference is subtle because it only shows up in the falsity conditions. For (5b), the sentence which motivated the implementation of homogeneity in the first place, the truth-conditions are affected (the homogeneous reading has stronger truth-conditions). This is in line with experimental results by Xiang (2014).

The theory also inherits from Spector (2013) the prediction that homogeneity projects universally in sentence (5c) and accounts for the fact that (5d) does not show homogeneity (because the adverb *completely* replaces the silent adverb $\mathcal{H}$).

3.3 New predictions and puzzles

We have seen that the theory derives the correct readings for simple sentences. We will now inspect its predictions on a wider variety of cases (in particular, with more question-embedding verbs).

3.3.1 Rogative verbs

I adopted Beck and Sharvit's (2002) idea of quantification over subquestions rather than answers in order to derive QVE for rogative verbs as well. The theory treats homogeneity as the counterpart of QVE in sentences which lack an overt adverb. Therefore, it predicts that any verb which allows QVE should also give rise to homogeneity effects. In the case of rogative verbs, there seems to be some restrictions on QVE (in particular, in the case of *wonder*). Without discussing these restrictions, the theory at least predicts a correlation between the availability of QVE and homogeneity.

***Depend on*:** Based on the sentence (8) repeated below, Beck and Sharvit (2002) argue that *depend on* allows QVE (at least in its first argument). This predicate also seems to give rise to homogeneity effects. At least under a certain reading, (22a) suggests that the committee has no influence on any admission. As in previous examples, the adverb *completely* in (22b) blocks homogeneity (and probably introduces a scalar implicature as well), as predicted by the current theory.

(8) Who will be admitted depends for the most part (exclusively) on this committee.

[10] I use informal quantifiers '$most_\tau$' on types τ: "$most_\tau\, x_\tau \in P, P'(x)$" iff $|P \cap P'| > \alpha|P|$. For simplicity, we can assume $\alpha = 1/2$ but the threshold is likely to be vague.

(22) a. Who will be admitted doesn't depend on this committee.
b. Who will be admitted doesn't completely depend on this committee.

***Wonder*:** This predicate usually does not to give rise to QVE: it cannot be modified by adverbs like *completely* and QV readings are not available in sentences such as (23a). However, in a sentence like (23b), *wonder* seems to allow QVE. Without a clear characterization of the sentences where *wonder* allows QVE, we cannot extract clear predictions about the distribution of homogeneity effect. Even though a definite argument would be hard to build, we can still exhibit some sentences which may be problematic for a theory that does not allow homogeneity with *wonder*.

(23c) intuitively feels a bit contradictory. This suggest that one cannot wonder about a question which is mostly resolved. Hence we can reject an existential semantic for *wonder*. However, (23d) intuitively implies that no professor wonders about any of her students.[11] The simplest way to account for these sentences may be to allow *wonder* to sometimes give rise to homogeneity, as predicted by the theory.

(23) a. John mostly wonders which students called.
b. John mostly knows, but still partly wonders which students called.
c. ??John mostly knows, but still wonders which students called.
d. No professor wonders which of her students called.

To conclude, *wonder* seems to give rise to QVE or homogeneity under certain conditions. The current theory predicts that the two should be parallel, but this prediction is hard to evaluate.

3.3.2 *Surprise*

(24) *It surprised Mary whether Peter called.

(25) It surprised Mary which students called.

(26) For the most part, it surprised Mary which students called.

Surprise does not embed *whether*-questions, as shown in (24). It does not seem to exhibit any homogeneity effect either. Otherwise, (25) would mean that every student who called surprised Mary, while it is clear that only a few unexpected callers are sufficient to make the sentence true.[12] In the theory I presented, it should be easy to link these two facts: if *surprise* cannot embed *whether*-questions, it should not allow structures with IR, hence it should not give rise to homogeneity nor QVE. Nevertheless, (26) naturally receives a QVE reading.

[11] For some reason, *wonder* under negation sounds odd. One exception would be contrastive focus, as in:

(i) John doesn't wonder which candidates were admitted, he KNOWS which candidates were admitted.

