ISSUES IN THE SEMANTICS OF QUESTIONS WITH QUANTIFIERS

by

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ABSTRACT OF THE DISSERTATION

Issues in the Semantics of Questions with Quantifiers

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This dissertation proposes a semantics of questions which accounts for quantificational variablility effects and the singular-plural distinction of wh-phrases. The number feature of the wh-phrase determines how many quantificationally variable readings simple constituent questions and questions with quantifiers have. In order to account for the singular-plural distinction of wh-phrases and quantificational variability effects I propose a semantics of questions that defines complete, possible answers to questions and their parts. Questions denote sets of sets of propositions such that the generalized intersection of each element of the question denotation is a complete, possible answer to the question. Each element of the question denotation also specifies the parts of the answer that adverbs of quantity such as *for the most part* quantify over.

The proposed semantics of questions relies on translating wh-phrases into expressions with maximality conditions. In order to extend this approach to degree

questions with predicates that are upward entailing or non-entailing rather than downward entailing I propose to translate *how-many* phrases into quantifiers over pluralities of degrees rather than quantifiers over degrees. This allows to translate *how-many* phrases into expressions with maximality conditions even if the predicate is not downward entailing. The analysis is extended to account for strongly exhaustive readings of questions that exhibit quantificational variability effects.

The proposed semantics of questions employs a minimality operator in order to rule out irrelevant sets of propositions. Such a semantics correctly predicts that not all elements allow pair list readings. E.g. if *no* outscopes the wh-phrase the resulting expression denotes the empty set of sets of propositions. The fact that questions with *most* do not allow pair list readings is accounted for since *most* is vague. The proposed semantics predicts that questions with universal terms such as *every NPs*, plural definites and NPs with *all* or *both* allow pair list readings if the universal term allows a distributive reading. Questions with numerals allow pair list readings if the numeral is interpreted as a specific indefinite that translates into a choice function. Expressions that translate into choice functions act like universal terms.

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1. Chapter: Introduction

In the introduction I provide an overview of the empirical and theoretical claims of the dissertation and I introduce previous accounts of the semantics of simple constituent questions and the semantics of questions with quantifiers. I use the term *quantifier* to refer to elements such as *every woman, no woman, most women, two women, at least two women* and *the women*. They have in common that they take scope because they allow for a distributive reading. Hence they are quantifiers in the sense that they are scope bearing elements. This does not mean that I analyse all of them as generalized quantifiers.

1.1 Overview of the dissertation

In the first chapter I briefly review previous accounts of the semantics of simple constituent questions, in particular Hamblin (1973), Karttunen (1977), Groenendijk & Stokhof (1982) and Lahiri (1991). I adopt a Hamblin-style semantics of questions in which questions involve possible answers rather than true answers in order to account for the lack of factivity effects of questions embedded under predicates such as *be certain*. Then I review previous accounts of pair list readings, in particular Engdahl (1980, 1986), Groenendijk and Stokhof (1982) and Chierchia (1993). I adopt a quantificational analysis of pair list readings because - unlike Chierchia's (1993) functional analysis - it allows a uniform treatment of quantifiers such as *every*. They translate into universal quantifiers independent of whether they occur in pair list readings of questions with quantifiers or in other types of sentences/questions. Also, there is evidence from languages such as German that the subject-object asymmetries that Chierchia's (1993) functional analysis treats as WCO-effects are not WCO-effects.

In the second chapter I discuss Quantificational Variability Effects (QVE) of embedded questions and the singular-plural distinction of wh-phrases. I adopt Lahiri's (1991) proposal that QVE of embedded questions involves quantification over plural propositions. According to Lahiri's theory the sentence

(1) John knows for the most part which students called.

is true if John knows most atomic parts of the maximal true answer to the question *which students called*. If the proposition *Ann, Bill and Chris called* is the maximal true answer to the question then it has three atomic parts, namely the propositions *Ann called, Bill called* and *Chris called*. If John knows most of the atomic parts of the maximal true answer to the question then the above sentence is true.

Lahiri's analysis does not account for plurality effects of plural wh-phrases. E.g. the sentence

(2) #Exactly one student called and John knows which students called.

is infelicitous because the sentence specifies that only one student called but the plural wh-phrase is only licit if more than one student called. Lahiri's analysis does not account for plurality effects of plural wh-phrases because his analysis of QVE does not distinguish between atomic parts of answers to a question and answers to a question. In his analysis a proposition can only be an atomic part of an answer to a question if it is also an answer to the question. Hence e.g. the proposition *Ann called* can only be an atomic part of the answer to the question *which students called* if it is also an answer to the question. This is so because Lahiri (1991) uses the set of possible answers to define atomic parts of answers. In a world with three students, Ann, Bill and Chris, the question *which students called* has the following set of possible answers:

(3) which students called?
{Ann called, Bill called, Chris called, Ann and Bill called, Ann and Chris called, Bill and Chris called, Ann and Bill and Chris called}

If the proposition *Ann called* is not a possible answer to the question then it is also not an atomic part of any possible answer to the question. Since the truth conditions of (1) are only accounted for if propositions such as *Ann called* are atomic parts of answers such as *Ann and Chris called* Lahiri has to assume that the proposition *Ann called* is a possible answer to the question in (3). Lahiri (1991, 2000, to appear) does not account for uniqueness effects of questions with singular wh-phrases either. E.g. the sentence

(4) #Two students called and John knows which student called.

is infelicitous because the sentence specifies that more than one student called but the singular wh-phrase is only licit if exactly one student called. Lahiri (1991, to appear) does not account for uniqueness effects of singular wh-phrases because his answerhood operator treats questions with singular and plural wh-phrases alike. Hence the question *which student called* has the same set of answers as the question *which students called*.

Since Lahiri's (1991, to appear) analysis does not account for the singular-plural distinction of wh-phrases, it also does not account for the fact that the number feature of the wh-phrase determines how many quantificationally variable readings are available. Simple constituent questions with plural wh-phrases have one quantificationally variable reading whereas simple constituent questions with singular wh-phrases have no quantificationally variable reading:

(5) John knows for the most part which students called.
one reading: John knows for most students that called that they called.

(6) #John knows for the most part which student called.
no reading

Lahiri's (1991, to appear) analysis incorrectly assigns the same truth conditions to the sentences in (5) and (6).

I propose a semantics of simple constituent questions in which parts[1] of complete possible answers to the question are not necessarily possible answers to the question. This allows me to account for QVE and the singular-plural distinction of wh-phrases. I assume that questions denote sets of sets of propositions. Each element of the question denotation is a set of propositions that defines a complete, possible answer and its parts. The set of propositions itself is identical to the set of parts of a complete, possible answer and the generalized intersection of the set of propositions is a complete, possible answer.

The singular-plural distinction of wh-phrases is part of the notion of completeness. If the wh-phrase is plural, the elements of the question denotation contain at least two propositions, if the wh-phrase is singular, the elements of the question denotation are singleton sets. In a world with three students, Ann, Bill and Chris, the following questions have the following denotations:

(7) which students called?
{{Ann called, Bill called}, {Ann called, Chris called}, {Bill called, Chris called}, {Ann called, Bill called, Chris called}}

(8) which student called?
{{Ann called}, {Bill called}, {Chris called}}

[1]Not all parts are atomic. See the definition of atomic parts in section 2.2.1.2 and section 2.3.6.

In (7) the complete possible answer *Ann and Bill called* has two atomic parts, namely *Ann called* and *Bill called*. In order to obtain the above question denotations I assume that the following question translates into the following expression:

(9) which students called?

$\lambda P\ [\exists j\ [$ — existential quantification over worlds j

$P = \mu P'\ [$ — minimality

$\exists X\ [{}^{*}\text{student}\ (a)\ (X)\ \&$ — plurality

$\forall x\ [\text{student}\ (a)\ (x)\ \&\ \text{call}\ (j)\ (x) \rightarrow x \leq X]\ \&$ — maximality

$\forall x\ [\text{atom}(x)\ \&\ x \leq X \rightarrow$ — distributivity

$\exists p\ [p(j)\ \&\ P'(p)\ \&\ p = \lambda i\ [\text{call}\ (i)\ (x)]]]]]]]$

I leave an explanation of the different parts of the expression to later sections, part of the expression is motivated by the analysis of pair list readings of questions with quantifiers, in particular the fact that the minimality operator outscopes the translation of the wh-phrase is motivated by the semantics of questions with quantifiers. If the minimality operator outscopes the translation of the wh-phrase it is necessary to translate plural wh-phrases into expressions with maximality conditions.

I also discuss QVE of pair list readings of questions with quantifiers and the singular-plural distinction of wh-phrases. Again, the number feature of the wh-phrase determines how many quantificationally variable readings are available. If the wh-phrase is singular there is one quantificationally variable reading:

(10) John knows for the most part which wine every customer ordered.
reading: John knows for most customers which wine they ordered.

Thus, the sentence is true if twenty customers ordered some wine and John knows for fifteen of them which wine they ordered. If the wh-phrase is plural there are (at least) two readings:

(11) John knows for the most part which wines every customer ordered.
reading1: John knows for most customers which wine they ordered.
reading2: John knows for every customer most of the wines that s/he ordered.

The sentence is true on the second reading if every customer ordered ten wines and John knows for every customer seven wines that s/he ordered.

Chierchia (1993) proposes that the semantics of questions with quantifiers distinguishes possible answers from their parts. He proposes that questions with quantifiers denote sets of sets of sets of propositions. However, he does not account for the singular-plural distinction of wh-phrases. If the *every*-phrase outscopes the wh-phrase the corresponding question denotation contains[2] a set of propositions that specifies <u>any</u> part of <u>any</u> complete, possible answer to the question, irrespective of the number feature of the wh-phrase:

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[2]I use the term *contain* transitively: If A contains B and B contains C then A contains C.

(12) which wine(s) did every customer like?

{{{Ann likes Merlot, Ann likes Zinfandel, Bill likes Merlot, Bill likes Zinfandel, Chris likes Merlot, Chris likes Zinfandel}}}

The answerhood operator determines the maximal true answer by forming the generalized intersection of the subset of true propositions. Hence, Chierchia's (1993) analysis does not account for exhaustivity, as pointed out by Dayal (1996). Exhaustivity means that the question only has a true answer if every customer ordered some wine. However, if it so happens that Ann didn't order any wine in the actual world then Chierchia's (1993) analysis incorrectly predicts that the question has a maximal true answer. The answerhood operator yields e.g. *Bill ordered Merlot and Chris ordered Zinfandel* as maximal true answer to the above question.

Chierchia's (1993) analysis also does not rule out irrelevant propositions. E.g. it does not rule out that the maximal true answer to the question *which wine did every customer order?* is the proposition *the sun is shining and Ann is crazy and Bill is crazy and Chris is crazy*. This is so because the elements of the question denotation are solely restricted by a statement of the form $P(\lambda p\ [...])$, see (13). This statement ensures that certain sets of propositions are in P but it does not rule out that P contains further, irrelevant sets of propositions such as {Ann is crazy, Bill is crazy, Chris is crazy, the sun is shining}.

(13) which wine did every customer order?

$\lambda P\ \exists A\ [W(\text{every customer}, A)\ \&\ P\ (\lambda p\ [\exists f \in [A \rightarrow \text{wine}]$

$\exists x \in A\ [p = \lambda i\ [\text{order}\ (i)\ (x, f(x))]]])]$

{{{Ann ordered Merlot, Ann ordered Zinfandel, Bill ordered Merlot, Bill ordered Zinfandel, Chris ordered Merlot, Chris ordered Zinfandel}},

{{Ann ordered Merlot, Ann ordered Zinfandel, Bill ordered Merlot, Bill ordered Zinfandel, Chris ordered Merlot, Chris ordered Zinfandel},

{Ann is a crazy, Bill is crazy, Chris is crazy, the sun is shining}}}

If the irrelevant true propositions outnumber the relevant true propositions then the maximal true answer to the above question is the generalized intersection of the irrelevant propositions, for the details of Chierchia's (1993) analysis see section 2.1.4.

Lahiri (2000, to appear) accounts for exhaustivity of questions with quantifiers by introducing more structure into the semantics of questions. His semantics of questions contains one set of propositions for each customer:

(14) which wine did every customer order?

{{{{Ann ordered Merlot, Ann ordered Zinfandel},

{Bill ordered Merlot, Bill ordered Zinfandel},

{Chris ordered Merlot, Chris ordered Zinfandel}}}}

The answerhood operator ensures that the question only has a true answer if each set of propositions contains a true proposition. The answerhood operator intersects the set of true propositions for each customer. If one customer didn't order any wine(s), the generalized intersection of the empty set of proposition is T and the answerhood operator yields nil. Hence Lahiri (to appear) builds part of the notion of complete, possible answer to the question into the answerhood operator. However, - like Chierchia (1993) - Lahiri (to appear) does not account for the singular-plural distinction of wh-phrases and he does not rule out irrelevant propositions. The latter problem arises because again, the elements of the question denotation are solely restricted by a statement of the form $P(\lambda Q\ [...])$.

(15) which wines did every customer order?

$\lambda P\ \exists A\ [W\ (every\ (customer(a)), A)\ \&$

$P\ (\lambda Q\ \exists x \in A\ [Q = \lambda p\ \exists f \in [A \rightarrow wine\ (a)]\quad [p = \lambda i\ [order\ (i)\ (x, f\ (x))]]]])]$

Lahiri (to appear) also does not account for the second reading of questions with quantifiers and plural wh-phrases. Recall that the sentence *John knows for the most part which wines every customer ordered* is true if John knows for every customer seven out of the ten wines that s/he ordered. Lahiri does not account for this reading because the answerhood operator intersects the set of true propositions for each customer. Hence the maximal true answer to the question has only as many atomic parts as there are customers. To give an example, the atomic parts of the maximal true answer might be: {Ann ordered Merlot and Zinfandel, Bill ordered Merlot and Zinfandel, Chris ordered Merlot and Zinfandel}.

I propose that questions with quantifiers - like simple constituent questions - denote sets of sets of propositions such that each element of the question denotation is a set of parts of a complete, possible answer to the question. Exhaustivity and the singular-plural distinction of wh-phrases are part of the notion of completeness. If the wh-phrase is singular as in *which wine did every customer order* then every element of the question denotation contains exactly one proposition for each customer. In a world with three customers, Ann, Bill and Chris, and two wines, Zinfandel and Merlot, the question has the following denotation on a pair list reading:

(16) which wine did every customer order?

{{Ann ordered Merlot, Bill ordered Merlot, Chris ordered Merlot},
{Ann ordered Zinfandel, Bill ordered Zinfandel, Chris ordered Zinfandel},
{Ann ordered Zinfandel, Bill ordered Merlot, Chris ordered Merlot},
{Ann ordered Merlot, Bill ordered Zinfandel, Chris ordered Merlot},
{Ann ordered Merlot, Bill ordered Merlot, Chris ordered Zinfandel},
{Ann ordered Merlot, Bill ordered Zinfandel, Chris ordered Zinfandel},
{Ann ordered Zinfandel, Bill ordered Merlot, Chris ordered Zinfandel},
{Ann ordered Zinfandel, Bill ordered Zinfandel, Chris ordered Merlot}}

I adopt a quantificational analysis of pair list readings in which the non-wh-quantifier outscopes the wh-phrase, see section 1.3.1.4. The above denotation is assigned to the following question meaning:

(17) which wine did every customer order?

$\lambda P\ [\exists j\ [$	existential quantification over worlds j
$\quad P = \mu P'\ [$	minimality operator
$\quad\quad \forall x\ [customer\ (a)\ (x) \rightarrow$	quantificational analysis of pair list
$\quad\quad\quad \exists y\ [wine\ (a)\ (y)\ \&\ \exists p\ [P'(p)\ \&$	
$\quad\quad\quad\quad p\ (j)\ \&$	possible answers
$\quad\quad\quad\quad\quad p = \lambda i\ [order\ (i)\ (x,y)]]]]]]]$	

The minimality operator μ rules out irrelevant propositions in P.[3]The elements of the question denotation are restricted by an expression of the following form: $P = \mu P'\ [\exists p\ [P'\ (p)\ \&\ p = ...]]$. In pair list readings the minimality operator outscopes the universal quantifier in order to define complete, possible answers and hence it also outscopes the translation of the wh-phrase. Existential quantification over worlds j is necessary to define possible answers of questions if the minimality operator outscopes the wh-phrase.

The analysis accounts for the impact of the the singular-plural distinction of wh-phrases on the number of quantificationally variable readings. If the wh-phrase is singular, each possible answer has as many parts as there are customers, hence the sentence *John knows for the most part which wine every customer ordered* is true if John knows for the majority of customers which wine they ordered. If the wh-phrase is plural and there are ten customers that ordered seven wines each, then the complete true answer to the question *which wines did every customer order* has $10 \times 7 = 70$ parts. The sentence *John* *knows for the most part which wines every customer ordered* is true if John knows most of those parts. This is the case if he either knows for most customers which wines they ordered or if he knows for every customer most of the wines s/he ordered.[4] The question translates into the following expression:

(18) which wines does every customer like?

$\lambda P\ [\exists j\ [P = \mu P'\ [\forall x\ [\text{customer (a) (x)} \rightarrow$ minimality

$\exists Y\ [\text{``wine (a) (Y)} \ \&$ plurality

$\forall y\ [\text{wine (a) (y)} \ \&\ \text{like (j) (x,y)} \rightarrow y \leq Y]\ \&$ maximality

$\forall y\ [\text{atom (y)} \ \&\ y \leq Y \rightarrow$

distributivity

$\exists p\ [P'(p)\ \&\ p(j)\ \&\ p = \lambda i\ [\text{like (i) (x,y)}]]]]]]]]$

Again, since the minimality operator outscopes the translation of the wh-phrase it is necessary to translate plural wh-phrases into expressions with maximality conditions. This property leads to apparent problems in the analysis of degree questions.

Beck & Rullmann (1999) show that *how-many* phrases cannot translate into expressions with maximality conditions that determine maximal degrees. They point out that *how-many*-phrases in questions with upward scalar predicates do not determine maximal but minimal degrees. The question

(19) how many eggs are sufficient to bake this cake?

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[3]Pafel (1999) also uses a minimality operator to rule out irrelevant propositions, see section 2.1.5 for a

asks for the minimal number of eggs that is sufficient to bake the cake. Beck and Rullmann adopt Heim's (1994) intersective answerhood operator in order to determine maximally informative answers:

(20) answer1(a) (Q) = $\cap$\{p: Q (a) (p) & p (a)\}

Heim's (1994) intersective answerhood operator also accounts for maximally informative answers of questions with non-scalar predicates:

(21) How many people can play this game?

$\lambda p\ [\exists n\ [p = \lambda i\ [poss(i)\ (\lambda i'\ [\exists X\ [people\ (i')\ (X)\ \&$

$n = |X|\ \&\ play\ (i')(this\_game)(X)]])]]]$

{one person can play, two people can play, three people can play, four people can play, five people can play, six people can play, ..., m people can play}

If two, four or six people can play this game then the maximal answer to the question is the proposition *two, four and six people can play this game*.

Heim's (1994) intersective answerhood operator does not account for uniqueness effects of singular wh-phrases. If John and Mary called then the intersective answerhood operator incorrectly predicts that the question *which student called* has a maximal true answer, namely the proposition *John and Mary called*. Dayal's (1996) entailment-based

discussion of his proposal.

answerhood operator accounts for uniqueness effects of singular wh-phrases. Dayal's answerhood operator determines the unique true proposition in the question denotation that entails all other true propositions in the question denotation:

(22) $\text{Ans}(Q) = \iota p\, [p \in Q \;\&\; p(a) \;\&\; \forall p'\, [p'(a) \rightarrow p \subseteq p']]$

Beck and Rullmann (1999) do not adopt Dayal's entailment-based answerhood operator because in their analysis of questions with non-scalar predicates some complete, possible answers to the question are not part of the question denotation. E.g. the proposition *two, four and six people can play this game* is not part of the question denotation, hence Dayal's entailment-based answerhood operator would incorrectly predict that the question does not have a maximal true answer.

I show that if *how-many* phrases translate into quantifiers over pluralities of degrees the denotation of questions with non-scalar predicates contains all complete, possible answers to the question and Dayal's entailment-based answerhood operator can be used to account for maximal true answers and uniqueness effects of singular wh-phrases. In the following expression N is a variable over pluralities of degrees such as 2+4+6:

(23) $\lambda p\, [\exists N\, [p = [\lambda w'\, [\forall n \leq N\, [\text{poss}(i)\, (\lambda i'\, [\exists X\, [\text{people}\, (i')\, (X) \;\&$
$n = |X| \;\&\; \text{play}\, (i')(\text{this\_game})(X)]])]]]]]$

{one person can play, two people can play, one and two people can play, three

[4]The analysis runs into the proportion problem, which I leave as an unresolved problem.

people can play, two and four and six people can play, ... }

The pluralities-of-degrees analysis also allows to re-introduce maximality conditions into the translation of wh-phrases. Maximality conditions that determine maximal pluralities of degrees rather than maximal degrees account for the minimality effects of questions with upward scalar predicates. This is so because the plurality 3 + 4 + ... + m is a subpart of the plurality 2 + 3 + 4 + ... + m.

(24) how many eggs are sufficient to bake the cake?

$\lambda p\ [\exists N\ [$

$\forall N'\ [\forall n' \leq N'\ [\exists X\ [{}^*egg\ (a)\ (X)\ \&\ n' = |X|\ \&$ maximality condition

$sufficient\ (a)\ (X)]] \rightarrow N' \leq N]\ \&$

$p\ (a)\ \&\ p = \lambda i\ [\forall n \leq N\ [\exists X\ [{}^*egg\ (a)\ (X)\ \&\ sufficient\ (i)\ (X)\ \&\ n = |X|]]]]]$

A possible question denotation is {two and three and four and ... m eggs are sufficient}. Because of the entailment properties of *be sufficient* the proposition *two and three and four and ... m eggs are sufficient* is identical to *two eggs are sufficient.* Maximality conditions that determine maximal pluralities of degrees also account for *how-many* phrases in questions with non-scalar predicates and downward scalar predicates. Thus, it is possible to provide a uniform analysis for all types of questions. Degree questions - like any other type of question - denote sets of sets of propositions. In the following expression the maximality condition is needed in order to counteract the effects of the minimality operator:

(25) how many eggs are sufficient to bake this cake?

$\lambda P\ [\exists j\ [P = \mu P'\ [\exists N\ [$

$\forall N'\ [\forall n' \leq N'$ maximality

$[\exists X\ [{*}egg\ (a)\ (X)\ \&\ sufficient\ (j)\ (X)\ \&\ n' = |X|]] \rightarrow N' \leq N]\ \&$

$\forall n\ _{a}\leq N$ distributivity

$[\exists p\ [p\ (j)\ \&\ P'(p)\ \&$

$p = \lambda i\ [\exists X\ [{*}egg\ (a)\ (X)\ \&\ sufficient\ (i)\ (X)\ \&\ n = |X|]]]]]]]]$

A possible question denotation is the following:

(26) {{one egg is sufficient, two eggs are sufficient, three eggs are sufficient, ..., m eggs are sufficient},
{two eggs are sufficient, three eggs are sufficient, ..., m eggs re sufficient},
{three eggs are sufficient, ..., m eggs are sufficient}, ...,
{m eggs are sufficient}}

I also discuss strongly exhaustive readings of questions that exhibit QVE. Groenendijk & Stokhof (1993) claim that the sentence

(27) John knows for the most part who called.

has a strongly exhaustive reading that puts restrictions on the number of people about who John incorrectly believes that they called if they in fact did not call. They claim that the above sentence has a reading according to which it is true if John knows for most people that called that they called and if in addition the number of people that did not call and about who John erroneously believes that they called does not outnumber the number of people that called and about who John correctly believes that they called.

Hence the above sentence is true in a situation in which twenty people called and John correctly believes that they called but he also incorrectly believes that some other five people called that actually did not call. However, the sentence is false on a strongly exhaustive reading if twenty people called and if John correctly believes that twenty people called but also incorrectly believes that some other thirty people called who actually did not call. Hence, unlike the strongly exhaustive reading of questions that do not exhibit QVE, the strongly exhaustive reading of questions that exhibit QVE allow for some incorrect beliefs about the negative extension of the question-predicate. G&S's (1993) analysis of QVE runs into a formal error and therefore they do not really account for the above reading. I show that the above reading can be accounted for in a semantics of questions that defines parts of possible, complete answers to questions.

I also argue that predicates that have to do with finding out the truth have a yet stronger strongly exhaustive reading, namely one in which John cannot have any false beliefs about the negative extension of the question. The following sentence:

(28) John found out to a large extent who took bribes.

has a reading according to which it is false if John found out that twenty out of thirty people took bribes but also incorrectly accuses five people of taking bribes that did not take any bribes. This reading is accounted for by ruling out that John has false beliefs about propositions that are atomic parts of possible answers to the question. Unlike Groendijk & Stokhof's (1982) strongly exhaustive de re reading the current analysis accounts for Bromberger's example because the denotation of a question and its negation are not identical:

(29) Feynman knew in 1978 which elementary particles had been discovered in 1978.
≠> Feynman knew in 1978 which elementary particles had not been discovered in 1978.

I also discuss functional readings of questions with quantifiers. I claim that functional readings exhibit uniqueness effects. Answers that specify more than one function are infelicitous even if the functions express the same mapping in the actual world. E.g. even if it is the case that in the actual world the wine in front of every customer is the wine his boss recommended the following is infelicitous:

(30) There is one wine that no customer ordered and John knows which wine no customer ordered, namely the wine his boss recommended (#and the wine in front of him).

In the third chapter I discuss which elements allow pair list readings. Groenendijk and Stokhof (1983) point out that questions with universal terms such as *every* allow pair list readings whereas questions with *no* do not allow pair list readings.

(31) a. which wine did every customer like? pair list

b. which wine did no customer like? no pair list

Srivastav (1992) and Krifka (1992) argue that plural definites do not allow pair list readings:

(32) which movie did the boys watch?

#Al watched Wings of Desire and Bill watched Stranger than Paradise.

Groenendijk and Stokhof (1984), Chierchia (1993) and Dayal (1996) use the notion of witness sets in order to define which quantifiers allow pair list readings.

Since I adopt Pafel's (1999) minimality operator in order to define relevant answers my analysis predicts that not all elements allow pair list readings. This is so because if certain elements outscope the wh-phrase there are no minimal sets of propositions. In particular, if *no* outscopes the wh-phrase the question denotes the empty set of sets of propositions.

Questions with *most* do not allow pair list readings. The question

(33) which wine did most customers order? no pair list

does not have a pair list reading. A semantics of questions that employs the minimality operator in order to account for relevant answers accounts for the fact that questions with *most* do not allow pair list readings if *most* is vague. It does not specify a precise cut-off point. Hence there are no minimal sets of propositions that qualify as elements of the question denotation.

The analysis predicts that questions with universal terms that allow distributive readings allow pair list readings. *Every* and *each* are inherently distributive. Hence they allow pair list readings. Plural definites are not inherently distributive. Hence the availability of pair list readings is restricted. Contra Srivastav (1992) and Krifka (1992) I point out that there are questions with plural definites that allow pair list readings. The following example that was suggested to me by Roger Schwarzschild is a case in point:

(34) which grade the students got depended on which capital they named.

While I do not have a theory that explains why and when plural definites allow a distributive reading the point remains that there are cases in which they allow pair list readings. Hence pair list readings of questions with plural definites are not completely ruled out. Pair list readings of questions with plural definites are also marginally possible if the context makes the distributive reading salient:

(35) During the summer break every boy watched a movie every night.
Oh, really? which movie did the boys watch last night?
Al watched City of Sadness and Bill watched Stranger than Paradise.

Each allows pair list readings whereas *all* and *both* do not allow pair list readings:

(36)	a. which movie did the boys each rent?	pair list
	b. which movie did the boys all rent?	no pair list
	c. which movie did the boys both rent?	no pair list

Again, the difference correlates with the fact that *each* is inherently distributive whereas *all* and *both* are not as Brisson (1998) convincingly argues.

Szabolcsi (1997) claims that only questions embedded under extensional predicates allow pair list readings with non-universal quantifiers. Matrix questions and questions embedded under intensional predicates do not.

(37)	a. John knows which grade two students got in Semantics.	pair list
	b. John wonders which grade two students got in Semantics.	no pair list
	c. which grade did two students get in Semantics?	no pair list

However, questions with numerals allow pair list readings if they are embedded under *wonder* if the numeral contains a pronoun that is coreferent with the matrix subject:

(38)	$John_i$ wonders which grade two of his_i students got in semantics.	pair list

I analyse numerals that allow pair list readings as specific indefinites that translate into choice functions as in Reinhart (1992, 1997) and Winter (1997). The analysis of numerals as specific indefinites offers an explanation why pair list readings are easier to get if the question-embedding predicate is *know* than if it is *wonder*. The predicate *know* is factive. The factivity presupposition seems to facilitate a specific reading of numerals. Predicates such as *wonder* are not factive. The coreferent pronoun facilitates a pair list reading, possibly because it is easier to infer that John has two specific students in mind. Matrix questions with numerals do not allow pair list readings because even if the questioner has two specific students in mind the answerer has no clue which two specific students are under consideration:

(39) which grade did two students get in semantics? no pair list

Numerals that are analysed as specific indefinites act like universal terms. Hence a specific indefinite such as *two customers* can outscope the wh-phrase even if the context specifies that more than two customers ordered some wine:

(40) John knows which wine ten customers ordered and
Peter knows which wine two customers ordered. pair list

Contra Szabolcsi (1997) I claim that questions with modified numerals do not allow pair list readings:

(41) a. Which wine did more than three customers order? no pair list
b. Which wine did less than three customers order? no pair list

The lack of pair list readings is not the only property that distinguishes modified numerals from unmodified numerals. Following Reinhart (1997) I assume that modified numerals cannot translate into choice functions. On a quantificational interpretation they do not allow pair list readings if it is assumed that they are vague, i.e. they do not define a precise cut-off point.

1.2 Previous accounts of simple constituent questions

This section provides a brief review on the literature on the semantics of simple constituent questions. The semantics of questions draws from intuitions about what constitutes an answer to a question, intuitions about embedded questions and intuitions about relations between questions. Using intuitions about embedded questions has the advantage that intuitions about truth conditions and entailment relations of sentences can be used.

1.2.1 Hamblin (1973)

Hamblin's (1973) semantics of questions is based on the intuition that questions denote sets of possible answers. He proposes that questions denote sets of propositions, i.e.

sets of possible answers. [56]

(42) who called?

$\lambda p\ [\exists x\ [\text{person (a) (x)}\ \&\ p = \lambda i\ [\text{call (i) (x)}]]]$

1.2.2 Karttunen (1977)

Karttunen (1977) uses intuitions about embedded questions in order to argue that questions denote sets of true answers. The empirical motivation for assuming that questions denote sets of *true* propositions is the following: Some non-factive predicates license certain entailment relations only when they take questions as arguments. The sentence in (43) shows that factivity is not part of the lexical semantics of the verb *tell*.

(43) John told Mary that Anna called.

$\not\Rightarrow$ Anna called. no factivity

The predicate *tell* licenses the following entailment relations:

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[5] I use Gallin's (1975) TY2 instead of Montague's IL throughout the paper. TY2 is the language of two-sorted type theory which allows abstraction and quantification over worlds. Worlds are of type s, which is a basic type in TY2. Zimmermann (1985) proves that TY2 and IL are equivalent. The major translations from IL to TY2 are the following: In IL predicates do not have a world variable, in TY2 they do. Hence IL-formulas such as pred (x) translates into TY2 formulas of the form pred (i) (x) with i being the world variable. Montague's up-operator ^ translates into abstraction over worlds. Hence $^\wedge\alpha$ translates into $\lambda i\ [\alpha\ (i)]$. Montague's down operator $^\vee$ as in $^\vee\alpha$ translates into α (a). The variable *a* refers to the actual world. If an expression is evaluated with respect to a model the actual world is the world of evaluation.

[6] To be more precise, Hamblin (1973) proposes the following:

i. $\lambda p\ [\exists x\ [p = \lambda i\ [\text{person (a) (x) and call (i) (x)}]]$

(44) John told Mary who called.

Anna called.

$\Rightarrow$ John told Mary that Anna called.

Hence questions embedded under *tell* exhibit factivity effects. In order to account for these factivity effects Karttunen proposes that questions denote sets of true propositions rather than sets of propositions.

(45) who called?

$\lambda p\ [\exists x\ [\text{person (a) (x) \& p (a) \& p} = \lambda i\ [\text{call (i) (x)}]]]$

In Karttunen predicates that take interrogatives and *that*-clauses as complements are semantically ambiguous. E.g $tell_Q$ is of type $\langle\langle s,\langle\langle s,t\rangle,t\rangle\rangle,\langle\langle s,e\rangle,\langle s,e\rangle\rangle\rangle$, i.e it takes question intensions and individual concepts as arguments, wheras $tell_t$ is of type $\langle\langle s,t\rangle,\langle\langle s,e\rangle,\langle s,e\rangle\rangle\rangle$, i.e. it takes propositions and individual concepts as arguments. In order to account for the entailment relation in (44) Karttunen assumes that there is a meaning postulate that relates the meaning of $tell_Q$ to the meaning of $tell_t$. The meaning postulate in (46) states that the $tell_Q$-relation holds between an individual concept and a question intension if the $tell_t$-relation holds between the individual concept and every element of the question extension, see Karttunen (1977:18:fn11):

(46) $\forall x \forall F\, [\delta_{IV/Q}(x,F) \leftrightarrow [\forall p[F\{p\} \rightarrow \delta_t(x,p)]\ \&$

$[\neg\exists q F\{q\} \rightarrow \delta_t(x,{}^\wedge\neg\exists q F\{q\})]]$

where δ is the translation of *tell, know* ...

translation into TY2:

(47) $\forall x \forall F\, [\delta_Q\,(a)\,(x,F) \leftrightarrow [\forall p\,[F\,(a)\,(p) \rightarrow \delta_t\,(a)\,(x,p)]\ \&$

$[\neg\exists q\,[F\,(a)\,(q) \rightarrow \delta_t\,(a)\,(x, \lambda i\,[\neg\exists q\,[F\,(i)\,(q)]])]]]$

where δ is the translation of *tell, know* ...

The variable x is a variable over individual concepts. It is of type <s,e>. *F* is a variable over question intensions. It is of type <s,<<s,t>,t>>. The second conjunct in the meaning postulate states that if the question extension is the empty set of propositions then x stands in the $know_t$-relation to the proposition that the question denotation is the empty set of propositions. Predicates such as *wonder* do not take *that*-clauses as complements:

(48) *John wondered that Mary called.

Therefore they do not exhibit the entailment relation in (44). This is accounted for in Karttunen's analysis because they are not subject to the meaning postulate in (46).

In the following I call question denotations that involve possible answers Hamblin-style question denotations and I call question denotations that involve true answers Karttunen-style question denotations.

1.2.3 Groenendijk & Stokhof (1982)

Groenendijk & Stokhof (1982:179) use intuitions about embedded questions in order to modify Karttunen's analysis. They point out that Karttunen's analysis does not account for the following entailment:

(49) John believes that Bill and Suzy called.
Only Bill called.
⇒ John does not know who called.

Karttunen's (1977) analysis incorrectly predicts that *John knows who called* is true if the two premisses in (49) are true because John knows of everyone who called that s/he called. The fact that John has incorrect beliefs about people who didn't call is irrelevant for Karttunen's analysis of *John knows who called*. In order to account for the inference in (49) G&S (1982:180) propose that *John knows who called* is only true if John knows of everyone who called that s/he called and if he also knows the negative extension of the predicate, i.e if he also knows who didn't call. Thus the sentence *John knows who called* can be paraphrased as *John knows for every individual x whether x called.*

In G&S predicates such as *tell* and *know* are not ambiguous. Question intensions and *that*-clauses denote propositional concepts. Hence both interrogative-embedding *tell* and *that*-clause embedding *tell* are of type <<s,<s,t>>,<<s,e>,<<s,e>>>>, i.e. they take propositional concepts and individual concepts as arguments and no meaning postulate is needed in order to relate question-embedding *tell* and *that*-clause embedding *tell*. However, there is a meaning postulate that accounts for the difference between *tell* and *wonder*, see G&S (1982:194). It applies to predicates such as *tell* and *know* irrespective of whether they take interrogatives or *that*-clauses as complements but it does not apply to *wonder*. It reduces intensional relations between individual concepts and propositional concepts to corresponding extensional relations between individuals and propositions.

(50) $\exists M\ \forall x\ \forall r\ \forall i\ [\delta(i)\ (x,r) = M(i), (x\ (i), r\ (i))]$

M is a variable of type $<s,<<s,t>,<e,t>>>$; x of type $<s,e>$; r of type $<s,<s,t>>$; i of type s; and δ is the translation of *know, tell*, etc.

Thus the extensional version of *tell* takes propositions as argument. [7] G&S account for the factivity effect observed with question-embedding *tell* because in their analysis question extensions denote true propositions:

(51) who called?

$\lambda j\ [\lambda x\ [call\ (a)\ (x)] = \lambda x\ [call\ (j)\ (x)]]$

G&S call predicates such as *know* extensional and predicates such as *wonder* intensional. G&S call the reading that Karttunen's semantics of questions accounts for weakly exhaustive and they call the reading that is accounted for by (51) strongly exhaustive.

[7]Unlike Karttunen's meaning postulate that relates interrogative and *that*-clause embedding *know* the above meaning postulate is needed to account for extensional predicates in any intensional semantics that adopts

G&S (1982:182) point out that both Karttunen's (1977) weakly exhaustive and their strongly exhaustive semantics of questions predict that the following inference holds:

(52) John knows who called.
⇒ John knows which students called.

The conclusion holds since the set of students is a subset of the set of individuals. Hence, if John knows who called he also knows which students called. G&S call the reading under which the conclusion holds de re. However, there is a reading of the question under which the conclusion does not hold. Suppose that only Ann called and that Ann is a student and that John knows that only Ann called but does not believe that Ann is a student. In this situation John knows who called but he does not know which student called. G&S call this the de dicto reading. Under the de dicto reading, *John knows which students called* is also false if John incorrectly believes that student Ann called if student Ann didn't call.[8] G&S's analysis of the de dicto reading also accounts for the fact that the following inference does not hold: (The example is attributed to Sylvain Bromberger.) [9]

Montague's (1970:232) correspondence principle which states that there is a uniform correspondence between (syntactic) categories and semantic types.

[8]G&S's analysis of the de dicto reading predicts that *John knows which students called* is true if Ann is a student that didn't call and if John erroneously believes that Ann is not a student and that Ann called. Thus the de dicto reading is less exhaustive than the strongly exhaustive de re reading but more exhaustive than the weakly exhaustive de re reading. G&S distinguish different degrees of exhaustiveness.

[9]Neither G&S's analysis of the strongly exhaustive reading nor their analysis of the de dicto reading rule out that *John knows which students called* is true if John incorrectly believes of someone who is not a student that this person is a student who called.

(53) Feynman knew in 1978 which elementary particles had been discovered in 1978.

≠> Feynman knew in 1978 which elementary particles had not been discovered in 1978.

The following model distinguishes Karttunen’s (1977) analysis of weakly exhaustive de re readings, G&S’s (1982) analysis of strongly exhaustive de re readings and their analysis of de dicto readings:

(54)

	w1:	w2:	w3:
student:	a,b	a	∅
call:	a	a,b	a

(55) which students called?

a. Karttunen's analysis of weakly exhaustive de re readings:

€λp [∃x [student (a) (x) & p (a) & p = λi [call (i) (x)]]],$^{M, g [w1/a]}$

= {{w1, w2, w3}}

= {a called}

b. G&S's (1982) analysis of strongly exhaustive de re readings:[10]

$€\lambda i\ [\lambda x\ [student\ (a)\ (x)\ \&\ call\ (a)\ (x)] = \lambda x\ [student\ (a)\ (x)\ \&$

$call\ (i)\ (x)]],^{M,g[w1/a]}$

$= \{w1, w3\}$

= a called and b didn't call

c. G&S's (1982) analysis of de dicto readings:[11]

$€\lambda i\ [\lambda x\ [student\ (a)\ (x)\ \&\ call\ (a)\ (x)] = \lambda x\ [student\ (i)\ (x)\ \&$

$call\ (i)\ (x)]],^{M,\ g\ [w1/a]}$

$= \{w1, w2\}$

= student a called and no other student called

The inference in (53) does not hold for G&S's analysis of the de dicto reading. In w1 the question *which students called?* denotes the proposition {w1, w2} and the question *which students didn't call?*denotes the proposition {w1}, i.e. *student b didn't call and no other student didn't call*. Since {w1,w2} is not a subset of {w1} the former does not entail the latter.

(56) which students didn't call?

$\lambda i\ [\lambda x\ [student\ (a)\ (x)\ \&\ \neg\ call\ (a)\ (x)] = \lambda x\ [student\ (i)\ (x)\ \&\ \neg\ call\ (i)\ (x)]]$

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[10]G&S's (1982) strongly exhaustive de re reading predicts that (i) and (ii) are equivalent:

i. which student called?

$\lambda i\ [\lambda x\ [student\ (a)\ (x)\ \&\ call\ (a)\ (x)] = \lambda x\ [student\ (a)\ (x)\ \&\ call\ (i)\ (x)]]$

ii. which student didn't call?

$\lambda i\ [\lambda x\ [student\ (a)\ (x)\ \&\ \neg\ call\ (a)\ (x)] = \lambda x\ [student\ (a)\ (x)\ \&\ \neg\ call\ (i)\ (x)]]\|$

[11]As Heim (1994:136) points out, the de dicto semantics also makes the (unwelcome) prediction that *John knows which students called* and *John knows which callers are students* are equivalent.

Hence, G&S's analysis of the de dicto reading is not strongly exhaustive. The sentence

(57) John knows which students called.

can be true on the de dicto reading if Bill is a student who did not call and John believes that Bill called if John also incorrectly believes that Bill is not a student. Hence John's beliefs about students that did not call are only relevant if John also believes that they are students. However, G&S's analysis of the de dicto reading is not weakly exhaustive like Karttunen's analysis of the de re reading, either. G&S's analysis of the de dicto reading correctly predicts that the above sentence cannot be true if John believes that Bill is a student who called if Bill is a student but did not call.

1.2.4 Lahiri (1991)

Lahiri (1991) uses evidence from embedded questions to argue contra Karttunen (1977) and pro Hamblin (1973) that questions denote sets of possible answers rather than sets of true answers. His evidence is based on non-factive predicates such as *be certain*. The predicate *be certain* - like *tell* - is non-factive if it takes a *that*-clause as complement:

(58) John is certain that Anna called.
≠> Anna called.

Unlike *tell*, the predicate *be certain* does not license the following entailment relation if it takes an interrogative as complement:

(59) John is certain who called.
Anna called.
≠> John is certain that Anna called.

Hence questions embedded under *be certain* do not exhibit factivity effects. Lahiri does not classify *be certain* with *wonder* but with *tell* because *be certain* shares two properties with *tell*, namely it takes *that*-clauses as complements and it allows QVE:

(60) John is certain, for the most part, about which students called.

(61) John told Mary for the most part, which students called.