[12] Note that a denotation *à la* Guerzoni and Sharvit (2007) would make *surprise* very similar to *forget*, since it has a positive presupposition and a negative assertion. Nevertheless, the two verbs behave very differently. We will see in section 4.2 that *forget* even provides a further argument for homogeneity.

3.3.3 Other types of questions

So far we varied the embedding contexts, but we only discussed questions such as (9), which have a few important features. First of all, they only contain one *wh*-phrase. Second, this *wh*-phrase is plural-marked. Third, the verb in the question (e.g., *call*) is a distributive predicate. Let me first note that replacing a plural *which*-phrase with a neutral *wh*-word, such as *who* or *what*, does not affect any of the judgments. As a consequence, the domain for these words should include pluralities. We will now discuss what happens with other types of questions, and how the theory must be updated to account for all this.

Multiple *wh*-questions and questions with quantifiers: Under a pair-list reading, multiple *wh*-questions exhibit QVE effects (see Fox, 2012 for a recent discussion). As pointed out by Lahiri (2002), if we want to account for these questions, the definition of *At* given in (12) must be refined. In order to get rid of propositions of the form "$a \oplus b$ read $c \oplus d$", the updated definition in (27) is necessary. Unsurprisingly, the prediction that homogeneity correlates with QVE extends to multiple *wh*-questions. This seems correct, as illustrated in (28).

QVE for questions with quantifiers may require a slightly complex denotation, but it is possible (see Preuss, 2001). However, the intuitions about (29b) suggest that it does not display homogeneity. This may be because the quantified DP *every boy* is able to take scope on its own (see example 90 in Fox, 2000, p64), or because it can trigger a scalar implicature that John knows for some boys which book they read. In any case, this may be an argument in favor of Križ (2015)'s account of homogeneity in questions.

(27) Updated definition of the *At* operator (see Lahiri, 2002, p.202):

$$At = \lambda Q_{<st,t>}.\lambda p_{st}.\Big[\ p \in Q \wedge \forall r \in Q, [(p \subseteq r) \rightarrow (p = r)] \wedge \\ \bigwedge \left\{ q \in Q | q \neq p \wedge \forall r \in Q, [(q \subseteq r) \rightarrow (q = r)] \right\} \not\subseteq p \Big]$$

(28) a. For the most part, John knows which boy read which book.

b. John doesn't know which boy read which book.
$\rightsquigarrow$ For no boy x, John knows which book x read.

(29) a. For the most part, John knows which book every boy read.

b. John doesn't know which book every boy read.
$\not\rightsquigarrow$ For no boy x, John knows which book x read.

Singular *which*-phrase: Dayal (1996) noted that questions with a singular *which*-phrase, as $\mathcal{Q}$ in (30a), trigger a uniqueness presupposition (only one student called). The number-marking can be translated in the denotation.

(30) a. $\mathcal{Q}$ = Which student called?

b. $[\![\mathcal{Q}]\!] = \lambda p_{st}.\ \exists x \in [\![\text{student}]\!] : [p = \lambda w.[\![\text{called}]\!]^w(x)]$

Crucially, the denotation in (30b) does not contain any proposition of the form $\lambda w.[\![\text{called}]\!]^w(p \oplus m)$, which involves plural individuals. This means that $Q \cap C$ will usually not be closed under conjunction or contain a maximal element and $\sigma(Q \cap C)$ will not be defined, unless $Q \cap C$ is a singleton set. In the case of veridical predicates, this correctly derives the uniqueness presupposition. For other predicates, the presupposition depends on the restrictor.

However, the theory as it stands does not prevent the question from scoping out of σ. *Sub*, unlike σ, does not presuppose anything, and it does not distinguish between singular and plural marked questions, so the theory incorrectly predicts that the presupposition can be obviated. Several solutions are conceivable: we could either encode in *Sub* some presupposition about its argument, block IR for singular questions, or require that the presupposition of σ be satisfied before IR. I will pursue the first solution, and simply assume that *Sub* presupposes that its complement has a maximal element.