(60) is true in a situation in which John considers it likely that Ann, Bill and Chris called and he is certain that Ann and Bill called. (61) is true in a situation in which Ann, Bill and Chris called and John told Mary that Ann and Bill called. Thus there are two properties that *be certain* shares with *tell*: Both take *that*-clauses and interrogatives as complements and both allow QVE. These two properties distinguish *be certain* from predicates such as *wonder*. The predicate *wonder* neither takes *that*-clauses as complements nor does it exhibit QVE:

(62) a. #John wonders that Mary came.

b. #John wonders, for the most part, which students called.

The sentence in (62b) does not have a reading in which John wonders for most students that called whether they called. The only property that *wonder* and *be certain* share is that there are no factivity effects if they embed for a question.

Lahiri (1991) assumes that *know* takes arguments of type <s,t> and that *wonder* takes arguments of type <<s,t>,t>. <<s,t>,t> is also the basic type of question denotations. <s,t> is derived by an answerhood operator.

The following chart summarizes the properties of question embedding predicates:

(63)

	factivity:	no factivity:
QVE, *that*-clauses:	know, tell	be certain
no QVE, no *that*-clauses:	----	wonder

Lahiri (1991) does not provide an analysis of the factivity effects of questions embedded under *tell*. Lahiri (to appear) assumes that the lexical properties of question-embedding *tell* are such that they account for the observed factivity effects.

In the following I adopt a Hamblin-style semantics of questions, i.e. I assume that questions involve possible answers rather than true answers. I also restrict myself to de re readings. Exhaustiveness of questions in QVE contexts is discussed in section 2.4.

1.3 Previous accounts of questions with quantifiers

1.3.1 Functional versus quantificational analysis of pair list answers

It is well known that questions with quantifiers allow different kinds of answers, namely individual, functional and pair list answers. However, this by itself is not a reason to assume that questions with quantifiers have different readings. E.g. Engdahl (1980, 1986) proposes a functional analysis of questions with quantifiers that accounts for all three types of answers. Groenendijk & Stokhof (1983, 1984) are the first to claim that questions with quantifiers have three different readings. Their major argument for distinguishing functional and pair list readings is that pair list readings are restricted to certain quantifiers whereas functional readings are not. They assume that in pair list readings the quantifier outscopes the wh-phrase. However, they do not provide any arguments against a functional analysis of pair list readings. Therefore Chierchia (1991, 1993) is able to go back to a functional analysis of pair list readings. He also distinguishes functional and pair list readings because pair list readings are restricted to certain quantifiers. However, he points out that functional and pair list readings have in common that they exhibit subject-object asymmetries. His functional analysis of pair list readings analyses subject-object asymmetries as WCO-effects. I adopt a quantificational analysis of pair list readings, mainly in order to adopt a uniform treatment of quantifiers such as *every*. In my analysis *every* translates into a universal quantifier, irrespective of whether it occurs in a question with a pair list reading or in some other type of sentence. In

Chierchia (1993) *every* does not translate into a universal quantifier if it is part of a question with a pair list reading. A quantificational analysis does not account for subject-object asymmetries. However, there is evidence that the subject-object asymmetries of pair list readings are not WCO-effects. German for example does not exhibit WCO-effects but pair list readings exhibit subject-object asymmetries.

1.3.1.1 Functional analysis of pair list answers (Engdahl 1980, 1986)

Engdahl (1980, 1986:10) notices that questions with quantifiers allow three types of answers, namely individual answers, functional answers[12] and pair list answers.

(64) which wine did every customer order?

a. Chardonnay (individual)

b. his favorite wine (functional)

c. Ann ordered Chardonnay, Bill ordered Shiraz and Chris ordered Merlot. (pair list)

The fact that questions with quantifiers allow different types of answers does not mean that questions with quantifiers have different readings. Engdahl (1986:177) points out that there is one interpretation of the question in (64) that accounts for all three answers, namely the one in which wh-phrases introduce existential quantification over functions. Engdahl adopts a Karttunen-style semantics of questions in which questions denote sets

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[12]Engdahl (1986:11) calls functional answers relational.

of true propositions. f^n is an n-ary function from n individual concepts into individual concepts: <(<s,e>, ... <s,e>), <s,e>>.[13] z and x are variables of type <s,e>.

(65) which wine did every customer order?

$$\lambda p\ [\exists f^n\ [\forall z\ [wine\ (f\ (z))]\ \&\ p\ (a)\ \&$$
$$p = \lambda i\ [\forall x\ [customer\ (x) \rightarrow order\ (i)\ (x\ (i),\ f\ (i)(x))]]]]$$

If n = 0, f^0 is a function of type <s,e>. If f^0 is a constant function it accounts for individual answers. E.g. if f^0 maps every world into Chardonnay then the individual answer is Chardonnay. f^1 is of type <<s,e>,<s,e>>. If f^1 maps the individual concept *x is customer in s* into x's favorite wine in s it accounts for the functional answer *his favorite wine*. Engdahl (1986) assumes that pair list answers are a spell out of the members of a function f^1 in the actual world a. Thus if in a Charles' favorite wine is Chardonnay, Chynthia's favorite wine is Shiraz and Claude's favorite wine is Merlot we get the pair list answer.[14]

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[13]Engdahl (1986:177) simplifies and says that f is of type <e,e> but in the expressions that she provides they are of type <<s,e>,<s,e>>. In footnote 11, page 253, she points out this simplification in the text and provides an argument why the first argument of f is of type <s,e>. NPs like *the mayor of Boston* crucially involve individual concepts:

i. The mayor of Boston used the city revenue to gamble.
What did every other mayor use?

Engdahl (1986) adopts Montague's correspondence principle and assumes that the arguments of the function are of the highest possible type. Engdahl (1986:240) also discusses wh-phrases in opaque contexts as in:

i. what is John looking for?

She adopts Carlson's (1977) analysis of bare plurals for NPs in opaque contexts. Carlson's bare plurals denote kinds. Kinds are of type e.

[14]Since there is a potentially infinite number of functions that characterize the answer to a question the question denotation is a potentially infinite set of propositions. In order to avoid question denotations with an infinite number of elements Engdahl (1986:180) makes the common assumption that the domain of quantification is contextually restricted.

Summing up, Engdahl's (1986) argument for a functional analysis of pair list answers is based on Occam's razor: Under the assumption that every question with a quantifier allows all three types of answers an analysis in which all three types of answers are derived from a single translation of the question is preferrable over an analysis in which the three types of answers correspond to different translations of the question.

1.3.1.2 Quantificational analysis of pair list readings (Groenendijk & Stokhof 1983, 1984)

Groenendijk & Stokhof (1983, 1984:177) argue that functional, pair-list and individual answers correspond to three different readings of the question because they do not have the same distribution. G&S's major argument for disitnguishing functional and pair list readings is that questions with quantifiers such as *no* allow functional answers but they do not allow pair list answers.

(66) which woman does no Englishman love?

a) #John loves Mary and Peter loves Sue.

b) his mother.

Hence functional answers and pair list answers do not have the same distribution.

G&S's argument for distinguishing individual readings and pair list readings is not very convincing. It runs as follows: if the quantifier binds a possessive pronoun in the wh-phrase pair list answers are licit but individual answers are not licit (G&S 1983, 168):

(67) which of his relatives does every man love?

a) #Mary.

b) John loves (his wife) Mary, Bill loves (his sister) Suzy, ...

In my opinion (67) does not have an individual answer not because of grammatical constraints but because an individual answer is in conflict with our knowledge of the world. In our world there is no woman that is a relative of every man in the world. G&S themselves point out in fn 2 (p. 168) that question (67) allows an individual answer if it is slightly modified as in (68).

(68) which of his (blood-)relatives does every man (in our family) love?

Aunt Mary.

G&S (1983, 1984) adopt a quantificational analysis of pair list readings which means that in pair list readings the quantifier outscopes the wh-phrase. They distinguish three translations for questions with quantifiers. G&S assume that f is of type <e,e>.

(69) which wine did every customer order?

a. individual reading:

$\lambda i\ [\lambda x\ [wine\ (a)\ (x)\ \&\ \forall y\ [customer\ (a)\ (y) \rightarrow order\ (a)\ (y,x)]] =$

$\lambda x\ [wine\ (i)\ (x)\ \&\ \forall y\ [customer\ (i)\ (y) \rightarrow order\ (i)\ (y,x)]]]$

b. functional reading:

$\lambda i\ [\lambda f\ [\forall x\ [wine\ (a)\ (f\ (x))]\ \&\ \forall x\ [customer\ (a)\ (x) \rightarrow order\ (a)\ (x, f\ (x))]] =$

$\lambda f\ [\forall x\ [wine\ (i)\ (f\ (x))]\ \&\ \forall x\ [customer\ (i)\ (x) \rightarrow order\ (i)\ (x, f\ (x))]]]$

c. pair list reading:

$\lambda i\ [\forall y\ [customer\ (a)\ (y) \rightarrow [\lambda x\ [wine\ (a)\ (x)\ \&\ order\ (a)\ (y, x)] =$

$\lambda x\ [wine\ (i)\ (x)\ \&\ order\ (i)\ (y, x)]]]]$

discussion:

A minor technical point[15] is that G&S's (1983, 1984) analysis of functional readings does not account for functional answers because the function does not take any world indices as argument. In a model with two customers, John and Paul, and two wines, Chardonnay and Shiraz, and assuming that in the actual world Chardonnay is John's favorite wine and Shiraz is Paul's favorite wine and every customer ordered his favorite wine, G&S's functional reading denotes the set of worlds in which John ordered Chardonnay and Paul ordered Shiraz, even if in the non-actual worlds Chardonnay is not John's favorite wine and Shiraz is not Paul's favorite wine. Hence the propositions denoted by the question do not express the functional answer *his favorite wine*. Functional answers are accounted for if the functions f take a world variable as argument. Then there is a function f (i) (x) that denotes the favorite wine of x at i.[16]

(70) which wine did every customer order?

a) his favorite wine.

b) $\lambda i\ [\lambda f\ [\forall x\ [wine\ (a)\ (f\ (a)\ (x))]\ \&$

$\forall x\ [customer\ (a)\ (x) \rightarrow order\ (a)\ (x, f\ (a)\ (x))]]$

$= \lambda f\ [\forall x\ [wine\ (i)\ (f\ (i)\ (x))]\ \&$

$\forall x\ [customer\ (i)\ (x) \rightarrow order\ (i)\ (x, f\ (i)\ (x))]]]$

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[15]This problem has been pointed out to me by Roger Schwarzschild.

[16]If one adopts the correspondence principle then functions are of type <<s,e>,<s,e>> as in Engdahl (1986) and x is of type <s,e>:

Summary: G&S provide an argument for distinguishing pair list readings and functional readings but they do not provide an argument for distinguishing pair list readings and individual readings. Hence individual readings could be a special instance of a pair list reading, namely they arise if every customer ordered the same wine.

Chierchia (1991, 1993) provides an argument for distinguishing pair list readings and individual readings. He claims that the former exhibits subject-object asymmetries, the latter does not. If the wh-phrase is the subject and the quantifier is the object as in (71) an individual answer is possible but a pair list answer is not possible:

(71) which woman likes every man?

a) Mary.

b) #Mary likes John and Sue likes Peter.

1.3.1.3 Back to a functional analysis of pair list readings (Chierchia 1991, 1993)

Chierchia's main point is that even though pair list readings and functional readings have to be distinguished because pair list readings are restricted to certain quantifiers whereas functional readings are not, they have in common that they both exhibit subject-object asymmetries.

Functional and pair list answers have in common that they are possible if the wh-phrase is the object and the quantifier is the subject as in (72).

---

i. $\lambda i\ [\lambda f\ [\forall x\ [wine\ (a)\ (f\ (x)\ (a))]\ \&\ \forall x\ [patron\ (a)\ (x\ (a)) \rightarrow order\ (a)\ (x\ (a),\ f\ (x)(a))]]] =$
$\lambda f\ [\forall x\ [wine\ (i)\ (f\ (x)\ (i))]\ \&\ \forall x\ [patron\ (i)\ (x\ (i)) \rightarrow order\ (i)\ (x\ (i),\ f\ (x)\ (i))]]]]$

(72) which woman does every man like?

a) John likes Mary and Peter likes Sue.

b) his mother.

Functional and pair list answers are not available if the wh-phrase is the subject and the quantifier is the object as in (73).

(73) which woman likes every man?

a) #Mary likes John and Sue likes Peter.

b) #his mother.

In Chierchia (1991, 1993) the subject object asymmetries of functional and pair list answers as in (73) are analysed as weak crossover effects. Weak crossover effects arise if a quantifier moves 'across' a coindexed pronoun. Thus in the following declarative clauses neither *every* nor *which* can bind the pronoun *his*:

(74) his mother visited every patient.

LF: $[_{IP}$[every patient]$_i$ [his$_i$ mother visited t$_i$]]

↑___________x____________|

(75) which patient did his mother visit?

$[_{CP}$[which patient]$_i$ [did his$_i$ mother visit t$_i$]]

↑____________x___________|

The lack of functional and pair list answers is accounted for if wh-phrases in functional and pair list readings leave a functional trace.[17] In (76) *every man* moves across a coindexed element, namely the functional trace e_i^j.

(76) which woman likes every man?

[[which woman]$_i$ [$_{IP}$[every man]$_j$ [e_i^j like e_j]]]

↑__________x_____|

Individual answers as in

(77) which customer liked every wine?

a) Bill

[[which customer]$_i$ [$_{IP}$[every wine]$_j$ t_i like t_j]]

↑_____________|

do not exhibit subject-object asymmetries. Hence not all wh-phrases leave functional traces. Chierchia's (1993) analysis ensures that the wh-phrase in pair list readings leaves a functional trace. This is so because pair list readings are the result of absorption. The rule that assigns a translation to the absorbed structure ensures that the trace of the wh-phrase is interpreted functionally:

[17]There are several accounts of WCO-effects. Chierchia does not commit himself to any particular analysis.

(78) absorption: (Chierchia 1993:210)

$[\text{wh } N_i\ [NP_j\ S]] \Rightarrow [[\text{wh } N_i\ NP_j]\ S]$

(79) translation rule:

$\text{wh } N_i + NP_j + S \Rightarrow \lambda P\, \exists X\, [W(NP_j, X)\ \&\ P\, (\lambda p\, [\exists f_i \in [X \rightarrow N]$

$\exists x_i \in X\, [p = {}^\wedge S]])]$

The pair list reading of the following question translates into the following expression where A is the minimal non-empty witness set[18] of *every student*.

(80) which professor did every student like?

$[[[\text{which professor}]_j\ [\text{every student}]_i]\ [t_i \text{ like } t^i_j]]$

$\lambda P\, \exists A\, [W\, (\text{every student}, A)\ \&$

$P\, (\lambda p\, [\exists f \in [A \rightarrow \text{professor}\ (a)]\ \exists x \in A\, [p = \lambda i\, [\text{like}\ (i)\ (x, f\ (x)]]])$

The absorption operation has the effect that the quantifier is a sister of the wh-phrase. Hence Chierchia's analysis of pair list readings shares with quantificational analyses of pair list readings that the universal quantifier is interpreted outside of S (=IP). This accounts for QVE of pair list answers as in:

(81) John knows for the most part which professors every student liked.

---

[18]See section 2.1.4 for a definition of minimal witness sets.

The question denotation contains at least one proposition for each student because the translation of *every student* is not part of the definition of the propositions p. A possible question denotation for (80) is the following:

(82) {{{{s1 likes p1, s1 likes p2, s2 likes p1, s2 likes p2, s3 likes p1, s3 likes p2}}}}

Functional readings do not exhibit QVE. This can be seen with questions with *no*. Since *no* does not allow pair list readings the following sentence is infelicitous:

(83) #John knows for the most part which professor no student liked.

Chierchia's (1993) analysis accounts for the lack of QVE of functional readings by assuming that in functional readings the non-wh quantifier is interpreted inside IP. Hence the maximal true answer to the question does not have any proper parts and the lack of QVE is accounted for:[19]

[19]Chierchia's (1991, 1993) functions have to be of type <<s,e>,<s,e>> rather than of type <e,e> in order to account for functional readings in opaque contexts:

i. which woman do you believe that every Englishman likes?

$\lambda P\ P\ (\lambda p\ [\exists f\ [\forall x\ [woman\ (a)\ (f\ (x)\ (a))]\ \&\ p = \lambda i\ [\forall y\ [Englishman\ (i)\ (y\ (i)) \rightarrow like\ (i)\ (y\ (i), f\ (y)\ (i))]]]])$

(84) which professor does every student like?

$[[\text{which professor}]_j\ [[\text{every student}]_i\ [t_i \text{ like } t_j^i]]]$

$\lambda P\ P\ (\lambda p\ [\exists f\ [\forall x\ [\text{professor (a) (f (x))}]\ \&\ p = \lambda i\ [\forall y\ [\text{student (i) (y)} \rightarrow$

$\text{like (i) (y, f (y))}]]]]])$

{{{{every student likes his/her advisor, every student likes his/her favorite professor, every student likes his/her math teacher}}}}

Thus, Chierchia (1993) - unlike Engdahl (1980, 1986) - does not assume that pair list answers are a spell out of functional answers. Functional readings and pair list readings only have in common that they leave a functional trace.

discussion:

Chierchia's (1993) functional analysis of pair list readings assumes that subject-object asymmetries of questions with quantifiers are WCO-effects. However, there are languages that exhibit subject-object asymmetries in pair list readings of questions with quantifiers but they do not exhibit WCO-effects. German is such a language. In German pair list readings exhibit subject-object asymmetries but the following binding is possible, see Chierchia (1993:223fn32):

(85) Jeden Mann_1 mag seine_1 Mutter.
every man-acc_1 likes his_1 mother-nom
'every man_1 is liked by his_1 mother'.
Jeden Mann_1 mag seine_1 Mutter t_1.

Hence the claim that subject-object asymmetries are an instance of WCO-effects is considerably weakened. I adopt a quantificational analysis of pair list readings and leave it to future research to provide an analysis of the subject-object asymmetries of pair list readings and functional readings.

1.3.1.4 Back to a quantificational analysis of pair list readings

I adopt a quantificational analysis of pair list readings in which the universal quantifier outscopes the wh-phrase because it allows for a uniform treatment of quantifiers such as *every*. In my analysis *every* translates into a universal quantifier independent of whether it occurs in a question with a pair list reading or in some other type of sentence. I adopt Fox's (2000) theory of QR according to which quantifiers can adjoin to CP [+wh]. Fox (2000) assumes that quantifiers can adjoin to CP if there is an operator in CP. This is the case if CP is [+wh]. This is motivated by the fact that quantifiers in embedded questions can take matrix scope whereas quantifiers in *that*-clauses cannot:[20]

[20]This contrast is discussed in Moltmann and Szabolcsi (1994). They do not assume that the quantifier moves out of CP. Instead they assume that questions denote generalized quantifiers over questions:
i. [which book every boy $\text{needed}]_1$ [some librarian or other found out t_1]

(86) Some librarian or other found out which book every boy needed.

$\exists < \forall$, $\forall < \exists$

(87) Some librarian or other found out that every boy needed help.

$\exists < \forall$; $*\forall < \exists$

This sentence has a reading according to which it is true if for every student there is some librarian who knows which book the student needs. Fox’s theory predicts that quantifiers can adjoin to CP and use it as an escape hatch for movement out of CP if there is an operator in C. This is the case if CP is +wh.

The quantificational analysis of pair list readings makes the prediction that questions with quantifiers have four readings: If the wh-phrase outscopes the quantifier there are two readings: if the wh-phrase introduces quantification over individuals we get the individual reading and if the wh-phrase introduces quantification over functions we get the functional reading. Likewise, if the quantifier outscopes the wh-phrase there are also two readings. If the wh-phrase is interpreted individually we get the pair list reading and if the wh-phrase is interpreted functionally we get a functional pair list reading in which functions vary with e.g. customers. Consider the following sentence:[21]

$\lambda R\ \forall x[\text{ boy } (x) \rightarrow R \text{ (which book y [x needs y])}]\ (\lambda Q \text{ [found-out (j, Q)]})$

An argument in favor of their analysis is that the embedded quantifier cannot bind a pronoun in the matrix clause:

ii. More than one librarian$_1$ found out which book every boy stole from her$_1$.

*for every boy, there is more than one librarian who found out which book he stole from her.

Fox (2000:64 fn 52) points out that the same contrast emerges in:

iii. A girl expected every boy to come to the party. $\exists < \forall$, $\forall < \exists$

A girl$_i$ expected every boy to come to her$_i$ party. $\exists < \forall$, $*\forall < \exists$

An extension of M&S's (1994) analysis to these cases seems extremely implausible.

[21]Another example was suggested to me by Roger Schwarzschild:

i. The fortune teller predicted/told us which of our children each of us would like best.

(88) John predicted which wine every customer would order.

If the customers are Ann, Bill and Chris and if John predicted that Ann would order her favorite wine, Bill would order the wine his best friend recommended and Chris would order the wine her colleague recommended then the sentence is true even if if John does not know which wine Ann's favorite wine is or which wine Bill's best friend recommended or which wine Chris' colleague recommended. [22]

In the next two chapters I propose an analysis which - like Chierchia's (1993) analysis - links the fact that pair list answers are restricted to certain quantifiers and exhibit QVE and the fact that functional readings are not restricted to certain quantifiers and do not exhibit QVE to different scope relations.

John - his first child,
Mary - her oldest girl.

[22]Engdahl (1986) accounts for functional pair list answers because her functions are of type <<s,e>,<s,e>>, i.e. they map individual concepts into individual concepts. Chierchia (1993) also accounts for the above reading if functions are of type <<s,e>,<s,e>>.

(89) Summary of the data:

scope relations:	wh-phrase:	reading:	properties:
wh-phrase < quantifier	individual	individual	no restriction to certain quantifiers no QVE if wh-phrase is singular
wh-phrase < quantifier	functional	functional	no restriction to certain quantifiers no QVE if wh-phrase is singular
quantifier < wh-phrase	individual	individual pair list	restriction to certain quantifiers QVE if wh-phrase is singular
quantifier < wh-phrase	functional	functional pair list	restriction to certain quantifiers QVE if wh-phrase is singular

1.3.1.5 Quantifying into questions

The next step is to develop a semantics of questions in which the quantifier outscopes the wh-phrase. Since quantifiers are of type $<\alpha, t>$ it is not possible to quantify in a question of type $<s,<s,t>>$. Karttunen (1977:31, fn 15) points out that quantifying in a subexpression of type t of a question meaning of type $<s,<s,t>>$ yields the correct types but does not account for the meaning of pair list readings:

(90) a. which boy did every dog bite?

b. $\lambda p\ [\forall x\ [dog\ (a)\ (x) \rightarrow \exists y\ [boy\ (a)\ (y)\ \&\ p\ (a)\ \&\ p = \lambda i\ [bite\ (i)\ (x, y)]]]$

The expression in (90b) is inappropriate as a translation of the question in (90a) because in any world in which there is more than one dog the expression in (90b) denotes the empty set of propositions. Karttunen (1977) adopts quantification in a superexpression of the question denotation in order to account for pair list readings. He assumes that direct questions are analysed as complements of silent performative verbs and that the universal quantifier quantifies in the matrix clause. This is called the performative hypothesis.

(91) I ask which boy every dog bit.

$\forall x\ [dog\ (a)\ (x) \rightarrow ask\ (I, \lambda p\ [\exists y\ [boy\ (a)\ (y)\ \&\ p\ (a)\ \&\ p = \lambda i\ [bite\ (i)\ (x, y)]]])]$

However, the performative hypothesis does not account for pair list readings of embedded questions, e.g. the embedded question in (92) has a pair list reading but it cannot be embedded under a performative verb:

(92) which grade every student got depended on how well they did on the final.

Groenendijk & Stokhof's (1983, 1984) quantify into a subexpression of type t of the question meaning of type <s,t> in order to account for pair list readings:

(93) which boy did every dog bite?

$\lambda i\ [\forall x\ [dog\ (a)\ (x) \rightarrow [\lambda y\ [boy\ (a)\ (y)\ \&\ bite\ (a)\ (x,y)] = \lambda y\ [boy\ (i)\ (y)\ \&\ bite\ (i)\ (x,y)]]]]$

I do not adopt G&S's (1983, 1984) analysis of pair list readings because it does not account for quantificational variability effects of questions with quantifiers, see section 2.1.3.

Szabolcsi (1997:314)[23] - drawing on Hendriks' (1993) technique to generate extraclausal scope - points out that question denotations of higher types than <<s,t>,t> allow to quantify into a subexpression of type t of the question denotation without running into the problems that Karttunen's (1977) proposals face:

(94) which boy did every dog bite?

$\lambda P\ [\forall x\ [dog\ (a)\ (x) \rightarrow P\ (\lambda p\ [\exists y\ [boy\ (a)\ (y)\ \&\ p\ (a)\ \&\ p = \lambda i\ [bite\ (i)\ (x,\ y)]]]])]]$

The question denotation is of type <<<<s,t>,t>,t>,t> and the expression P (λp [$\exists$y [boy (a) (y) & p (a) & p = λi [bite (i) (x, y)]]]]) is of type t. In chapter two we will see that questions of higher types are independently needed in order to account for QVE. However, the above Karttunen-style question denotation does not account for questions embedded under *be certain*, the singular-plural distinction of wh-phrases and the fact that

[23]Szabolcsi (1997) adopts G&S's (1984) analysis of questions with quantifiers instead of the above analysis for reasons that have to do with her claim that questions embedded under extensional predicates are different than matrix questions and questions embedded under intensional predicates. See section 3.1.5 for a discussion of her claims.

pair list readings are restricted to certain quantifiers. In the next chapter I develop a Hamblin-style semantics of questions that accounts for all of the above phenomena.[24]

[24]Karttunen & Peters (1980) point out that quantifying into super- or subexpressions of yes-no questions makes the incorrect prediction that (i) has a reading on which it is equivalent to (ii):

i. Does John love everybody?

ii. Who does John love?

Fox's (2000) semantically driven QR does not rule out quantification into yes-no questions either because the two structures have two different interpretations. Hence, - like G&S (1983, 1984) and Szabolcsi (1997) - I have to leave this problem unresolved.

2. Chapter: Quantificational Variability Effects (QVE)

In the first part of this chapter I discuss the singular-plural distinction of wh-phrases and QVE of questions with quantifiers and simple constituent questions. I start by discussing previous accounts of QVE such as Berman (1991), Lahiri (1991), Chierchia (1993), Groenendijk & Stokhof (1993), Lahiri (2000, to appear) and Pafel (1999) and then present my own analysis. In later sections I discuss degree questions, strongly exhaustive readings of questions that exhibit QVE and uniqueness effects of functional readings.

2.1 Previous accounts of quantificational variability effects

2.1.1 QVE as unselective binding of variables (Berman 1991)

Berman (1991) provides the earliest account of QVE. His analysis accounts for the singular-plural distinction of wh-phrases in simple constituent questions but it does not account for all quantificationally variable readings of questions with pair list readings. Berman (1991) observes that wh-phrases adopt the quantificational force of adverbs of quantification. [25]

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[25] Berman (1991: 172ff) observes that one difference between indefinites and wh-phrases is that indefinites adopt the quantificational force of same-clause adverbial quantifiers whereas wh-phrases only adopt the quantificational force of adverbial quantifiers that modify a superordinate clause:

i.	Rich people often eat at Maxim's.	QVE	(=111)
ii.	which people often eat at maxim's?	no QVE	(=112)
iii.	John often knows which people eat at Maxim's.	QVE	

(95) The principal usually finds out which students cheat on the final exam. (=25a)

For most students who cheat on the final exam the principal finds out of them that they cheat on the final exam.

They share this property with indefinites, see Lewis (1972), Heim (1982):

(96) Riders on the Thirteenth Avenue line seldom find seats.

For few riders on the Thirteenth Avenue line is there a seat that they each find (when they ride on the Thirteenth Avenue line).

Berman adopts Heim's (1982) non-quantificational analysis of indefinites for wh-phrases in order to account for quantificational variability effects (QVE). He proposes that wh-phrases do not have any quantificational force of their own. They introduce free variables. The resulting question denotation is an open proposition with an unbound variable. QVE emerges because the adverb of quantification unselectively binds the variable that is introduced by the wh-phrase. The question denotation restricts the adverb of quantification if the question denotation is presupposed. E.g. the following sentence exhibits QVE because the adverb of quantification unselectively binds the variable x which is part of the translation of the wh-phrase. The open proposition λi *[call (i) (x)]* is

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Berman assumes that wh-phrases are not in the scope of same-clause sentential adverbs because they move to a syntactic position that c-commands the sentential adverb. Indefinites on the other hand are c-commanded by the sentential adverb.

accomodated into the restriction of the adverb of quantification because *know* carries a factivity presupposition.[26]

(97) John knows for the most part who called.

$most_x$ (λi [call (i) (x)], know (a) (j, λi [call (i) (x)])

Predicates such as *wonder* do not exhibit QVE:

(98) The principal seldom wonders which classes a student enrolls in. (=138)

Predicates such as *wonder* do not project any presuppositions. Hence the question denotation is not accomodated into the restriction of the adverb of quantification. In order to prevent the adverb of quantification from unselectively binding the free variable that is introduced by the wh-phrase Berman assumes that predicates such as *wonder* s-select for a Q-operator. The Q-operator takes open propositions as arguments and denotes a set of (closed) propositions in which all free variables are bound and which corresponds to a Hamblin-question denotation (Berman 1991:226):[27]

(99) €Q ϕ,^{M,g} = {p: $\exists$(x_1 ... x_n) [p = €ϕ,$^{M,g'}$]}, where g' $=_\phi$ g.

---

[26]Berman (1991) does not provide the actual translation of the sentence. He only says that he adopts a Hintikka-style semantics in which questions have the same type as declaratives, namely they denote propositions, and he uses semi-logical paraphrases.

[27]More precisely this should be:

Berman (1991:249ff) notes that simple constituent questions only exhibit QVE if the wh-phrase is plural and not if the wh-phrase is singular:

(100) a. The maitre d' seldom knows which customers of Maxim's are rich. (=152a,b)

b. The maitre d' seldom knows which customer of Maxim's is rich.

Berman (191:248ff) adopts Heim's (1982) analysis of definites for wh-phrases. In Heim definites presuppose their descriptive content. In order to account for the singular-plural distinction Berman assumes that singular wh-phrases carry a uniqueness presupposition. Berman also assumes that quantifiers such as *seldom* presuppose 'more than one'. Hence there is a clash of presuppositions if only one entity satisfies the descriptive content of the wh-phrase and the lack of QVE in (100b) is accounted for.

QVE of pair list readings

Berman (1991:244) observes that questions with pair list readings exhibit QVE:

(101) John mostly knows which wines every customer ordered. (=150)

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i. €Q $\phi,^{M,g}$ = {p: there exist d_1, ..., $d_n \in D_e$ such that p = €$\phi,^{M,g[d1/x1, ... ,dn/xn]}$}.

Berman (1991:237ff) adopts a functional analysis of pair list readings. Wh-phrases introduce free variables over functions f that are unselectively bound by adverbs of quantification: [28]

(102) John mostly knows which wines every customer ordered. (=150)

$$\mathrm{MOST}_f\ [\forall z\ [\text{wine (a) (f (a) (z))}]\ \&$$
$$\forall x\ [\text{customer (a) (x)} \rightarrow \text{order (a) (x, f (a) (x))}]]$$
$$[\ \text{know(j,}\ [\forall z\ [\text{wine (a) (f (a) (z))}]\ \&$$
$$\forall x\ [\text{customer (a) (x)} \rightarrow \text{order (a) (x, f (a) (x))}]])]$$

The translation in (102) predicts that (102) is true if it is the case that John knows most functions f from customers into wines such that every customer x ordered f (x). As Berman (1991:245) points out, this is the case in the following situation: each customer ordered all of the following: his favorite wine, the wine his best friend recommended, and the wine he saw advertised in the paper this morning, but John only knows that every customer ordered his favorite wine and the wine his best friend recommended.

discussion:

Berman's analysis faces several problems. Some of them have been pointed out by Lahiri

[28]Berman does not adopt a quantificational analysis of pair list readings in which the non-wh-quantifier outscopes the wh-phrase because he has established as a rule that wh-phrases outscope same-clause quantifiers in order to account for the fact that same-clause adverbs cannot unselectively bind the translations of wh-phrases. In the following sentence *seldom* cannot quantify over callers:

i. John knows who seldom called.
#For few people that called John knows that they called.

(1991) and Lahiri (to appear). Lahiri (1991) points out that Berman's analysis does not account for non-distributive readings of question-embedding predicates such as *be surprising*. The following sentence

(103) It is surprising who came to the party.

is true if Bill and Mary came to the party and if it is surprising that Bill and Mary came to the party together (because they normally avoid each other) but it is not surprising that Bill came to the party (because he is a party animal) and it is not surprising that Mary came to the party (because she is also a party animal). Berman's analysis of QVE does not account for the non-distributive reading. Berman's analysis only accounts for the distributive reading. It predicts that the sentence is true if Mary and Bill came to the party and it is surprising that Mary came to the party and it is surprising that Bill came to the party:

(104) It is surprising who came to the party.
all_x [x came to party] [it is surprising that x came to the party]

In order to account for non-distributive readings Lahiri (1991) assumes that QVE involves quantification over parts of propositions that constitute possible answers to the question.

Lahiri (to appear:259ff) points out that Berman's analysis also does not account for semi-distributive readings which arise if the subject of the question-embedding predicate is plural.

(105) The witnesses know which Klansmen were present at the lynching.

Lahiri points out that the above sentence has not only a distributive reading according to which it is true if each witness knows which Klansmen were present at the lynching but that the above sentence also has a semi-distributive reading according to which it is true in a situation in which John, Bill and Mary are the witnesses in question and Jeremiah, Bubba and Zachariah are the Klansmen that were present at the lynching and John knows that Jeremiah and Bubba were present at the lynching and Bill knows that Jeremiah was present at the lynching and Mary knows that Bubba and Zachariah were present at the lynching. If questions are interpreted as open propositions as in Berman (1991) the semi-distributive reading is not accounted for:

(106) all_x [x is a Klansman and x was present at the lynching] [the witnesses know that x is a Klansman and that x was present at the lynching]

If questions denote plural propositions as proposed by Lahiri (1991) the semi-distributive reading can be accounted for. Lahiri (to appear) adopts Schwarzschild's (1996) theory of distributivity in order to account for semi-distributive readings. He also points out that if the complement of *know* is a *that*-clause instead of an interrogative, the sentence does not have a semi-distributive reading. The sentence

(107) The witnesses know that the Klansmen were present at the lynching.

is not true if John knows that Jeremiah and Bubba were present at the lynching and Mary knows that Bubba and Zachariah were present at the lynching. This is predicted by Lahiri's analysis because *that*-clauses do not denote plural propositons.

Another problem for Berman's (1991) analysis has to do with QVE. Berman's analysis does not account for all quantificationally variable readings of questions with quantifiers. Berman (1991:247 fn3) himself points out that the sentence

(108) John knows for the most part which wines every customer ordered.

is true if John knows for most customers which wines they ordered and that his analysis does not account for this reading because in his analysis the adverb of quantification quantifies over functions from customers into wines and not over customers. If the wh-phrase is singular as in

(109) John knows for the most part which wine every customer ordered.

the sentence has only one reading, namely the one in which the adverb of quantification quantifies over customers. The above sentence is true if John knows for most customers which wine they ordered. Again, unselective binding of the functions that are introduced by the wh-phrase does not account for this reading.

2.1.2 QVE as quantification over plural propositions (Lahiri 1991, 2000, to appear)

Lahiri (1991, 2000, to appear) assumes the QVE of embedded questions involves quantification over plural propositions. His analysis does not account for uniqueness effects of singular wh-phrases. E.g. the sentence

(110) John knows which student called.

presupposes that there is a unique student that called. In Lahiri the above sentence is true if twenty students called and John knows of all twenty students that they called.

Let's see why Lahiri does not account for uniqueness effects of singular wh-phrases. Lahiri (1991, 200, to appear) adopts a Hamblin-style semantics of questions in which questions denote sets of possible answers. Hence questions with singular wh-phrases have the following denotation:

(111) which student called?

$\lambda p\ [\exists x\ [student\ (a)\ (x)\ \&\ p = \lambda i\ [call\ (i)\ (x)]]]$

In a world with three students, Ann, Bill and Chris, the above expression has the following denotation: {Ann called, Bill called, Chris called}. However, in Lahiri (1991, 2000, to appear) the set of possible answers is not defined by the question denotation but by the answerhood operator. And the two sets are not identical if the wh-phrase is singular.

The definition of the answerhood operator is the same in Lahiri (1991) and Lahiri (to apppear). The answerhood operator closes the question denotation under generalized conjunction. This means that questions with singular wh-phrases have not only the elements of the question denotation as possible answers but also any possible conjunction[29] of elements of the question denotation. Hence a question such as *which student called*? has not only *Ann called* and *Bill called* as possible answer but also the proposition *Ann and Bill called*. Lahiri's (1991:147) answerhood operator states that a proposition p is an answer to a question Q if p is the generalized intersection of one of the elements of the powerset of Q:

(112) $Ans(p,Q)$ is true iff $\exists S \in Pow(Q)\ [p = \cap S]$.

---

[29]Conjunction of propositions amounts to set-theoretic intersection, given that propositions are sets of worlds.

Lahiri's analysis does not account for uniqueness effects of questions with singular wh-phrases because a proposition such as *Ann and Bill called* counts as possible answer to the question *which student called?*

Another weakness of Lahiri's analysis is that it depends on the assumption that plural wh-phrases have singularities in their extension. Lahiri (1991) assumes that plural wh-phrases have singularities and pluralities in their extension. Link's (1983) star * marks predicates that have singularities and pluralities in their extension.

(113) which students called?

$\lambda p\ \exists X\ [{*}student\ (a)\ (X)\ \&\ p = \lambda i\ [\forall x\ [x \in X \rightarrow call\ (i)\ (y)]]$

If Ann, Bill and Chris are the only students in the actual world the above question denotes the following set of propositions: {Ann called, Bill called, Chris called, Ann and Bill called, Ann and Chris called, Bill and Chris called, Ann, Bill and Chris called}. In Lahiri (to appear:96ff) plural wh-phrases have only singularities in their extension. Hence the questions *which students called?* and *which student called?* have the same denotation:

(114) $\lambda p\ \exists x\ [student\ (a)\ (x)\ \&\ p = \lambda i\ [call\ (i)\ (x)]]$

Thus if Ann, Bill and Chris are the students in the actual world both questions denote the set of propositions {Ann called, Bill called, Chris called}. Assuming that plural wh-phrases have only singularities in their extension is unusual but since the answerhood operator and not the question denotation defines the set of possible answers it does not make a difference. The set defined by the answerhood operator is closed under conjunction and hence the set of possible answers of (113) and (114) is the same. Since the proposition *Ann called* is a possible answer to the question *which students called?* Lahiri's analysis predicts that the sentence

(115) John knows which students called.

is true if Ann is the only student that called and John knows that Ann called. However, plural wh-phrases exhibit plurality effects. The above sentence is inapproriate in a context that makes explicit that only one student called:

(116) #Only one student called and John knows which students called.

In Lahiri plural wh-phrases have singularities in their extension because the set of possible answers is used in order to define atomic parts of plural propositions. The proposition *Ann and Bill called* only has the propositions *Ann called* and *Bill called* as atomic parts if they are element of the set of possible answers and we will see that this is relevant in order to account for QVE. We will also see later that the assumption that plural *which*-phrases have only singularities in their extension is used by Lahiri (to appear) in order to define which questions allow QVE. Questions that allow QVE have question denotations whose elements are logically independent of each other, i.e. there are no entailment relations between the propositions *Ann called, Bill called* and *Chris called*. [30]

Lahiri (1991) assumes that QVE involves quantification over plural propositions. In order to define the atomic parts of plural propositons (and the complement operation) Lahiri defines an atomic Boolean Algebra of plural propositions. The powerset of any set is the domain of an atomic Boolean Algebra. The domain of an Atomic Boolean Algebra is closed under sum (set-theoretic union), product (set-theoretic intersection) and unique complement and the notion of atom is defined. Lahiri (1991, to appear) defines a set Q' whose elements are the generalized intersection of the elements of the powerset of Q where Q is the question denotation.

(117) $Q' = \lambda p\ [\exists S \in \text{Pow}(Q)\ [p = \cap S]]$

The set Q' is equal to the set of propositions defined by the answerhood operator: $Q' = \lambda p\ [\text{Ans}(p, Q)]$. The set Q' is the domain of an atomic Boolean Algebra if there is a 1-1 mapping between the elements of Pow(Q) and the elments of Q'. Such an isomorphism exists if the elements of Q are such that no proposition is the logical consequence of the conjunction of the other propositions, see Lahiri (to appear:99):

[30]In section 2.3.6 we will see that degree questions such as *how many students called* do not allow QVE and that the propositions that constitute possible answers to the question are not logically independent of each other. E.g. the proposition *three students called* entails the proposition *two students called*.

(118) The condition of logical independence:

$\forall p \in Q\ \exists i\ [\forall q \in Q\ (q \neq p \rightarrow i \in q)\ \&\ i \notin p]$

The condition above states that any p in Q can be false in a situation in which all the other propositions are true. The isomorphism between Q' and Pow(Q) is defined as follows: Given any proposition $p \in Q'$, let f (p) be the function from Q' to Pow(Q) such that f (p) is the set $S \subseteq Q$ such that $p = \cap S$.

(119) Pow (Q)	$\cap$	Q'
$\{p_1, p_2, p_3\}$		$p_1 \cap p_2 \cap p_3$
$\{p_1, p_2\}$		$p_1 \cap p_2$
$\{p_1, p_3\}$		$p_1 \cap p_3$
$\{p_2, p_3\}$		$p_2 \cap p_3$
$\{p_1\}$		p_1
$\{p_2\}$		p_2
$\{p_3\}$		p_3
$\varnothing$		T (the tautology)

Then, $<Q', \oplus, \otimes, -, 0, 1>$ is the Boolean Algebra with sum (set-theoretic union), product (set-theoretic intersection)[31], complement and 0 and 1 defined as follows:

[31]The sum and product-operations correspond to union and intersection respectively if the domain of the Boolean algebra is the powerset of Q.

(120) $p \oplus q = \cap (f(p) \cup f(q))$

$p \otimes q = \cap (f(p) \cap f(q))$

$p^{-} = \cap (Q - f(p))$

$0 = \cap\varnothing$

$1 = \cap Q$

Lahiri (to appear:101) points out that subsets S of Q' are also atomic Boolean Algebras if they are closed under conjunction and the elements of the corresponding set Q are logically independent. The properties of S can be characterized as follows:

(121) $\forall p_1, p_2, ... \in Q' (p_1, p_2, ... \in S \leftrightarrow p_1 \cap p_2 \cap \in S)$

The set of true answers or the set of answers that John considers likely are subsets S of Q' where Q is a Hamblin-style question denotation. Lahiri (to appear) uses subsets S in order to define complementation with respect to the maximal element of e.g. the set of true answers.

Lahiri (1991, to appear:141) adopts a version of Higginbotham's quantification over mass terms in order to define adverbs of quantity such as *for the most part*. [32] ψ is a function from pluralities A into the set of atomic parts of A.

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[32]See the discussion of Berman's analysis in section 2.1.1 for reasons why Lahiri (1991) uses Higginbotham's quantification over mass terms instead of regular set theoretic quantification in order to account for QVE. One reason is that quantification over sets of propositions does not account for the non-distributive reading of:

i. It is surprising who came.