Collective predicates: Collective predicates, such as *lift the piano*, are predicates which take as arguments genuine pluralities of individuals. In particular, they do not distribute over atomic parts when applied to a plural individual, so the inference in (31) is not valid.

(31) Peter and his friends lifted the piano.
          Peter lifted the piano.

(32) $\mathcal{Q}$ = Which students lifted the piano?
$[\![\mathcal{Q}]\!] = \lambda p_{st}.\, \exists x\colon [[\![{}^\star\text{student}]\!](x) \wedge p = \lambda w.[\![\text{l.t.p.}]\!]^w(x)]$

Since $[\![\text{l.t.p.}]\!](a \oplus b)$ is not equivalent to the conjunction of the propositions $[\![\text{l.t.p.}]\!](a)$ and $[\![\text{l.t.p.}]\!](b)$, the denotation of the question will not be closed under conjunction and will usually not have a maximal element. However, the presupposition of (32) will be easier to satisfy or accommodate. Indeed, (32) will presuppose that there is a unique plurality of students who lifted the piano, with no constraints on how many students composed this plurality.

Since there is in general no maximal element, we predict no homogeneity or QVE effect here. However, some questions with collective predicates seem to be ambiguous between a question about a single plurality or about a set of pluralities, thus allowing more than one answer. As an example, it seems possible to ask "Which students are siblings?" in a situation where one expects several sibling groups, and sibling groups are the atoms for quantification in one reading of the sentence (33). Furthermore, even when a question has a unique plural answer, it seems to allow quantification on atomic individuals involved in the unique answer, as in (34).

(33) John knows, for the most part, which students are siblings.

(34) John knew, for the most part, which students lifted the piano, and he gave them $5 for their help.

4 More on lexical restrictors

4.1 On the necessity of lexical restrictors

Most veridical responsive verbs happen to be factive, and conversely, all factive verbs that embed questions are veridical responsive. For this reason, Berman (1991); Lahiri (1991) assumed that the restrictor for QVE is determined by accommodating the presuppositions of the verb. Following Lahiri (2002), I departed from this view and assumed that each responsive verb comes with a restrictor that is a lexical property of the verb.

One argument of Lahiri (2002) against the presupposition accommodation solution has to do with the controversial status of so-called *intermediate accommodation* (see Beaver, 1995), but recent literature seemed to reach a consensus for the availability of such a mechanism (Geurts and van der Sandt, 1999; Singh, 2008, 2009). However, two simple facts challenge the intermediate accommodation solution for question embedding. First, communication verbs such as *tell* or *predict* are not factive nor even veridical when embedding propositions, but are usually veridical when embedding a question (this argument is already present in Lahiri, 2002). Second, complex factive verbs such as *forget* or *discover* have stronger presuppositions than *know*, but they are simply veridical when embedding questions.

Spector and Egré (2015) provide arguments against the first point. As we will see in section 4.3, they show that communication verbs (a) are factive in some contexts and (b) are not always veridical when embedding questions. The second point however has not been challenged. We will now look at complex factive verbs in detail.

4.2 Complex factive verbs

We will focus on the case of *forget*, as in the sentence (35), for a concrete example.

The most natural entry for *forget that p*, illustrated in (35a), introduces two presuppositions (factivity and knowledge in the past) and asserts that the agent no longer knows *p*. According to the presupposition accommodation approach, this implies that (35) should receive the truth-conditions in (35b), which seem clearly wrong. (35c) looks like a much better paraphrase of (35). One way to maintain the presupposition accommodation approach would be to attribute different statuses to the two presuppositions of *forget*, so that only factivity would play a role in accommodating the restrictor.[13]

In the lexical restrictor approach, we need to postulate that the restrictor is a simple veridical restrictor (the same as *know*). This makes the factivity presupposition trivially satisfied. However, the 'knowledge in the past' presupposition remains, and the underlined