Another reason is that quantification over propositions does not account for semi-distributive readings such as

ii. The witnesses knew which clansmen were present at the lynching.

(122) ψ (A) = {a: atom (a) & a $\leq$ A}

Lahiri (to appear:146) makes use of the fact that natural language quantifiers are conservative.

(123) A quantifier QUANT is conservative if

$$\text{QUANT (A) (P)} = \text{QUANT (A) (A} \cap \text{P)}$$

Lahiri (to appear:147) proposes the following truth conditions for adverbs of quantity:

(124) a. $\text{most}^{+}(P)\ (S) = 1 \text{ iff } |\psi\ (\text{sup}_P\ (P) \otimes \text{sup}_P\ (P \cap S))| >$
$$|\psi\ (\text{sup}_P\ (P) \otimes (\text{sup}_P\ (P \cap S\ ))^{-})|$$

b. $\text{all}^{+}\ (P)\ (S) = 1 \text{ iff } |\psi\ (\text{sup}_P\ (P) \otimes (\text{sup}_P\ (P \cap S))^{-})| = 0$

In Lahiri (to appear) P is the domain of an atomic Boolean Algebra. The operator sup_P denotes the maximal element of P. Complementation is defined with respect to P. Assume that Q in (125) is the translation of *which students called?*. If twenty students called and John knows of fifteen students that they called the following sentence is correctly predicted to be true:

(125) John knows for the most part, which students called.

$most^{+}$ (λp [Ans(p,Q) & C (p)], λp [know (a) (j,p)])

In Lahiri (to appear:139) the context variable C is determined by lexical properties of the question-embedding predicate and by contextual factors. E.g. if the question-embedding predicate is *tell* or *know* the set of propositions denoted by C is a subset of the set of propositions that are true in the actual world:[33]

(126) C $\subseteq$ λp [p(a)] (tell, know, ...)

The expression in (125) is derived compositionally in the following steps: Predicates that allow QVE of embedded questions take propositions as arguments. Since questions denote sets of propositions, questions embedded under predicates such as *know* cannot be interpreted in situ. Lahiri (1991, 2000, to appear) assumes that there is a rule of Interrogative Raising which allows the interrogative to adjoin to IP. Adverbs of quantity take the CP in IP-adjoined position as restriction and the IP that they c-command as nuclear scope, see Lahiri (to appear:120). Thus the sentence

(127) John knows for the most part who called.

[33]In Lahiri (1991) presupposition accomodation plays a prominent role in determining the restriction of the adverb of quantification. Lahiri (to appear) drops this assumption for the following reasons: predicates such as *tell* are not factive, hence the restriction that C is a subset of the set of true propositions cannot be the result of presupposition accomodation. Also, presupposition accomodation into the restriction of the adverb of quantity is an instance of intermediate presupposition accomodation and recent work on presupposition accomodation (van der Sandt 1993, Beaver 1995) shows that intermediate presupposition accomodation only takes place if global presupposition accomodation fails for some reason.

has the following structure:

```
( 128)                     IP:1
                      /             \
              CP1:2                    IP:3
        (restriction)              /        \
        who called          ADV:4        IP:5
                            most      (nuclear scope)
                                      John knows t1
```

Lahiri (to appear) adopts Bittner's (1994) assumption that the semantic type of an argument trace depends on the semantic type of its sister node. If the sister node is of type $<\tau,\rho>$ the argument trace is of type τ. Hence t_1 is of type $<s,t>$. After λ-abstraction[34] of the free variable introduced by t_1 the semantic type of IP:5 is $<<s,t>,t>$. The translation of IP:5 is λp [know (a) (j,p)]. The adverb of quantification is interpreted by a construction-specific rule that introduces the answerhood operator[35] and the context variable C. Simplifying Lahiri's (to appear:120) rule somewhat the Adverbial Binding rule is the following:[36]

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[34]Lahiri (to appear:107ff) adopts Bittner's (1994) variable binding rules, I skip the details for the sake of brevity, for details see Lahiri (to appear).

[35]The answerhood operator does not function as a type shifter because the adverb of quantification takes expressions of type $<<s,t>,t>$ as arguments, which is the semantic type of the interrogative. Lahiri (to appear) needs the answerhood operator in order to add propositions to the question denotation. The answerhood operator closes the question denotation under generalized conjunction.

[36]In Lahiri (to appear:120) the answerhood operator and the context variable C are introduced by the !-operator and the rule of adverbial binding introduces the !-operator. Also, Lahiri allows multiple CP-translations in the restriction of the adverb of quantification.

(129) If ADV has the translation α and κ dominates ADV and β, and furthermore, β has the translation β', then

$$\lambda Q\ \alpha\ (\lambda p\ [Ans\ (p, Q)\ \&\ C\ (p)], \beta')$$

is a translation of κ.

Since the restriction and nuclear scope of α are of the same type, i.e. α is of type $<T,<T,t>>$ and since Ans (p, Q) takes propositions and sets of propositions as arguments, Q is of type $<<s,t>,t>$ and the restriction of α is of type $<<s,t>,t>$ and the translation of κ is only a well-formed expression if β' is of type $<<s,t>,t>$. The translation of IP:3 is:

(130) IP:3 $\approx>$ λQ [most (λp [Ans (p, Q) & C (p)], λp [know (a) (j,p)])]

And assuming that the translation of CP_1:2 is Q*, the translation of IP:1 is:

(131) IP:1 $\approx>$ most (λp [Ans (p, Q*) & C (p)], λp [know (a) (j,p)])

Questions embedded under *wonder* do not exhibit QVE. The sentence

(132) John wondered for the most part who called.

is not true if twenty people called and John wondered for fifteen of them whether they called. Lahiri assumes that predicates such as *wonder* take sets of propositions as arguments. If the interrogative undergoes Interrogative Raising QVE is ruled out because the resulting expression is ill-formed. The restriction and nuclear scope of the adverb of quantity are of different types. The restriction is of type <<s,t>,t> and the nuclear scope is of type <<<s,t>,t>,t>. This is so because the trace of the interrogative is of type <<s,t>,t>, thus the translation of the IP that is the sister of *most* is of type <<<s,t>,t>,t> after λ-abstraction.

(133) #most^{+} (λp [Ans(p,Q) & C (p)], λQ[wonder (Q)])

If interrogative raising does not take place and the interrogative is interpreted in situ the resulting expression is illformed because the restriction of the adverb of quantity is empty. Hence questions embedded under predicates that take questions as arguments do not exhibit QVE. Following a tradition that started with Lewis (1972), Lahiri (1991)[37] assumes that there is a silent universal quantifier if there is no overt adverb of quantity. Hence the sentence

(134) John knows which student(s) called.

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[37]Lahiri (to appear:227) adopts a quantifier of pragmatically variable strength called ENOUGH in order to account for cases of weakest exhautiveness such as:
i. John knows where to buy gas.
For the above sentence to be true John does not have to know all places that sell gas, just one place will do. He quotes Roberts (1986) and Emmon Bach for introducing it.

has the following translation:

(135) all^{+} (λp [Ans(p,Q) & C (p)], λp [know (a) (j,p)])

discussion:

Lahiri's (1991, 2000, to appear) proposal has two weaknesses: It does not account for uniqueness effects of singular wh-phrases. The sentence

(136) John knows which student called.
all^{+} (λp [Ans(p,Q) & C (p)], λp [know (a) (j,p)])

is true if Ann, Bill and Chris are the only students that called and John knows that Ann, Bill and Chris called.

The second weakness is that Lahiri's (to appear) analysis of QVE depends on the assumption that plural *which*-phrases have only singularities in their extension. If instead plural wh-phrases have only pluralities in their extension Lahiri's analysis incorrectly predicts that questions with plural wh-phrases do not allow QVE because the elements of the question denotation do not have the property of logical independence, i.e. there is no 1-1 mapping between Pow(Q) and Q'. Link's (1983) star in a circle « marks predicates that have only pluralities in their extension:

(137) which students called?

$$Q = \lambda p [{}^{\text{“}}\text{student (a) (X) \& } p = \lambda i [\forall x \in X [\text{call (i) (x)}]]]$$

If there are three students Ann, Bill and Chris in the actual world, then Q = {Ann and Bill called, Ann and Chris called, Bill and Chris called, Ann and Bill and Chris called}. The condition of logical independence is not fulfilled because there is no world in which e.g. the proposition *Ann and Bill called* is false and all the other propositions of the question denotation are true. Hence there is no 1-1 mapping between Q' and Pow(Q) and Q' is not the domain of an Atomic Boolean Algebra. And hence QVE is not defined for questions with plural *which*-phrases.

To my knowledge nobody has claimed before that plural NPs have only singularities in their extension. But even the claim that plural NPs have singularities in addition to pluralities in their extension is not undisputed, see e.g. Chierchia (1998). If plural NPs have singularities and pluralities in their extension the following contradiction is accounted for:

(138) #No men came but John came.

If *men* only has pluralities in its extension the contradiction is not accounted for because *John* denotes a singularity. However, the sentence

(139) The boys came in.

is not true if only one boy came in. Hence a theory that assumes that plural NPs have singularities and pluralities in their extension needs some extra assumptions to account for determiners other than *no*.

The other position, namely that plural NPs have only pluralities in their extension has been argued for most recently by Chierchia (1998). He derives all the well-known differences between count and mass nouns from the assumption that plural count nouns have only pluralities in their extension whereas mass nouns have pluralities and singularities in their extension. Determiners are classified according to what kind of NP they combine with. E.g. English *no* is compatible with singular and plural count nouns and mass nouns (*no man, no men, no water*). Assuming that NP-denotations form a lattice structure, Chierchia proposes that English *no* is such that it quantifies over atomic and non-atomic parts of the supremum of the NP-denotation. This has the same effect as adding singularities to the NP denotation if the determiner is *no*. NPs with the definite determiner *the* on the other hand simply denote the supremum of the lattice formed by the elements of the NP denotation. Since plural NPs have pluralities in their extension the supremum is a pluralitiy and not a singularitiy. His theory also accounts for crosslinguistic variation. E.g. Italian *nessun* 'no' only combines with singular count nouns but not with plural count nouns or mass nouns (*nessun uomo* 'no man', **nessun uomi* 'no men', **nessuna acqua* 'no water'). Hence it combines with NPs that have only singularities in their extension. There are also determiners that only combine with NPs that have only pluralities in their extension. Italian *alcuni* 'some' is an example. It only combines with plural count nouns but not with singular count nouns or mass nouns (*alcuni uomi* 'some men', **alcuno uomo* 'some man', *alcuna acqua* 'some water'). In the following I assume that plural wh-phrases have only pluralities in their extension.

Lahiri's (2000, to appear) analysis of pair list readings is discussed after Chierchia's (1993) analysis of pair list readings because Lahiri (2000, to appear) builds on Chierchia's (1993) semantics of questions.

2.1.3 QVE and existential disclosure (Groenendijk & Stokhof 1993)

Groenendijk & Stokhof's (1993) analysis is a reaction to Berman (1991) and Lahiri (1991). They criticize the following assumptions of the B/L analysis. The first point is that Berman and Lahiri adopt question denotations that are weakly exhaustive instead of strongly exhaustive. I discuss this point in section 2.1.3.

Their second point has to do with the analysis of the verb *tell*. Berman (1991) is forced to assume that any question-embedding predicate that allows QVE is factive because in his analysis QVE is triggered by the accomodation of factivity presuppositions. Since *tell* exhibits QVE he has to assume that *tell* is factive if it takes interrogatives as complements even though *tell* is non-factive when it takes *that*-clauses as complements.

Lahiri assumes that questions denote sets of propositions rather than sets of true propositions in order to account for the lack of factivity effects observed with *be certain*.

Thus he does not straightforwardly account for the factivity effect observed with questions embedded under *tell*. G&S (1993) follow Karttunen and assume that the factivity effect observed with questions embedded under *tell* is accounted for by the semantics of questions. They assume that questions denote true propositions. In order to account for the lack of factivity effects observed with *be certain* G&S (1993) assume that *be certain* like *wonder* is intensional. In their analysis the fact that *be certain* allows QVE whereas *wonder* does not follows from lexical properties of the respective verbs.

G&S's analysis of QVE runs into a formal error. It is based on two stepping stones. One is that they adopt Hintikka's (1962) semantics of propositional attitude verbs. In Hintikka propositional attitude verbs are associated with a predicate $V_{x,w}$ which denotes a set of possible worlds. For example, with T for *tell* and j for *John*, the extension of $T_{j,w}$ is the set of worlds compatible with what John tells in w. Thus it follows that John tells p in w iff all worlds w' for which $T_{j,w}$ holds are worlds in which p is true. Thus the following equivalence holds:

(140) $T(w)(j,p) \Leftrightarrow \forall w' [T_{j,w}(w') \rightarrow p(w')]$

G&S use this equivalence in order to show that (141) and (142) are equivalent, i.e. universal quantification over girls that sleep can be raised over the verb:[38]

[38] This is the weakly exhaustive question denotation. The strongly exhaustive question denotation has a double arrow instead of a one-way arrow.

John tells which girl(s) sleep(s).

(141) $T(w)\ (j, \lambda w'\ \forall x\ [[G(w)\ (x)\ \&\ S(w)\ (x)] \rightarrow [G\ (w')\ (x)\ \&\ S\ (w')\ (x)]])$ (=22b)

(142) $\forall x\ [[G(w)(x)\ \&\ S\ (w)\ (x)] \rightarrow T(w)(j, \lambda w'\ [G(w')\ (x)\ \&\ S(w')(x)])]$ (=23)

To break it down into steps, using (140), (141) can be represented as (143), and (142) as (144).

(143) $\forall w'\ [T_{j,w}(w') \rightarrow \forall x[[G(w)(x)\ \&\ S(w)(x)] \rightarrow [G(w')(x)\ \&\ S(w')(x)]]]$ (=24)

(144) $\forall x\ [[G(w)(x)\ \&\ S(w)(x)] \rightarrow \forall w'\ [T_{j,w}\ (w') \rightarrow [G(w')(x)\ \&\ S\ (w')(x)]]]$ (=25)

The equivalence between (143) and (144) follows from:

(145) $A \rightarrow [B \rightarrow C] \Leftrightarrow B \rightarrow [A \rightarrow C]$

The second stepping stone in G&S's (1993) analysis of QVE is that in dynamic semantics the following equivalence holds:

(146) $\exists x\ \phi \rightarrow \psi \Leftrightarrow \forall x\ [\phi \rightarrow \psi]$

Hence (142) is equivalent to (147):

(147) $\exists x\ [[G(w)(x)\ \&\ S\ (w)\ (x)] \rightarrow T(w)(j, \lambda w'\ [G(w')\ (x)\ \&\ S(w')(x)])]$ (=44)

G&S's (1993) analysis rests on the assumption that the following equivalence also holds:

(148) $AQ\ \exists x\ \phi \rightarrow \psi \Leftrightarrow AQ\ [\exists x\ \phi]\ [\psi]$

However, this equivalence only holds for universal and existential quantifiers but not for *most*. Lahiri (to appear) quotes Heim (pc.) for pointing this out, see also Barwise and Cooper (1981). Hence G&S's (1993) proposal does not account for QVE. The last step in G&S's (1993) proposal is existential disclosure which allows the adverb of quantification to unselectively bind a variable. G&S point out that in Dekker's (1990) and Chierchia's (1992, 1995) versions of dynamic semantics a formula of the form $\exists x\phi$ outputs all those assignments that assign values to x that satisfy ϕ. This makes the variable x available for further quantification. Dekker (1990) calls this existential disclosure. And because of existential disclosure the adverb of quantification AQ in $AQ\ [\exists x\phi][\psi]$ can unselectively bind the variable x:

(149) $AQ\ [\exists x\phi][\psi] \Leftrightarrow Q_x[\phi][\psi]$

where Q is the ordinary quantifier that corresponds to the adverb of quantification AQ. G&S's account of QVE has the following steps, whereby the step from (d) to (e) is not legitimate:

(150) a. John usually tell which girl(s) sleep(s).

b. $T(w)\ (j, \lambda w'\ \forall x\ [[G(w)\ (x)\ \&\ S(w)\ (x)] \rightarrow [G\ (w')\ (x)\ \&\ S\ (w')\ (x)]])$

c. $\forall x\ [[G(w)(x)\ \&\ S\ (w)\ (x)] \rightarrow T(w)(j, \lambda w'\ [G(w')\ (x)\ \&\ S(w')(x)])]$

d. $\exists x\ [G(w)(x)\ \&\ S\ (w)\ (x)] \rightarrow T(w)(j, \lambda w'\ [G(w')\ (x)\ \&\ S(w')(x)])]$

e. $USUALLY\ [\exists x\ [G(w)(x)\ \&\ S\ (w)\ (x)]]\ [T(w)(j, \lambda w'\ [G(w')\ (x)\ \&\ S(w')(x)])]$

f. $MOST_x\ [G(w)(x)\ \&\ S\ (w)\ (x)]\ \ [T(w)(j, \lambda w'\ [G(w')\ (x)\ \&\ S(w')(x)])]$

discussion:

Since G&S's (1993) analysis of QVE runs into a formal error it is not a viable alternative to other approaches. Their empirical claim that questions in QVE-contexts have strongly exhaustive readings is discussed in section 2.1.3.

2.1.4 QVE of pair list readings (Chierchia 1993, Lahiri 2000, to appear)

Chierchia (1993) is the first to propose an analysis of QVE of pair list readings. He adopts Lahiri's (1991) analysis of QVE of simple constituent questions. Hence simple constituent questions denote sets of propositions. In order to account for QVE of pair list readings Chierchia (1993:218) proposes that questions with quantifiers denote sets of sets of sets of propostions. They are of type <<<<s,t>,t>,t>,t>.[39]

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[39] Chierchia (1993) adopts a functional analysis of pair list readings for reasons that were discussed earlier. For present purposes this assumption is irrelevant. The relevant point here is that Chierchia (1993) adopts a higher-typed semantics in order to account for the semantics of pair list readings. Chierchia's (1993) claim that any quantifier that has minimal witness sets allows pair list readings is discussed in the next chapter.

(151) which wine did everyone like? (= 86)

$\lambda P\ \exists A\ [W(\text{everyone}, A)\ \&\ P(\lambda p\ [\exists f \in [A \rightarrow \text{wine}]$

$\exists x \in A\ [p = \lambda i\ [\text{like (i) (x, f(x))}]]]])]$

Following Lahiri (1991) the maximal answer to the embedded question that makes C true serves as the restriction for the adverb of quantity.[40]

(152) Mary knows, for the most part, which wine everyone likes. (≈30, 87)

most q $[q \leq_Q \sigma p\ [A_Q(p)\ \&\ C\ (p)]]$ [know (m, q)]

Chierchia (1993) adopts Lahiri's (1991) answerhood operator. The answerhood operator determines propositions that are the generalized intersection of a subset of Q (Chierchia 1993:192):

(153) $A_Q(p) = \exists S\ [S \subseteq Q\ \&\ p = \cap S]$ (=25)

Notice that the answerhood operator does not straightforwardly apply to question denotations of type <<<<s,t>,t>,t>,t>. In order to yield propositions as possible answers Q has to be of type <<s,t>t>. For questions with quantifiers this means that the

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[40]Chierchia (1993:193) introduces the variable C which is of type <<s,t>,t>. C is specified by the context. It accomodates the presuppositions of the embedding verb. If the embedding verb projects a factivity presupposition C minimally constrains p to true propositions. Chierchia (1993:192) assumes that $\leq_Q$ orders propositions relative to their informativeness. In order to account for QVE the relation $x \leq_Q y$ should determine the atomic parts x of y. Chierchia does not adopt Lahiri's definition of *most*. Hence Chierchia's analysis does not account for non-distributive readings of predicates such as *be surprising*.

answerhood operator applies to elements of elements of the question denotation rather than to the question denotation itself.

discussion:

Chierchia's (1993) analysis faces several problems. First, since Chierchia adopts Lahiri's (1991) analysis of simple constituent questions he inherits all the problems that Lahiri's analysis faces. Secondly, Chierchia's analysis does not ensure that the denotations of questions with quantifiers contain only relevant sets of propositions. I.e. the question denotation of the question in (154) contains not only sets of propositions that specifiy which person likes which wine but the question denotation also contains sets of propositions that are intuitively irrelevant for answering the question such as *Ann is crazy*. In a world with three people, Ann, Bill and Chris, and two wines, Merlot and Zinfandel, any superset of the set of set of propositions {{Ann likes Merlot, Ann likes Zinfandel, Bill likes Merlot, Bill likes Zinfandel, Chris likes Merlot, Chris likes Zinfandel}} is an element of the question denotation. This is so because in the expression in (154) the elements of the question denotation are only restricted by the statement P (λp [...]). This statement only ensures that P contains certain sets of propositions as elements, it does not rule out that P contains other elements.

(154) which wine did everyone like?

$\lambda P\ \exists A\ [W(\text{everyone}, A)\ \&\ P\ (\lambda p\ [\exists f \in [A \rightarrow \text{wine}]$

$\exists x \in A\ [p = \lambda i\ [\text{like (i) (x, f(x))}]]]])]$

{{{Ann likes Merlot, Ann likes Zinfandel, Bill likes Merlot, Bill likes Zinfandel, Chris likes Merlot, Chris likes Zinfandel}},

{{Ann likes Merlot, Ann likes Zinfandel, Bill likes Merlot, Bill likes Zinfandel, Chris likes Merlot, Chris likes Zinfandel}, {Ann is crazy, Bill is crazy, Chris is crazy, the sun is shining}}, ...}

If the context variable C is the only device that puts further restrictions on what counts as the maximal relevant answer then in a world in which Ann likes Merlot, Bill likes Zinfandel and Chris likes Merlot and in which it is also true that Ann is crazy, Bill is crazy, Chris is crazy and the sun is shining, there should be a context in which the sentence

(155) Mary knows which wine everyone liked. (=28)

$\text{know}\ (m, \sigma p\ [A_Q(p)\ \&\ C\ (p)])$

is only true if Mary knows that Ann, Bill and Chris are crazy and that the sun is shining because this constitutes the maximal true answer to the question. Such a context does not exist.

A third problem, which has been noted by Dayal (1996:115), is that Chierchia's (1993) analysis does not account for exhaustivity of pair list answers. Exhaustivity means that the question

(156) Which wine did everyone like?

does not have a true answer if some people did not like any wine. E.g. if Ann liked Zinfandel and Bill liked Merlot but Chris did not like any wine the above question does not have a true answer. Chierchia's analysis incorrectly predicts that the above question has a true answer in the above situation because the proposition *Ann liked Zinfandel and Bill liked Merlot* counts as the maximal true answer to the question. This is so because according to Lahiri's and Chierchia's answerhood operator any proposition that is the generalized intersection of a <u>subset</u> of a set of propositions that is an element of an element of the question denotation qualifies as an answer to the question.

Lahiri (2000, to appear) modifies Chierchia's (1993) analysis in order to account for exhaustivity of pair list answers. He introduces more structure into the question denotation such that there is a set of propositions for each element x of the minimal witness set X. In Lahiri (to appear:178ff) question denotations of questions with quantifiers are type <<<<<s,t>,t>,t>,t>,t> instead of type <<<<s,t>,t>,t>,t>.

(157) which wines did everyone like?

$\lambda P\ \exists X\ [W\ (\text{every}\ (\text{person}\ (a)), X)\ \&\ P\ (\lambda Q\ \exists x \in X\ [Q = \lambda p\ \exists f \in [X \rightarrow \text{wine}(a)]$
$[p = \lambda i\ [\text{like}\ (i)\ (f(x))\ (x)]]]])]$

In the above expression each proposition in the set of propositions Q specifies for one element x of the minimal witness set X which wines x liked. Thus in a world with three people, Ann, Bill and Chris and two wines, Merlot and Zinfandel, the above expression has the following denotation, ignoring irrelevant propositions:

(158) {{{{Ann likes Merlot, Ann likes Zinfandel},
{Bill likes Merlot, Bill likes Zinfandel},
{Chris likes Merlot, Chris likes Zinfandel}}}}

In order to account for exhaustivity Lahiri (to appear:179) defines a set $Q_{C'}$ and an answerhood operator that work together in such a way that the question only has an answer that makes C true if the question denotation contains an element Q that contains an element S such that each element S' of S contains a proposition that makes C true.

(159) $Q_c = \{S: \exists S' \in Q\ [S = \{p: \exists S'' \in S'\ p = \cap \{q: q \in S'' \ \&\ C(q)\}\}]\}$

$Q_{c'} = Q_C - \{S \in Q_C: T \in S\}$

$Ans_H'(p, Q, C) = \text{undefined if } Q_{C'} = \varnothing$

$= \exists S'\ \exists S\ [S' \in Q_{C'}\ \&\ S \in Pow(S')\ \&\ p = \cap S]$ otherwise.

If Ann liked Merlot and Chris liked Merlot and Zinfandel but Bill did not like any wine then the question does not have a true answer because if C is a subset of the set of true propositions then Q_C = {{Ann liked Merlot, T, Chris liked Merlot and Zinfandel}}. T is the intersection of the empty set. $Q_{C'}$ is empty because Q_C contains an element that contains T and Ans' (p, Q, C) is undefined because $Q_{C'}$ is empty.

Lahiri's (to appear) analysis accounts for the proportion problem. If twenty people liked one wine and one person liked fifty wines and if John only knows which wines the person liked that liked fifty wines then the sentence

(160) John knows for the most part which wine everybody liked.

is intuitively false. Lahiri (to appear:182) modifies the rule of adverbial binding in order to account for QVE of higher order questions. As a result the above sentence has the following translation, assuming that Q* is the translation of the interrogative:

(161) John knows for the most part which wine everybody liked.
$most^{+}$ (λp [Ans_H' (p, Q*, C) & C (p)], λp [know (a) (j,p)])

Lahiri's analysis accounts for the proportion problem because the maximal true answer to the question contains only one proposition for each person. Thus the maximal true answer to the question has twenty-one atomic parts, whereas John only knows one atomic part of the maximal true answer to the question.

discussion:

Apart from the fact that Lahiri's semantics of questions with quantifiers - like Chierchia's (1993) - does not define the notion of relevant answer Lahiri's analysis also does not account for all readings of questions with plural wh-phrases and quantifiers in QVE contexts. The sentence

(162) John knows for the most part which wines everybody liked.

has a reading that can be paraphrased as: John knows for each person x most of the wines that x liked. The above sentence is true if everybody liked ten wines and John knows for each person seven out of the ten wines that the person liked. In this context the proportion problem does not arise. Since in Lahiri (to appear) the maximal true answer to the question has only as many atomic parts as there are people, the above reading is not accounted for. Lahiri only accounts for the reading that can be paraphrased as: John knows for most people which wine(s) they liked. In section 2.2.2 I propose an analysis that dissociates the exhaustivity effect from the proportion problem.

2.1.5 Pair list readings and minimal answers (Pafel 1999)

Pafel (1999) - like Lahiri (1991) - assumes that there are plural propositions. However, unlike Lahiri (1991), Pafel (1999) does not assume that the atomic parts of a plurality are defined by a lattice structure. Instead, atomicity is defined relative to a predicate ϕ (Pafel 1999:278). The part-of relation $\leq$ is primitive:

(163) $At(x,X,\phi) =_{df} \phi(x) \& x \leq X \& \neg\exists z (\phi(z) \& z \leq x \& z \neq x)$

So for example the atomic parts of the pluralities that are in the extension of the plural noun *novels* are those x that make the following statement true: (Pafel uses Link's star notation in order to mark predicates that have singularities and pluralities in their extension.)[41]

(164) $At(x,X, {}^*novel) = {}^*novel(x) \& x \leq X \& \neg\exists z ({}^*novel(z) \& z \leq x \& z \neq x)$

Pafel adopts a Karttunen-style semantics of questions without discussing questions embedded under *be certain* which have been introduced by Lahiri (1991) in order to argue for a Hamblin-style semantics of questions. In Pafel (1999) questions denote minimal plural propositions that are complete true answers to the question. Factivity is built into the translation of the wh-phrase. [42] [43]

[41]It is crucial for Pafel's definition of atomic parts of plural individuals that plural NPs have singularities and pluralities in their extension.
[42] Pafel (1999:274) uses $\exists^{max} x [\phi(x)]$ as an abbreviation for $\exists x [\phi(x) \& \forall x' [\phi(x') \rightarrow x' \leq x]]$. I choose to spell out all abbreviations to make the expressions more transparent.
[43] The μ-operator $\mu x [\phi(x)]$ denotes the smallest x such that $\phi(x)$ (Pafel 1999:274).

(165) which novels have been reviewed? (=50)

$\mu p[\exists X\ [{}^{*}\text{novel (a) (X)}\ \&$

$\forall x\ [\text{atom}\ (x, X, \lambda x'\ [\text{novel (a) (x')}]) \rightarrow \text{HR (a) (x)}]\ \&$ factivity

$\forall x\ [\text{novel (a) (x)}\ \&\ \text{HR (a) (x)} \rightarrow x \leq X]\ \&$ maximality

$\forall x\ [\text{atom}\ (x, X, \lambda x'\ [\text{novel (a) (x')}]) \rightarrow$ distributivity

$[\lambda i\ [\text{HR (i) (x)}] \leq p]]]]$

The question in (165) denotes the minimal proposition p such that for every x that denotes a novel that has been reviewed the proposition *x has been reviewed* is a subpart of p.

I want to point out here a dependency between minimality operators and maximality conditions because later on I propose a semantics of questions that also uses the minimality operator to rule out irrelevant propositions. If questions denote minimal propositions as in Pafel (1999) plural wh-phrases have to be translated into expressions with maximality conditions in order to define complete true answers to the question. If the maximality condition is missing as in (166) the question denotes nil if there is more than one novel that has been reviewed because there is no minimal true proposition that is an answer to the question. E.g. if War and Peace and Anna Karenina have been reviewed then both the proposition *War and Peace has been reviewed* and the proposition *Anna Karenina has been reviewed* are true but neither of them is minimal because neither is a subpart of the other:

(166) which novels have been reviewed?

$\mu p[\exists X\ [^{*}novel\ (a)\ (X)\ \&$

$\forall x\ [atom\ (x, X, \lambda x'\ [novel\ (a)\ (x')]) \rightarrow HR\ (a)\ (x)]\ \&$ factivity

$\forall x\ [atom\ (x, X, \lambda x'\ [novel\ (a)\ (x')]) \rightarrow$ distributivity

$[\lambda i\ [HR\ (i)\ (x)] \leq p]]]]$

Pafel (1999:280ff) adopts a quantificational analysis of pair list answers. He assumes that in pair list answers the non-wh-quantifier outscopes the wh-phrase. His evidence for this assumption is that whatever determines the scope relations between quantifiers also determines the scope relations between wh-phrases and quantifiers.

(167) which novel did every critic review? (=57)

$\mu p\ [\forall x\ [critic\ (a)\ (x) \rightarrow \exists y\ [novel\ (a)\ (y)\ \&$

$review\ (a)\ (x,y)\ \&$ factivity

$\forall y'\ [novel\ (a)\ (y')\ \&\ review\ (x,y') \rightarrow y' \leq y]\ \&$ maximality

$\lambda i\ [review\ (i)\ (x,y)] \leq p]]$

In a world in which there are four authors, Ann, Bill, Chris and Dan and four novels, Anna Karenina, The Brothers Karamasov, The Turn of the Screw and the magic Mountain, the following proposition is a possible question denotation:

(168) Ann reviewed Anna Karenina and Bill reviewed The Brothers Karamasov and Chris reviewed The Turn of the Screw and Dan reviewed The Magic Mountain.

Discussion:

Pafel (1999) does not spell out his analysis of QVE. In particular, he does not spell out which predicate defines the atomic parts of the plural propositions that are the complete, true answers to questions. Thus, assuming that QVE involves quantification over atomic parts of the question denotation Q as in:

(169) John knows for the most part, which novel every critic reviewed.
most^{+} (λp [atom (p, Q, ϕ)], λp [know (a) (j, p)])

the missing step is to determine the predicate ϕ that defines the atomic parts of the proposition that constitutes the minimal true answer to the question. The following predicate defines the appropriate atomic parts:

(170) $\phi = \lambda p\ [\exists x\ [\text{critic (a) (x)}\ \&\ \exists y\ [\text{novel (a) (y)}\ \&\ p = \lambda i\ [\text{review (i) (x,y)}]]]]$

However, one drawback of Pafel's non-lattice-theoretic approach to plural propositions is that the predicate ϕ does not correspond to any part of the question meaning. In particular, the universal quantifier *every critic* is translated into existential quantification over critics. This ensures that the atomic parts of the question denotation specify for exactly one critic which book s/he reviewed. The analysis of QVE of simple constituent questions with plural wh-phrases faces the same problem: Here the predicate that defines the appropriate atomic parts of the minimal true answer is such that the plural wh-phrase is translated into a predicate that ranges over singularities only:

(171) John knows for the most part, which novels have been reviewed.
$most^{+}$ (λp [atom (p, Q, ϕ)], λp [know (a) (j, p)])

(172) $\phi = \lambda p\, [\exists x\, [novel\, (a)\, (x)\ \&\ p = \lambda i\, [HR\, (i)\, (x)]]]$

Another drawback of Pafel's (1991) analysis is that it does not account for QVE of non-factive predicates such as *be certain*. As Lahiri (1991) has observed first, questions embedded under *be certain* allow QVE but do not exhibit factivity effects:

(173) John is certain for the most part about which novels have been reviewed.

The above sentence is true if John believes about ten novels that they have been reviewed and is certain about seven of them that they have been reviewed. Since Pafel adopts a Karttunen-style semantics of questions instead of a Hamblin-style semantics of questions, his analysis does not account for the lack of factivity effects of questions embedded under non-factive predicates such as *be certain*.

Summary:

Lahiri's (1991, to appear) analysis of QVE of simple constituent questions does not account for the singular-plural distinction of wh-phrases because his analysis does not distinguish between atomic parts of answers and possible answers to a question. In his analysis an atomic part of a possible answer is also a possible answer to the question. Hence, if the proposition *Ann called* is an atomic part of the maximal true answer to the question *which students called* Lahiri is forced to assume that it is also a possible answer to the question.

Chierchia (1993) proposes a semantics of questions with quantifiers that allows him to distinguish atomic parts of possible answers from possible answers. E.g. the proposition *Ann ordered Merlot* might be an atomic part of the maximal true answer to the question *which wine did every customer order* but it is not a possible answer to the question. However, his semantics of questions does not account for the singular-plural distinction of wh-phrases and exhaustivity. Neither does it rule out irrelevant propositions.

Lahiri's (to appear) semantics of questions with quantifiers builds exhaustivity of pair list readings partly into the semantics of questions and partly into the answerhood operator. However, his solution to the exhaustivity problem has as a consequence that his analysis does not account for all quantificationally variable readings of questions with quantifiers and plural wh-phrases. Also, his analysis shares with Chierchia's (1993) analysis that it does not account for the singular-plural distinction of wh-phrases and that it does not rule out irrelevant propositions.

2.2 QVE and the singular-plural distinction of wh-phrases

In the following I propose a semantics of questions that accounts for QVE of simple constituent questions and questions with quantifiers and the singular-plural distinction of wh-phrases. The number feature of the wh-phrase determines how many quantificationally variable readings are available. Simple constituent questions with singular wh-phrases do not exhibit QVE, simple constituent questions with plural wh-phrases exhibit QVE:

(174) #John knows for the most part which student called.
no reading

(175) John knows for the most part which students called.
one reading: John knows for most students that called that they called.

Questions with quantifiers and singular wh-phrases have one quantificationally variable reading, questions with quantifiers and plural wh-phrases allow (at least) two quantificationally variable readings:

(176) John knows for the most part which wine every customer ordered.
reading: John knows for most customers which wine they ordered.

(177) John knows for the most part which wines every customer ordered.
reading1: John knows for most customers which wine they ordered.
reading2: John knows for every customer most of the wines that s/he ordered.

In the next sections I propose a semantics of questions that accounts for the impact of the singular-plural distinction on QVE. I propose that questions denote sets of sets of propositions such that each element of the question denotation is a set of parts of a complete, possible answer to the question. The singular-plural distinction is part of the notion of completeness, as is exhaustivity of questions with quantifiers and the restriction to relevant answers.

In order to define question denotations in which the generalized intersection of each element of the question denotation is a complete, possible answer to the question I take ideas from Lahiri (1991, to appear), Chierchia (1993) and Pafel (1999). From Lahiri (1991) I adopt the idea that questions that allow QVE are associated with an atomic Boolean Algebra of propositions. I also follow Lahiri in adopting a Hamblin-style semantics of questions in order to account for QVE of non-factive predicates such as *be certain*. From Chierchia (1993) I adopt the idea that questions are of higher types than <<s,t>,t>. From Pafel (1999) I adopt the minimality operator in order to define relevant answers.

2.2.1 QVE of questions with quantifiers and singular wh-phrases

In this section I want to account for QVE of questions with quantifiers and singular wh-phrases. If the wh-phrase is singular, pair list readings of questions with quantifiers have only one quantificationally variable reading. The sentence

(178) John knows for the most part which wine every customer ordered.

is true if John knows for most customers which wine they ordered. Singular wh-phrases in pair list readings also exhibit uniqueness effects. The sentence

(179) John knows which wine every customer ordered.

presupposes that every customer ordered exactly one wine. Uniqueness effects of singular wh-phrases in pair list readings have been discussed under the heading of one-to-one mappings. Most people discuss mappings in pair list readings of multiple wh-questions rather than question with quantifiers. E.g. Engdahl (1986) assumes that pair list readings of mutiple wh-questions allow one-to-many mappings, based on the following example:

(180) which table ordered which wine?

Table A ordered the Ridge Zinfandel, Table B ordered the Chardonnay and Table C ordered the Rose and the Bordeaux.

The equivalent with questions with quantifiers is:

(181) which wine did every table order?

Table A ordered the Ridge Zinfandel, Table B ordered the Chardonnay and Table C ordered the Rose and the Bordeaux.

Dayal (1996:108) points out that multiple wh-questions do not allow one-to-many mappings if every mapping is one to many:

(182) which man likes which woman?

John likes Mary and Bill likes Sue.

#John likes Mary and Sue and Bill likes Jane and Sarah.

For questions with quantifiers one-to-many mappings are also infelicitous:

(183) which man did every woman like?

Mary like Paul and Sue liked Peter.

#Mary liked John and Paul, Sue liked Art and Bert and Chris liked Carl and Dan.

We will see that a version of Dayal's entailment-based answerhood operator is needed in order to account for uniqueness effects of singular wh-phrases.

2.2.1.1 A semantics of questions that defines complete, possible answers and their parts

I propose that question denotations are sets of sets of propositions. They are of type <<<s,t>,t>,t>. The elements of the question denotation are sets of propositions whose generalized intersection is a complete, possible answer to the question. E.g. in a world with three customers, Ann, Bill and Chris and two wines, Merlot and Zinfandel, the question

(184) which wine did every customer order?

has the following denotation:

(185) {{Ann ordered Merlot, Bill ordered Merlot, Chris ordered Merlot},
{Ann ordered Zinfandel, Bill ordered Zinfandel, Chris ordered Zinfandel},
{Ann ordered Zinfandel, Bill ordered Merlot, Chris ordered Merlot},
{Ann ordered Merlot, Bill ordered Zinfandel, Chris ordered Merlot},
{Ann ordered Merlot, Bill ordered Merlot, Chris ordered Zinfandel},
{Ann ordered Merlot, Bill ordered Zinfandel, Chris ordered Zinfandel},
{Ann ordered Zinfandel, Bill ordered Merlot, Chris ordered Zinfandel},
{Ann ordered Zinfandel, Bill ordered Zinfandel, Chris ordered Merlot}}

The following expression yields the desired question denotation:

(186) which wine did every customer order?

$$\lambda P\ [\exists j\ [P = \mu P'\ [\forall x\ [customer\ (a)\ (x) \rightarrow \exists y\ [wine\ (a)\ (y)\ \&$$
$$\exists p\ [P'(p)\ \&\ p\ (j)\ \&\ p = \lambda i\ [order\ (i)\ (x,y)]]]]]]]$$

Existential quantification over worlds j is necessary in order to define possible answers in a semantics of questions that uses the minimality operator in order to define relevant answers to the question. The minimality operator μ rules out irrelevant propositions. The minimality operator μ denotes the smallest d such that €ϕ,(d) is true:

(187) €μx [ϕ], = d iff €ϕ, (d) = 1 and for all d', €ϕ, (d') = 1 then d $\subseteq$ d', nil otherwise.

The minimality operator in (186) ensures that each set of propositions P is the smallest set of propositions such that for every customer x it contains a proposition that is true in j and that is of the form *x ordered y* where y is a wine. Hence propositions that are irrelevant for answering the question such as *the sun is shining* are not element of any P. Existential quantification over worlds j is necessary because P is the smallest set of propositions relative to some world j in which all the elements of P are true. Intuitively j is necessary in order to define the set of possible answers. If existential quantification over worlds is missing then the question denotation does not specify all possible answers to the question. It contains at most one set of propositions, i.e. at most one possible answer and it denotes nil if there is more than one world in which the question has an answer but the answers do not stand in the subset relation. In this case there is no minimal answer to the question.

(188) which wine did every customer order?

$\#\lambda P\ [P = \mu P'\ [\forall x\ [customer\ (a)\ (x) \rightarrow \exists y\ [wine\ (a)\ (y)\ \&$

$\exists p\ [P'(p)\ \&\ p = \lambda i\ [order\ (i)\ (x,y)]]]]]]$

To give an example, if Ann, Bill and Chris are the set of customers in the actual world and if Merlot and Zinfandel are the wines in the actual world and if in one world Ann ordered Merlot, Bill ordered Zinfandel and Chris ordered Merlot and in another world Ann ordered Zinfandel, Bill ordered Zinfandel and Chris ordered Merlot, then the question denotes nil because there is no minimal P'. Neither the set of propositions {Ann ordered Merlot, Bill ordered Zinfandel, Chris ordered Merlot} is minimal nor the set of propositions {Ann ordered Zinfandel, Bill ordered Zinfandel, Chris ordered Merlot} is minimal because neither is the subset of the other.

The answerhood operator Poss-Ans defines possible answers to the question Q. It denotes a set of propositions p that are the generalized intersection of one element of the question denotation:

(189) $\text{Poss-Ans}\ (Q) = \{p : \exists P\ [P \in Q\ \&\ p = \cap P]\}$

The semantics of questions proposed so far does not account for uniqueness effects of singular wh-phrases even though the minimality operator ensures that each answer to the question pairs each customer with exactly one wine. Consider the following model. In world w1 one customer, namely Ann, ordered two wines, namely Merlot and Zinfandel. All other customers ordered exactly one wine. The semantics of questions proposed so far incorrectly predicts that the question *which wine did every customer order?* has a true answer in w1.

(190)		customer:	wine:	order:
	w1:	a, b, c	m, z	<a,m>,<a,z>,<b,z><c,m>
	w2:	∅	∅	<a,m>,<b,z><c,m>
	w3:	∅	∅	<a,z>,<b,z>,<c,m>

In the above model the question denotes the following set of sets of propositions:

(191) {{Ann ordered Merlot, Bill ordered Zinfandel, Chris ordered Merlot},
{Ann ordered Zinfandel, Bill ordered Zinfandel, Chris ordered Merlot}}
= {{{w1, w2}, {w1, w2, w3}, {w1, w2, w3}},
{{w1, w3}, {w1, w2, w3}, {w1, w2, w3}}}

According to the definition of the answerhood operator the proposition *Ann ordered Merlot and Bill ordered Zinfandel and Chris ordered Merlot* is a possible answer to the question. Since it is also true in w1 it is a true answer to the question in w1. The same holds for the proposition *Ann ordered Zinfandel and Bill ordered Zinfandel and Chris ordered Merlot*. Hence the analysis incorrectly predicts that the question has two true answers in w1 instead of accounting for the fact that the question has no answer in w1.