[13] Such an analysis is sketched in Roelofsen et al. (2014) and Uegaki (2014), following a suggestion of Theiler (2014), although none of them apply it to factive verbs beyond *know* and emotive-factives. The idea is to derive the factivity of declarative entries from the presence of an operator which is responsible for the veridicality of the corresponding question-embedding predicates. Therefore, the factivity presupposition is not hard-coded in the semantics of the verb, but is rather a by-product of the verb being *extensional*, in Groenendijk and Stokhof's (1984) sense. Other presuppositions, such as the 'knowledge in the past' presupposition of *forget* would remain purely lexical and would not play any role in the restriction of the question. This approach seems promising, but it may not work well with non-veridical responsive predicates. As we will see, the restrictors for verbs like *be certain* or *agree* seem arbitrary and would, if anything, correspond to lexical presuppositions of these verbs.

part of (35c) is presumably a presupposition.

(35) John forgot which students called.

a. John forgot p: p and John used to know p, John does not know p (any more).

b. # For each student x who called and such that John knew that x called, John forgot that x called.

c. For each student x who called, John knew that x called and John forgot that x called.

Note in passing that this sentence provides one more argument for a decomposition of the embedded question into smaller units. Indeed, the most salient reading attributes exhaustive knowledge to John in the past, but also exhaustive oblivion. This would not be possible in an account which relates John to a single proposition. For instance, if a, b and c are the students who called, the true complete answer will be 'a, b and c called'. If John forgets about c, but still remembers about a and b, he would still count as having forgotten the proposition that a, b and c called. Conversely, a disjunctive proposition 'a, b or c called' would give the right assertion but a weak presupposition.

If we look at other complex factive verbs (e.g., *remember*, *discover*, *find out*), the same observation holds: all these verbs are simply veridical.

4.3 Communication verbs

Communication verbs were long thought to be veridical when embedding questions, but Spector and Egré (2015) recently proposed that they are ambiguous between a veridical and a non-veridical reading when embedding questions, and between a factive and a non-factive reading when embedding declaratives. The latter is supported by data from Schlenker (2007), repeated in (36). From (36a) we infer that Sue is indeed pregnant, and this inference projects out of negation or questions, a projection pattern typical of presuppositions. In support of the former point, Spector and Egré (2015) provide examples such as (37). Furthermore, they argue that the veridical readings correspond exactly to the factive entries of communication verbs and provide data from Hungarian in support of this view. Hungarian makes a distinction between factive and non-factive *tell*, and they show that the veridical reading of *tell* corresponds to the factive entry.

(36) a. Sue told someone that she is pregnant.

b. Sue didn't tell anyone that she is pregnant.

c. Did Sue tell anyone that she is pregnant?

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

(38) John told me which students called.

a. For each student x who called, John told me that x called.
$\rightarrow$ John told me the complete answer to Q

b. For each student x such that John believes that x called, John told me x called.
$\rightarrow$ John told me what he believes to be the complete answer to Q

The restrictor for the veridical entry must be $C = \lambda p.p(w_0)$, which yields the veridical reading in (38a). Spector and Egré's (2015) lexical rule involves existential quantification, hence the non-veridical reading they derive is simply "John told me some answer to Q" (most of recent work in the field also assumes some form of existential quantification for non-veridical predicates). In the theory we proposed, in the absence of any restrictor, (38) would mean "John told me that every student called", which is clearly wrong (and IR does not help here since Sub also relies on the restrictor). Non-veridical entries require a restrictor as well, and a reasonable option for non-veridical *tell* and other communication verbs is to use the set of propositions that John believes: $C = \lambda p.B_j(p)$. This yields the reading (38b).

4.4 Other non-veridical predicates

As we have just seen, every responsive verb must come with a lexical restrictor. In the case of non-veridical predicates, there is no obvious solution and the restrictor must be postulated. The solution adopted by Lahiri (2002) associates restrictors which are dependent on the agent, as exemplified by the restrictor for *be certain* in (39) and *agree on* in (40).