There are two ways to account for uniqueness effects of singular wh-phrases. One is to build a uniqueness condition into the meaning of the question as in:

(192) $\lambda P\ [\exists j\ [P = \mu P'\ [\forall x\ [customer\ (a)\ (x) \rightarrow \exists y\ [wine\ (a)\ (y)\ \&$
$\exists p\ [P'(p)\ \&\ p\ (j)\ \&\ p = \lambda i\ [order\ (i)\ (x,y)\ \&$
$\forall y'\ [wine\ (a)\ (y')\ \&\ order\ (i)\ (x,y') \rightarrow y' \leq y]]]]]]]]$ uniqueness

(193) {{Ann ordered Merlot and nothing else that is a wine in w1,
Bill ordered Zinfandel and nothing else that is a wine in w1,
Chris ordered Merlot and nothing else that is a wine in w1},
{Ann ordered Zinfandel and nothing else that is a wine in w1,
Bill ordered Zinfandel and nothing else that is a wine in w1,
Chris ordered Merlot and nothing else that is a wine in w1}}
= {{{w2}, {w1, w2, w3}, {w1, w2, w3}},
{{w3}, {w1, w2, w3}, {w1, w2, w3}}}

Now, the question does not have a true answer in w1 because none of the elements of the question denotation is such that its generalized intersection is true in w1.

The other possibility is to amend the answerhood operator in such a way that it accounts for uniqueness. E.g. Dayal (1996:116) builds a maximality condition into the definition of the answerhood operator in order to account for uniqueness effects of singular wh-phrases and maximality effects of plural wh-phrases. Dayal's answerhood operator defines maximal true answers. The proposition p is the maximal true answer to the question if all other propositions that are true answers to the question are supersets of p, i.e. they are entailed by p.

(194) Max-Ans(Q) = $\iota p\ [p\ (a)\ \&\ \exists P\ [P \in Q\ \&\ p = \cap P\ \&$

$\forall P'\ \forall p'\ [P' \in Q\ \&\ p' = \cap P'\ \&\ p'\ (a) \rightarrow p' \supseteq p]]]$ maximality

nil otherwise.

This rules out that the question in (186) has a true answer in w1 in the model in (190) because two possible answers are true in w1 but they do not stand in the entailment relation. I adopt the latter option because the maximality condition in the answerhood operator is needed anyway in order to account for questions with plural wh-phrases as we will see in section 2.2.3. [44]

2.2.1.2 Atomic Boolean Algebras for complete, possible answers

Lahiri (to appear) defines the domain of an atomic Boolean Algebra Q' for each question denotation Q first and then uses subalgebras of Q' as the restriction of adverbs of quantity such as *for the most part*. He also uses the question denotation Q in order to define which

[44]This analysis of uniqueness effects of singular wh-phrases presumes that models are rich enough to contain all relevant possibilities. The analysis does not account for uniqueness effects of singular wh-phrases if the model is such that in every world in which all customers ordered some wine every customer ordered more than one wine.

questions allow QVE. Only if the elements of Q are logically independent of each other is the set Q' the domain of an atomic Boolean Algebra.

I define Atomic Boolean Algebras not for question denotations Q but for each maximal answer that makes C true.[45] The elements of the set of propositions denoted by the answerhood operator Max-Ans are the atomic parts of the maximal answer that makes C true. The operator Max-Ans (Q,C) denotes a set of propositions whose generalized intersection is the maximal answer to Q that makes C true:

(195) Answerhood operator - final version:

Max-Ans(Q,C) = $\iota P\ [\exists p\ [C(p)\ \&\ P \in Q\ \&\ p = \cap P\ \&$

$\forall P'\ \forall p'\ [P' \in Q\ \&\ p' = \cap P'\ \&\ C(p') \rightarrow p' \supseteq p]]]$, maximality

nil otherwise.

In the following I sometimes refer to the set of propositions denoted by Max-Ans as the maximal answer that makes C true, even though strictly speaking the generalized intersection of the set of propositions denoted by Max-Ans is the maximal answer that makes C true. The operator '(S) defines a set that is closed under intersection. It defines a set of plural propositions if S is a set of propositions:

(196) $'(S) = \{p: \exists S'\ [S' \subseteq S\ \&\ p = \cap S]\}$

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[45]Following Chierchia (1993) and Lahiri (to appear) maximal answers are restricted to being a subset of C. This allows to account for QVE of questions embedded under non-factive predicates such as *be certain*.

The set denoted by '(S) is isomorphic to the powerset of S if the elements of S are logically independent. Like in Lahiri (to appear) I assume that the restriction of the adverb of quantity is the domain of an atomic Boolean Algebra. '(Max-Ans (Q,C)) qualifies as the restriction of the adverb of quantity because it is the domain of an Atomic Boolean Algebra:

(197) John knows for the most part which wine every customer ordered.

$most^{+}$ ('(Max-Ans(Q, C)), λp [know (a) (j, p)])

Lahiri's construction-specific rule of adverbial binding has to be modified as follows:

(198) If ADV has the translation α^{+} and κ dominates ADV and β, and furthermore, β has the translation β', then

$\lambda Q\ \alpha^{+}$ ('(Max-Ans(Q, C)), β')

is a translation of κ.

I adopt Lahiri's (to appear:147) definition of *most*$^{+}$:

(199) $most^{+}(P)\ (S) = 1$ iff $|\psi\ (sup_P\ (P) \otimes sup_P\ (P \cap S))| >$

$|\psi\ (sup_P\ (P) \otimes (sup_P\ (P \cap S\ ))^{-})|$

2.2.1.3 Compositional analysis of questions with quantifiers

My analysis of pair list readings rests on the assumption that the non-wh-quantifier outscopes the wh-phrase. Following Fox (1995, 2000:65) I assume that QR is licit if it yields an inverse scope reading. Since questions have an operator in C adjunction to CP yields an inverse scope reading. Therefore quantifiers can adjoin to CP [+wh].

Following von Stechow (1996) and Bittner (1998) I assume that the translation of the C-node allows for a purely type driven analysis of the semantics of questions. In my analysis the C-node translates into an expression that introduces the propositions p that are the atomic parts of answers and a variable P' that is used to specify the sets of propositions whose intersection constitutes a possible answer to the question:

(200) $C \approx> \lambda q\ [\exists p\ [P'\ (p)\ \&\ p\ (j)\ \&\ p = \lambda i\ [q\ (i)]]]$

Following Pafel (1999:276) I assume that the syntactic structure is enriched in such a way that there is a node U that takes the interrogative as complement and has the following translation: $\lambda Q\ [\lambda P\ [\exists j\ [P = \mu P'\ [Q\ (j)\ (P')]]$. Hence the U-node introduces existential quantification over worlds which allows to define maximal possible answers and it introduces the minimality operator that defines relevant answers. In the following I have not specified the indexing mechanism that constrains binding of free variables because it is not central to my issues and it would make the derivations even longer. Such an indexing mechanism ensures that e.g. in the following derivation the variable x is bound by the universal quantifier *every customer* and the variable y is bound by the existential quantifier *which wine*. For indexing mechanisms see Heim & Kratzer (1998) and Bittner (1998).

(201) which wine did every customer order?

```
            CP:1
            /    \
        U:2       CP:3
                  /    \
              QPi:4     CP:5
                |       /    \
    every customer    DPj:6     C':7
                        |       /    \
               which wine     C:8     IP:9
                                        |
                                    ti order tj
```

9:	order (a) (x,y)	t
9':	λa [order (a) (x,y)]	<s,t>
8:	λq [$\exists$p [P' (p) & p (j) & p = λi [q (i)]]]	<<s,t>,t>
7:	$\exists$p [P' (p) & p (j) & p = λi [order (i) (x,y)]]	t
7'	λy [$\exists$p [P' (p) & p (j) & p = λi [order (i) (x,y)]]]	<e,t>
6:	λQ [$\exists$y [wine (a) (y) & Q (y)]]	<<e,t>,t>
5:	$\exists$y [wine (a) (y) & $\exists$p [P' (p) & p (j) & p = λi [order (i) (x, y)]]]	t

5': $\lambda x\ [\exists y\ [wine\ (a)\ (y)\ \&\ \exists p\ [P'\ (p)\ \&\ p\ (j)\ \&\ p = \lambda i\ [order\ (i)\ (x, y)]]]]$

$\langle e,t \rangle$

4: $\lambda Q\ [\forall x\ [customer\ (a)\ (x) \rightarrow Q\ (x)]]$ $\langle\langle e,t\rangle,t\rangle$

3: $\forall x\ [customer\ (a)\ (x) \rightarrow \exists y\ [wine\ (a)\ (y)\ \&\ \exists p\ [P'\ (p)\ \&\ p\ (j)\ \&$

$p = \lambda i\ [order\ (i)\ (x, y)]]]]]$ t

3': $\lambda P'\ [\lambda j\ [\forall x\ [customer\ (a)\ (x) \rightarrow \exists y\ [wine\ (a)\ (y)\ \&\ \exists p\ [P'\ (p)\ \&\ p\ (j)\ \&$

$p = \lambda i\ [order\ (i)\ (x, y)]]]]]]]$

$\langle\langle\langle s,t\rangle,t\rangle,\langle s,t\rangle\rangle$

2: $\lambda Q\ [\lambda P\ [\exists j\ [P = \mu P'\ [Q\ (j)\ (P')]]]]$

$\langle\langle\langle\langle s,t\rangle,t\rangle,\langle s,t\rangle\rangle,\langle\langle\langle s,t\rangle,t\rangle,t\rangle\rangle$

1: $\lambda P\ [\exists j\ [P = \mu P'\ [\forall x\ [customer\ (a)\ (x) \rightarrow \exists y\ [wine\ (a)\ (y)\ \&\ \exists p\ [P'(p)\ \&\ p\ (j)\ \&$

$p = \lambda i\ [order\ (i)\ (x, y)]]]]]]]]$

$\langle\langle\langle s,t\rangle,t\rangle,t\rangle$

2.2.2 QVE of questions with quantifiers and plural wh-phrases

Pair list readings of questions with plural wh-phrases have several quantificationally variable readings. The sentence

(202) John knows for the most part which wines every customer ordered.

is true if John knows for most customers which wines they ordered. The second reading can be paraphrased as John knows for every customer most of the wines that s/he ordered. Both readings are accounted for if the universal quantifier *every customer* takes wide scope over the wh-phrase:

(203) which wines did every customer order?

$\lambda P\ [\exists j\ [P = \mu P'\ [\forall x\ [\text{customer (a) (x)} \rightarrow$

$\exists Y\ [{}^{\cup}\text{wine (a) (Y)}\ \&$

$\forall y\ [\text{wine (a) (y) \& order (j) (x,y)} \rightarrow y \leq Y]\ \&$ maximality

$\forall y\ [\text{atom (y)}\ \&\ y \leq Y \rightarrow$

distributivity

$\exists p\ [P'(p)\ \&\ p(j)\ \&\ p = \lambda i\ [\text{order (i) (x,y)}]]]]]]]]$

The resulting question denotation is such that each element of the question denotation contains for every customer in the actual world at least two propositions.

(204) {{Ann ordered Merlot, Ann ordered Shiraz, Bill ordered Merlot, Bill ordered Shiraz, Chris ordered Merlot, Chris ordered Shiraz},
{Ann ordered Merlot, Ann ordered Bordeaux, Bill ordered Merlot, Bill ordered Shiraz, Chris ordered Shiraz, Chris ordered Bordeaux}, ...}

The above question denotation correctly accounts for the second reading but it also runs into the proportion problem. It incorrectly predicts that the above sentence is true if one customer ordered one hundred wines and twenty customers ordered three wines and John knows all the one hundred wines that the first customer ordered but John does not know any of the wines that the other customers ordered, see Heim (1982) whose analysis of donkey sentences runs into the same problem. I leave the proportion problem as an unresolved open problem.

2.2.3 QVE of simple constituent questions with plural wh-phrases

In this section I want to account for QVE of simple constituent questions with plural wh-phrases as in:

(205) John knows, for the most part, which students called.

The sentence in (205) is true if John knows for most students that called that they called. Hence it is true if twenty students called and John knows of fifteen of them that they called. Plural wh-phrases exhibit plurality effects. The sentence

(206) #Exactly one student called and John knows which students called.

is infelicitous because the plural wh-phrase is only licit if more than one student called.

In order to account for plurality effects of plural wh-phrases and QVE I assume that simple constituent questions denote sets of sets of propositions such that each element of the question denotation is a set of parts of a complete, possible answer to the question. This step allows me to define the appropriate atomic parts of answers to questions with plural wh-phrases without assuming that plural wh-phrases have singularities in their extension. Following Chierchia (1998) I assume that plural count nouns have only pluralities in their extension.

Thus, - unlike in Chierchia (1993) and Lahiri (to appear) - simple constituent questions and questions with quantifiers are of the same type. Pair list answers have proper atomic subparts because the translation of the non-wh-quantifier outscopes existential quantification over propositītions p. Answers to simple constituent questions have proper atomic parts if the universal quantifier that is introduced by the distributivity operator outscopes existential quantification over propositions p:

(207) which students called?

$\lambda P\ [\exists j\ [P = \mu P'\ [\exists X\ [{}^{\text{“}}\text{student}\ (a)\ (X)\ \&$

$\forall x\ [\text{student}\ (a)\ (x)\ \&\ \text{call}\ (j)\ (x) \rightarrow x \leq X]\ \&$ maximality

$\forall x\ [\text{atom}(x)\ \&\ x \leq X \rightarrow$ distributivity

$\exists p\ [p(j)\ \&\ P'(p)\ \&\ p = \lambda i\ [\text{call}\ (i)\ (x)]]]]]]]$

If plural wh-phrases have only pluralities in their extension each element of the question denotation is a set of propositions that contains more than one proposition. In a world with three students Ann, Bill and Chris the above question denotes the following set of sets of propositions:

(208) {{Ann called, Bill called}, {Ann called, Chris called}, {Bill called, Chris called}, {Ann called, Bill called, Chris called}}

If the minimality operator is used to define relevant answers (i.e. relevant sets of propositions) it is necessary to translate plural wh-phrases into expressions with maximality conditions in order to counteract the effects of the minimality operator. Without the maximality condition the minimality operator has the effect that each possible answer specifies for no more than two students that they called. Hence the question denotation in (209) makes the incorrect prediction that the question *which students called?* does not have a maximal true answer in any world in which more than two students called:

(209) $\#\lambda P\ [\exists j\ [P = \mu P'\ [\exists X\ [{}^{«}\text{student (a) (X)}\ \&$

$\forall x\ [\text{atom}(x)\ \&\ x \leq X \rightarrow$ distributivity

$\exists p\ [p(j)\ \&\ P'(p)\ \&\ p = \lambda i\ [\text{call (i) (x)}]]]]]]]$

The maximality condition in the question denotation is necessary but not sufficient in order to account for maximality effects of plural wh-phrases. E.g. if three students called then the sentence

(210) John knows which students called.

is true if John knows for all three students that they called. If he only knows of two of them that they called, the above sentence is false. This is not accounted for if the answerhood operator does not contain a maximality condition because e.g. the proposition *Ann and Bill called* is entailed by the proposition *Ann, Bill and Chris called* and hence in any world in which the proposition *Ann, Bill and Chris called* is a true answer to the question, the proposition *Ann and Bill called* is also a true answer to the question. Hence it is necessary to have an answerhood operator that determines the maximal true answer to the question.

2.2.3.1 Compositional analysis of simple constituent questions with plural wh-phrases

Following Sternefeld (1998) I assume that a D-operator is inserted at LF. My proposal is not compatible with the assumption that the D-operator is introduced by the verbal predicate because it does not directly apply to the verbal predicate.

I also assume that plural wh-phrases have an anaphoric element M in Spec position that is coindexed with the IP-denotation. This is needed for the maximality condition. A plural predicate with a prefixed ^{a} (for atom) denotes a singular predicate: ^{a}«P = P. The distributivity operator Dist is adjoined to a C' projection.

(211) which students called?

```
                CP:1
               /    \
            U:2      CP:3
                    /     \
             DP_i:4        C':9
             /    \        /    \
        M_m:5    D':6   Dist:10  C':11
                /   \           /    \
              D:7  NP:8       C:12  IP_m:13
               |     |                |
             which students       t_i called
```

13:	call (a) (x)	t
13':	λa [call (a) (x)]	<s,t>
12:	λq [$\exists$p [P' (p) & p (j) & p = λi [q (i)]]]	<<s,t>,t>
11:	$\exists$p [P' (p) & p (j) & p = λi [call (i) (x)]]	t
11':	λx [$\exists$p [P' (p) & p (j) & p = λi [call (i) (x)]]]	<e,t>
10:	λR λX [$\forall$x [x $\leq$ X $\rightarrow$ R (x)]]	<<e,t>,<e,t>>
9:	$\forall$x [x $\leq$ X $\rightarrow$ $\exists$p [P' (p) & p (j) & p = λi [call (i) (x)]]]	t
9':	λX [$\forall$x [x $\leq$ X $\rightarrow$ $\exists$p [P' (p) & p (j) & p = λi [call (i) (x)]]]]	<e,t>
8:	«student (a) (x)	t
8':	λx λa [«student (a) (x)]	<e,<s,t>>

7: $\lambda P\ \lambda S\ \lambda Q\ [\exists X\ [P\ (a)\ (X)\ \&\ \forall x\ [{}^{a}P\ (a)\ (x)\ \&\ S\ (j)\ (x) \rightarrow x \leq X]\ \&\ Q\ (X)]]$

$<<e,<s,t>>,\ \ <e,<s,t>>,$

$<e,t>,t>$

6: $\lambda S\ \lambda Q\ [\exists X\ [{}^{«}\text{student}\ (a)\ (X)\ \&$

$\forall x\ [{}^{a«}\text{student}\ (a)\ (x)\ \&\ S\ (j)\ (x) \rightarrow x\ {}_{a}\!\leq X]\ \&\ Q\ (X)]]$ $<<e,<s,t>>,$

$<e,t>,t>$

5: $\text{call}\ (a)\ (x)$ t

5': $\lambda x\ \lambda a\ [\text{call}\ (a)\ (x)]$ $<e,<s,t>>$

4: $\lambda Q\ \exists X\ [{}^{«}\text{student}\ (a)\ (X)\ \&\ \forall x\ [\text{student}\ (a)\ (x)\ \&\ \text{call}\ (j)\ (x) \rightarrow x \leq X]\ \&$

$Q\ (X)]$

$<<e,t>,t>$

3: $\exists X\ [{}^{«}\text{student}\ (a)\ (X)\ \&\ \forall x\ [\text{student}\ (a)\ (x)\ \&\ \text{call}\ (j)\ (x) \rightarrow x \leq X]\ \&$

$\forall x\ [x\ {}_{a}\!\leq X \rightarrow \exists p\ [P'\ (p)\ \&\ p\ (j)\ \&\ p = \lambda i\ [\text{call}\ (i)\ (x)]]]]$ t

3': $\lambda P'\ \lambda j\ [\exists X\ [{}^{«}\text{student}\ (a)\ (X)\ \&\ \forall x\ [\text{student}\ (a)\ (x)\ \&\ \text{call}\ (j)\ (x) \rightarrow x\ {}_{a}\!\leq X]\ \&$

$\forall x\ [x\ {}_{a}\!\leq X \rightarrow \exists p\ [P'\ (p)\ \&\ p\ (j)\ \&\ p = \lambda i\ [\text{call}\ (i)\ (x)]]]]]$

$<<<s,t>,t>,<s,t>>$

2: $\lambda Q\ [\lambda P\ [\exists j\ [P = \mu P'\ [Q\ (j)\ (P')]]]]$

$<<<<s,t>,t>,<s,t>>,<<<s,t>,t>,t>>$

1: $\lambda P\ [\exists j\ [P = \mu P'\ [\exists X\ [\text{“student}\ (a)\ (X)\ \&$

$\forall x\ [\text{student}\ (a)\ (x)\ \&\ \text{call}\ (j)\ (x) \rightarrow x\ {}_{a}{\leq}\ X]\ \&$

$\forall x\ [x\ {}_{a}{\leq}\ X \rightarrow \exists p\ [P'\ (p)\ \&\ p\ (j)\ \&\ p = \lambda i\ [\text{call}\ (i)\ (x)]]]]]]]$

<<<s,t>,t>,t>

2.2.3.2 Collective readings of questions with plural wh-phrases

Lahiri (to appear:302) quotes Schwarz (1994) and Williams (2000) for claiming that if the questioned predicate is interpreted collectively, one can still get quantificationally variable readings. The following example is from Schwarz (1994):

(212) John knows for the most part which students form the bassoon quintett.

Suppose that Mary, Bill, Sue, Phil and Ann are the students who form the bassoon quintett. Schwarz and Lahiri claim that the above sentence is true if John knows that Mary, Bill and Sue are students who are part of the bassoon quintett and does not know that Phil and Ann are. If the following translation is adopted:

(213) which students form the bassoon quintett?