(39) $[\![x \text{ is certain about } Q]\!] = [\![\text{be certain}]\!](\sigma(C_x \cap Q))(x)$
$C_x = \lambda p_{st}.\exists w \in Dox_x(w_0) : p(w)$ ("x considers it possible that p")

(40) $[\![x \text{ and } y \text{ agree on } Q]\!] = B_x(\sigma(Q \cap C_{xy})) \wedge B_y(\sigma(Q \cap C_{xy}))$
$C_{xy} = \lambda p.\big[Dox_x(w_0) \subseteq p \vee Dox_y(w_0) \subseteq p\big]$ ("x or y believes p")

(41) Peter and Mary disagree on who called.
$[\![x \text{ and } y \text{ disagree on } Q]\!] = \neg B_x(\sigma(Q \cap C_{xy})) \vee \neg B_y(\sigma(Q \cap C_{xy}))$

Interestingly, this restrictor for *agree on* is not necessarily closed under conjunction, thus contradicts hypothesis (14a)[14]. For instance, Mary may believe that only Ann called, while Peter may believe that only Bill called. In such a case, 'Ann called' and 'Bill called' would be in C, but 'Ann and Bill called' would not. This seems wrong because in such a situation, (41) sounds true and not a presupposition failure. Therefore, we can assume that the hypothesis (14a) holds, and that the right restrictor for *agree* and *disagree* is the closure under conjunction of the restrictor in (40). In this case the maximal answer is 'Ann and Bill called', which both Peter and Mary believe to be false (note that they also disagree on every atom, so the sentence also satisfies homogeneity).

Now consider a situation where Mary believes that only Ann and Bill called, while Peter believes that only Bill and Celine called. The closure of the union of Peter and Mary's beliefs contains 3 atomic propositions, call them a, b and c, and the maximal answer is $a \wedge b \wedge c$. In this case, the assertion 'Peter and Mary agree on who called' is predicted to be false if the question is interpreted *in situ*, but not super-false, since Peter and Mary agree on b. Conversely, 'Peter and Mary disagree on who called' would be true under the *in situ* reading, but would violate homogeneity under the silent adverb reading.

[14] Thanks to Wataru Uegaki for pointing this to me.

4.5 *Believe* and embedded questions

A surprising fact about responsive verbs is that *believe* is not one of them, as shown by the ungrammaticality of (42). This has been a recurrent topic in the literature and several explanations have been proposed, none of which is fully satisfying.[15] The current framework allows for a new explanation for the fact, although it will remain speculative.

(42) *John believes which students called.

If *believe* was a responsive verb, we would need to determine its restrictor. We could imagine using a veridical restrictor, but then *believe* would be almost equivalent to *know*. In fact, *believe* does sometimes embed questions, and is then veridical with respects to its interrogative complement, as shown by the example (43a) from Egré (2008). However, this is only possible in negative, exclamative sentences, and *believe* then receives a semantic closer to an emotive-factive predicate than to a cognitive predicate. Egré (2008) shows that the parallel with emotive-factives extends to the fact that *believe* cannot embed *whether*-questions, even in negative exclamative sentences, as indicated by the ungrammaticality of (43b). Finally, (43c) seems to indicate that the corresponding declarative-embedding *believe* is indeed factive.

(43)
a. Peter will never believe who came to the party!
b. *Peter will never believe whether Mary came to the party!
c. Peter will never believe that Mary came to the party!
$\rightsquigarrow$ Mary came to the party.

Apart from the veridical restrictor, we could imagine using the default restrictor we used for non-veridical communication verbs: $C_x = \lambda p.[\![\text{believe}]\!](p)(x)$. Unfortunately, this would make (42) a tautology: "for each student x such that John believes that x called, John believes that x called".

Most theories treat non-veridical responsive predicates as existential quantifiers on possible answers, so they predict that – provided it was grammatical – (42) would mean something like "John believes some answer to the question". In a theory where responsive verbs *must* have a restrictor, such a weak reading is impossible. Of the two plausible restrictors, one gives a tautology and the other returns a veridical entry which is only available in very specific contexts and with an emotive-factive semantics, thus escaping the competition with *know*. Hence we may assume that the only special property of *believe* is that it is the default propositional attitude, and as such cannot embed questions without leading to a tautology, unless we add another dimension to its meaning.

[15] Vendler (1972) and Ginzburg (1995a,b) argue for a distinction between *facts* and *propositions*, but this misses the fact that *regret* cannot embed questions although it embeds facts just like *know*. Egré (2004) proposes a generalization for French based on a new class of verbs (*indicative factive* predicates), but this predicts that all responsive predicates are veridical, missing the fact that *agree* or *be certain* can embed questions.

5 Conclusion

Embedded questions give rise to quantificational variability effects which have been studied extensively since Berman (1991) and are usually treated as a consequence of the plurality feature of some questions. There are other effects related to plurality with embedded questions (cumulative readings, homogeneity), but they have not been studied in so much detail. Here I proposed a general theory of QVE and homogeneity, building on previous accounts (Lahiri, 2002 and Beck and Sharvit, 2002, for the most part) and on the super-valuationist theory of homogeneity (Krifka, 1996; Spector, 2013). This theory extends existing theories of questions and makes a few welcome predictions about homogeneity effects.

Following Lahiri (2002), I used a context variable C for restricting questions and assumed that its value is lexically determined by the embedding verb. This solution is less minimal than the presupposition accommodation approach of Berman (1991); Lahiri (1991), and it raises non-trivial questions about the acquisition of these lexical restrictors. However, it seems necessary if we want to derive the correct meaning for complex factive verbs. It also predicts stronger meaning for non-veridical responsive predicates than the existential quantification on answers which is usually proposed. This is a desirable feature when we look at predicates like *be certain* or *agree*. Finally, the lexical restrictor hypothesis points toward a new explanation for why *believe* does not embed questions.

Three points I did not discuss in this paper may have puzzled some readers. The first one has to do with what we call *plurality*. In this theory, questions denote sets of propositions and the *Sub* operator returns a set of questions. Strictly speaking, Link's (1983) pluralities are not just sets. Sets of propositions which are closed under conjunction (Lahiri's Proposition Conjunction Algebras) have the same structure as plural predicates of individuals, which are closed under sum-formation. Conjunction plays the role of a sum operator, and we can define everything we would define for regular pluralities (supremum operator, atoms). Sets of questions by contrast do not come with a natural ordering or binary operator. This makes the theory stipulative regarding why questions give rise to plurality effects.

The second point has to do with the $\mathcal{H}$ operator. The super-valuationist theories of homogeneity do not make use of such a thing. In the nominal field (at least in English), homogeneity arises when a plural noun is combined with a definite article. The phrase "the NP_{plural}" denotes a single plural individual, and combines with a (plural) predicate of individuals, of type $<e, \tau>$. In the case of questions, the situation is a bit more complicated because we have rogative and responsive predicates. We could account for homogeneity with responsive verbs in a much simpler way by giving up the null adverb and making our σ-operator responsible for the homogeneity effects (after all, it is a form of definite description). However, this would not work with rogative verbs, because they must combine with the whole question and not just its supremum.[16]

Thirdly, the current theory does not derive strong or intermediate exhaustive readings. I assume that such exhaustivity effects can be dealt with independently. This in particular

[16] A symmetric problem arises if we consider that questions denote sets of (proto)-questions instead of sets of propositions. This would work well with rogative verbs, but would make the restriction problem very complicated for responsive verbs.

can be attempted following Klinedinst and Rothschild's (2011) proposal. The key for such an approach is to define proper focus values for questions, so that they would percolate into alternative sets for sentences which embed questions. An exhaustivity operator can then strengthen these sentences and this is how we would derive the intermediate exhaustive reading. A few technicalities which make this extension non-trivial here explain why I considered that it was out of the reach of the present contribution, but I refer to Cremers (2015) for a similar implementation.

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