$\lambda p\ [\exists x\ [p = \lambda i\ [{*}\text{student}\ (a)\ (x)\ \&\ \text{f.t.b.q.}\ (i)\ (x)]]$

then there is only one proposition in the set of true answers to the question, namely the proposition *Mary, Bill, Sue, Phil and Ann form the Bassoon quintett.* Hence this analysis does not account for QVE of questions with collective predicates. Lahiri (to appear) adopts Williams' suggestion that wh-phrases quantify over instances of groups in order to account for QVE of questions with collective predicates. Thus the question

(214) which students form the bassoon quintett?

has the translation:

(215) $\lambda p\ [\exists x\ [p = \lambda i\ [\exists y\ [*student\ (a)\ (y)\ \&\ *student\ (a)\ (x)\ \&\ x \leq y\ \&\ f.t.b.q.\ (i)\ (y)]$

Thus the set of possible answers is {Ann is part of a group that forms the bassoon quintett, Bill is part of a group that forms the bassoon quintett, ...}

discussion:

I do not agree with the judgements, to me the sentence in (212) sounds rather odd. The following translation of the question predicts that questions with collective predicates do not allow QVE because each possible answer does not have any proper atomic subparts:

(216) which students form the orchestra?

$Q = \lambda P\ [\exists j\ [P = \mu P'\ [\exists X\ [^{«}\text{student (a) (X)}\ \&$

$\exists p\ [p(j)\ \&\ P'(p)\ \&\ p = \lambda i\ [\text{form-orchestra (i) (X)}]]]]]]$

If there are three students, Ann, Bill and Chris, then Q = {{Ann and Bill form the orchestra}, {Ann and Chris form the orchestra}, {Bill and Chris form the orchestra}, {Ann and Bill and Chris form the orchestra}}. However, if QVE of questions with collective predicates is licit then something along the lines of Williams' proposal can be incorporated into my analysis of questions as well:

(217) $Q = \lambda P\ [\exists j\ [P = \mu P'\ [\exists X\ [^{«}\text{student (a) (X)}\ \&$

$\forall Z\ [^{«}\text{student (a) (Z)}\ \&\ \text{form-orchestra (j) (Z)} \rightarrow Z \leq X]\ \&$ maximality

$\forall x\ {}_{a}\!\leq X$ distributivity

$[\exists Y\ [^{«}\text{student (a) (Y)}\ \&\ \exists p\ [p(j)\ \&\ P'(p)\ \&\ p = \lambda i\ [x\ {}_{a}\!\leq Y\ \&\ \text{form-orchestra}$

$\text{(i) (Y)}]]]]]]$

A compositional analysis of the above expression is possible if the following translations are adopted:

(218) *which* ≈> $\lambda P\ \lambda S\ \lambda Q\ [\exists X\ [P\ (a)\ (X)\ \&\ \forall Z\ [P\ (a)\ (Z)\ \&\ S\ (j)\ (Z) \rightarrow Z \leq X]\ \&$

$\forall x\ {}_{a}\!\leq X\ [\exists Y\ [P\ (a)\ (Y)\ \&\ Q\ (x)\ (Y)]]]$

form an orchestra ≈> $x\ {}_{a}\!\leq Y\ \&\ \text{form-orchestra (a) (Y)}$

In a world with three students Ann, Bill and Chris the above question has the following denotation:

(219) Q = {{Ann is a part of a group that forms an orchestra, Bill is part of a group that forms an orchestra},
{Ann is part of a group that forms an orchestra, Chris is part of a group that forms an orchestra},
{Bill is part of a group that forms an orchestra, Chris is part of a group that forms an orchestra},
{Ann is part of a group that forms an orchestra, Bill is part of a group that forms an orchestra, Chris is part of a group that forms an orchestra}}.

2.2.4 QVE of simple constituent questions with singular wh-phrases

Simple constituent questions with singular wh-phrases do not exhibit QVE. The following sentence is infelicitous:

(220) #John knows for the most part which student called.

In particular the sentence is not true if twenty students called and John knows of fifteen of them that they called. This is so because the singular wh-phrase presupposes that exactly one student called. The previously proposed semantics of questions in conjunction with a Dayal-style answerhood operator accounts for the uniqueness effects of singular wh-phrases. The minimality operator ensures that each element of the question denotation is a singleton set of propositions:

(221) which student called?

$\lambda P\ [\exists j\ [P = \mu P'\ [\exists x\ [student\ (a)\ (x)\ \&$

$\exists p\ [p(j)\ \&\ P'(p)\ \&\ p = \lambda i\ [call\ (i)\ (x)]]]]]]$

In a world with three students Ann, Bill and Chris the above expression has the following denotation:

(222) {{Ann called}, {Bill called}, {Chris called}}

Since each element of the question denotation is a singleton set of propositions, no possible answer has any proper parts. The question denotation by itself does not account for uniqueness effects of singular wh-phrases. It is possible that two possible answers, e.g. the proposition *Ann called* and the proposition *Bill called* are true in the same world. However, the maximality condition of the answerhood operator accounts for the uniqueness effect of singular wh-phrases. If more than one student called there is no maximal true answer to the question because e.g. neither the proposition *Ann called* nor the proposition *Bill called* is maximal in the sense that it entails the other proposition.

One last glitch is that Lahiri's definition of *most*$^{+}$ predicts that the sentence

(223) John knows for the most part which student called.

is true if exactly one student called and John knows the identity of the student who called. This is contrary to intuitions. The intuition is that (223) is infelicitous if exactly one student called because amount quantifiers such as *for the most part* quantify over entities that have proper subparts. If exactly one student called, the maximal true answer to the question is a proposition that does not have any proper parts. In order to account for this intuition I propose to modify the definition of $most^{+}$ in such a way that $most^{+}$ (P) (S) delivers a truth value only if the cardinality of the atomic parts of sup_P (P) is greater than one. The modified definition of $most^{+}$ predicts that (223) denotes nil if exactly one student called.

(224) $most^{+}(P)(S) = \begin{cases} 1 \text{ iff } |\psi(sup_P(P)| > 1 \ \& \\ \quad |\psi(sup_P(P) \otimes sup_P(P \cap S))| > \\ \quad |\psi(sup_P(P) \otimes (sup_P(P \cap S))^{-})|, \\ 0 \text{ iff } |\psi(sup_P(P)| > 1 \ \& \\ \quad |\psi(sup_P(P) \otimes sup_P(P \cap S))| \leq \\ \quad |\psi(sup_P(P) \otimes (sup_P(P \cap S))^{-})|, \\ \text{nil otherwise.} \end{cases}$

2.2.4.1 Compositional analysis of simple constituent questions with singular wh-phrases

Following Pafel (1999:276) I assume that the syntactic structure is enriched in such a way that there is a node U that takes the interrogative as complement and has the following translation:

(225) U ≈> λQ [λP [∃j [P = μP' [Q (j) (P')]]

(226) which student called?

CP:1
/ \
U:2 CP:3
/ \
DP_i:4 C':5
| / \
which student C:6 IP:7
|
t_i called

7: call (a) (x) t

7': λa [call (a) (x)] $<s,t>$

6: λq [∃p [P' (p) & p (j) & p = λi [q (i)]]] $<<s,t>,t>$

5: ∃p [P' (p) & p (j) & p = λi [call (i) (x)]] t

5' λx [∃p [P' (p) & p (j) & p = λi [call (i) (x)]]] $<e,t>$

4: $\lambda Q\ [\exists x\ [\text{student (a) (x)}\ \&\ Q\ (x)]]$ <<e,t>,t>

3: $\exists x\ [\text{student (a) (x)}\ \&\ \exists p\ [P'\ (p)\ \&\ p\ (j)\ \&\ p = \lambda i\ [\text{call (i) (x)}]]]$ t

3': $\lambda P'\ \lambda j\ [\exists x\ [\text{student (a) (x)}\ \&\ \exists p\ [P'\ (p)\ \&\ p\ (j)\ \&\ p = \lambda i\ [\text{call (i) (x)}]]]]$

<<<s,t>,t>,<s,t>>

2: $\lambda Q\ [\lambda P\ [\exists j\ [P = \mu P'\ [Q\ (j)\ (P')]]]]$

<<<<s,t>,t>,<s,t>>,<<<s,t>,t>,t>>

1: $\lambda P\ [\exists j\ [P = \mu P'\ [\exists x\ [\text{student (a) (x)}\ \&\ \exists p\ [P'\ (p)\ \&\ p\ (j)\ \&\ p = \lambda i\ [\text{call (i) (x)}]]]]]]$

<<<s,t>,t>,t>

2.3 Degree questions and the singular-plural distinction of wh-phrases

In the semantics of questions that has been introduced in the previous sections plural wh-phrases translate into expressions with maximality conditions in order to counteract the effects of the minimality operator. An apparaent problem for this analysis is that Beck & Rullmann (1999) provide two arguments against translating *how-many*-phrases into expressions with maximality conditions that determine maximal degrees. I discuss their arguments in turn and show that their analysis does not account for uniqueness effects of singular wh-phrases. Then I show that if *how-many* phrases introduce quantification over pluralities of degrees rather than quantification over degrees, uniqueness effects of singular wh-phrases can be accounted for and maximality conditions that determine maximal pluralities of degrees can be introduced into the semantics of questions.

Beck and Rullmann's (1999) first argument against maximality conditions is based on degree questions with upward scalar predicates, the second argument is based on degree questions with non-scalar predicates.

2.3.1 Minimality effects of degree questions with upward scalar predicates

Downward scalar predicates exhibit maximality effects. An answer to the question

(227) how many books did John read?

specifies the maximal number of books that John read. B&R (1999) point out that upward scalar predicates exhibit minimality effects rather than maximality effects. E.g. the answer to the question

(228) how many eggs are sufficient to bake this cake? (=29)

specifies the smallest rather than the largest number of eggs that is sufficient to bake the cake. Hence upward scalar predicates provide an argument against translating *how-many*-phrases into expressions that determine maximal degrees. B&R point out that both maximality effects and minimality effects of degree questions are accounted for if maximality applies at the level of propositions rather than at the level of degrees. The maximally informative answer to (227) specifies the maximal number of books that John read and the maximally informative answer to (228) specifies the minimal number of eggs that is needed to bake this cake. They adopt Heim's (1994) answerhood operator in order to determine maximally informative answers. The operator answer1 denotes the intersection of the propositions that are true in w.

(229) answer1 (w) (Q) = $\cap$\{p: Q (w) (p) & p (w)\}

The answerhood operator accounts for maximality effects of downward scalar predicates. B&R adopt a Hamblin-style semantics of questions in which questions denote sets of possible answers.

(230) how many books did John read?

$\lambda p\ \exists n\ [p = \lambda i\ [\text{John read n books in i}]]$

{John read one book, John read two books, John read three books}

If the propositions *John read one book* and *John read two books* are true in the actual world then the intersection of the two true propositions is *John read two books* because every world that is such that John read two books is also such that John read one book but not vice versa.

The answerhood operator also accounts for minimality effects of upward scalar predicates. Consider the following question and the set of possible answers that it denotes:

(231) how many eggs are sufficient to bake the cake?

$\lambda p\ [\exists n\ [p = \lambda i\ [\exists X\ [{*}egg\ (a)\ (X)\ \&\ sufficient\ (i)\ (X)\ \&\ n = |X|]]]]$

{one egg is sufficient, two eggs are sufficient, three eggs are sufficient, four eggs are sufficient, five eggs are sufficient}

If the actual world is such that three, four and five eggs are sufficient to bake the cake the intersection of these propositions is the proposition that *three eggs are sufficient to bake the cake* because every world that is such that three eggs are sufficient to bake the cake is also such that four and five eggs are sufficient to bake the cake but not vice versa. Hence the notion of maximal informativeness accounts for both maximality and minimality effects of degree questions.

2.3.2 Uniqueness effects of singular wh-phrases

Heim's (1994) answerhood operator does not account for uniqueness effects of questions with singular wh-phrases. In a world with two students, John and Mary, the translation of the question

(232) which student called?

$\lambda p\ [\exists x\ [student\ (a)\ (x)\ \&\ p = \lambda i\ [call\ (i)\ (x)]]]$

denotes the set of propositions {John called, Mary called}. If both John and Mary called the answerhood operator incorrectly generates the proposition *John and Mary called* as the maximal true answer to the question.

Dayal's (1996:116) answerhood operator accounts for uniqueness effects of singular wh-phrases and maximally informative answers of questions with downward scalar predicates and upward scalar predicates:

(233) Ans (Q) = $\iota p\ [p \in Q\ \&\ p\ (a)\ \&\ \forall p'\ [p'\ (a) \rightarrow p \subseteq p']]$

Minimality effects of upward scalar predicates are accounted for because if the actual world is such that three, four and five eggs are sufficient to bake the cake then the maximal true answer is that *three eggs are sufficient*. The answerhood operator also accounts for uniqueness. If the actual world is such that students John and Mary called then the question

(234) which student called?

does not have a maximal true answer because there is no entailment relation between the proposition *John called* and the proposition *Mary called*. In the next section we will see that Dayal's answerhood operator does not account for non-scalar predicates if B&R's (1999) semantics of degree questions with non-scalar predicates is adopted.

2.3.3 Questions with non-scalar predicates

Beck & Rullmann's (1999:264) second argument against translating *how-many* phrases into expressions with maximality conditions is based on non-scalar predicates. Non-scalar predicates exhibit neither maximality nor minimality effects. Consider the following question:

(235) how many people can play this game? (=43)

λp [$\exists$n [p = λi [poss(i) (λi' [$\exists$X [people (i') (X) &

n = |X| & play (i')(this_game)(X)]])]]]

{one person can play, two people can play, three people can play, four people can play, five people can play, six people can play}

If there is a game that can be played by two people this does not entail that it can also be played by one person or by three people, hence predicates such as *can be played* are non-scalar. If the game can be played by two, three, or six people then Heim's intersective answerhood operator accounts for the true answer to the question. The intersection of the elements of the question denotation that are true in the actual world is *this game can be played by two, three and six people*. Dayal's (1996) entailment-based answerhood operator incorrectly predicts that the question does not have a true answer in the actual world because the maximal true answer to the question is not element of the question denotation. I.e. the proposition *two, three and six people can play this game* is not element of the question denotation in (235). Only the three parts of the maximal true answer to the question are element of the question denotation. Thus, the problem is that Beck and Rullmann's (1999) semantics of degree questions with non-scalar predicates does not define a set that contains all complete, possible answers to the question. Instead it defines a set that contains all parts of all complete, possible answers.

2.3.4 Quantification over pluralities of degrees

Degree questions with non-scalar predicate denote the set of all complete, possible answers if *how many* is a quantifier over pluralities of degrees. E.g. the entity 2 + 4 + 6 is a plurality of degrees that has three atomic subparts, namely 2, 4 and 6. In the following expression N is a variable over pluralities of degrees. The symbol ≤ stands for the subpart relation:

(236) how many people can play this game?

λp [$\exists$N [p = [λi [$\forall$n ≤ N [poss(i) (λi' [$\exists$X [people (i') (X) &

n = |X| & play (i')(this_game)(X)]])]]]]]

{one person can play, two people can play, one and two people can play, three people can play, two and four and six people can play, ... }

Dayal's entailment-based answerhood operator can be used to determine maximal true answers to questions with non-scalar predicates. In a world in which two, four and six people can play this game, the maximal true answer is the proposition *two, four and six* *people can play this game*. It entails all the other elements of the question denotation that are also true in the actual world.

Quantification over pluralities of degrees also accounts for upward and downward scalar predicates.

(237) how many books did John read?

$\lambda p\ \exists N\ [p = \lambda i\ [\forall n \leq N\ [\text{John read n books in i}]]]$

{John read one book, John read one and two books, John read one and two and three books}

Since *read* is downward entailing the proposition *John read one and two books* is identical to the proposition *John read two books*, i.e. in every world in which John read two books he also read one book.

The possible answers to questions with upward scalar predicates have the form *n and ... and m eggs are sufficient* where n and m are natural numbers and n ≤ m.[46]

(238) how many eggs are sufficient to bake the cake?

$\lambda p\ [\exists N\ [p = \lambda i\ [\forall n \leq N\ [\exists X\ [\text{*egg (a) (X) \& sufficient (i) (X) \& } n = |X|]]]]]$

{one and two and ... and m eggs are sufficient, two and ... and m eggs are sufficient, three and ... and m eggs are sufficient, ... , m eggs are sufficient}

[46]The question denotation is not an infinite set of propositions if m is contextually restricted. E.g. m is the maximal number of eggs that is considered in a given context.

Since in every world in which two eggs are sufficient, three, four or more eggs are also sufficient, the proposition *two, three, four, ... and m eggs are sufficient* is identical to the proposition *two eggs are sufficient*.

2.3.5 Maximal pluralities of degrees

If *how-many* phrases are analysed as quantifiers over pluralities of degrees it is possible to (re-)introduce a maximality condition into the translation of *how-many* phrases, namely one that determines maximal pluralities of degrees rather than maximal degrees.

In particular, maximality conditions that determine maximal pluralities of degrees account for minimality effects of degree questions with upward scalar predicates. This is so because e.g. the plural degree 3 + 4 + ... + m is a subpart of the plural degree 2 + 3 + 4 + ... + m. Hence in a world in which two eggs are sufficient to bake the cake, 2 + 3 + 4 + ... + m is the maximal plurality N such that it is true for each element n of N that n eggs are sufficient to bake the cake.

(239) how many eggs are sufficient to bake the cake?

λp [$\exists$N [

$\forall$N' [$\forall$n' ≤ N' [$\exists$X [*egg (a) (X) & n' = |X| & maximality

sufficient (a) (X)]] $\rightarrow$ N' ≤ N] &

p (a) & p = λi [$\forall$n ≤ N [$\exists$X [*egg (a) (X) & sufficient (i) (X) & n = |X|]]]]]

Again, - because of the entailment properties of *be sufficient* - the singleton set of propositions {two and three and four and ... and m eggs are sufficient} is identical to {two eggs are sufficient}.

Questions with non-scalar predicates are also accounted for. In a world in which two, four and six people can play this game the following question translation denotes the singleton set of propositions {two, four and six people can play this game}.

(240) how many people can play this game?

λp [$\exists$N [

$\forall$N' [$\forall$n' $\leq$ N' [poss (a) (λw'' [$\exists$X [people (w'') (X) & maximality

n' = |X| & play (w'')(this_game)(X)]])] $\rightarrow$ N' $\leq$ N] &

p (a) & p = [λw' [$\forall$n $\leq$ N [poss(w') (λw'' [$\exists$X [people (w'') (X) & n = |X| &

play (w'')(this_game)(X)]])]]]]]

It also accounts for downward scalar predicates because if John read three books in the actual world then the maximal plurality of degrees N that is such that for every n that is a subpart of N it holds that John read n books is 1 + 2 + 3. The following question translation denotes singleton sets of propositions, namely the sets of propositions containing the maximal true answer to the question (or the empty set if there is no true answer to the question).[47]

[47]Rullmann (1995) has maximality conditions inside the definition of p in order to account for strongly exhaustive readings. Likewise if maximal pluralities of degrees are determined inside the definition of p, the strongly exhaustive reading is accounted for:

i. how many books did John read?

λp $\exists$N [p (a) & p = λi [$\forall$n $\leq$ N [John read n books in i] &

$\forall$N' [$\forall$n' $\leq$ N' [John read n' books in i] $\rightarrow$ N' $\leq$ N]]] maximality condition

(241) how many books did John read?

$\lambda p\ [\exists N\ [$

$\forall N'\ [\forall n' \leq N'\ [\text{John read } n' \text{ books in } a] \rightarrow N' \leq N]\ \&$ maximality

$p\ (a)\ \&\ p = \lambda i\ [\forall n \leq N\ [\text{John read } n \text{ books in } i]]]]$

In a world in which John read three books the above question translation denotes the singleton set of propositions {John read one and two and three books} which - because of the entailment properties of *read* - is identical to {John read three books}.

Since *how-many*-phrases can translate into maximality conditions that determine maximal pluralities of degrees a uniform semantics of questions is possible in which all types of questions denote sets of sets of propositions. *how-many*-phrases - like plural *which*-phrases - translate into maximality conditions in order to counteract the effects of the minimality operator:

(242) how many students called?

$\lambda P\ [\exists j\ [P = \mu P'\ [\exists N\ [$ minimality

$\forall N'\ [\forall n' \leq N'\ [\exists X\ [{*}student\ (a)\ (X)\ \&\ n' = |X|\ \&$ maximality

$\forall x \in X\ [call\ (j)\ (x)]]] \rightarrow N' \leq N]\ \&$

$\forall n \leq N$ distributivity

$[\exists p\ [p(j)\ \&\ P'(p)\ \&\ p = \lambda i\ [\exists X\ [{*}student\ (a)\ (X)\ \&\ n = |X|\ \&$

$\forall x \in X\ [call\ (i)\ (x)]]]]]]]]]$

{{one student called}, {one student called, two students called}, {one student called, two students called, three students called}, ...{one student called, two students called, ..., m students called}}

(243) how many eggs are sufficient to bake this cake?

$\lambda P\ [\exists j\ [P = \mu P'\ [\exists N\ [$ minimality

$\forall N'\ [\forall n' \leq N'\ [\exists X\ [{*}egg\ (a)\ (X)\ \&$ maximality

$sufficient\ (j)\ (X)\ \&\ n' = |X|]] \rightarrow N' \leq N]\ \&$

$\forall n \leq N$ distributivity

$[\exists p\ [p\ (j)\ \&\ P'(p)\ \&$

$p = \lambda i\ [\exists X\ [{*}egg\ (a)\ (X)\ \&\ sufficient\ (i)\ (X)\ \&\ n = |X|]]]]]]]]$

{{one egg is sufficient, two eggs are sufficient, three eggs are sufficient, ..., m eggs are sufficient},

{two eggs are sufficient, three eggs are sufficient, ..., m eggs are sufficient},

{three eggs are sufficient, ..., m eggs are sufficient}, ...,

{m eggs are sufficient}}

(244) how many people can play this game?

$\lambda P\ [\exists j\ [P = \mu P'\ [\exists N\ [$ minimality

$\forall N'\ [\forall n' \leq N'\ [\exists k\ [j \sim k\ \&\ \exists X\ [{*}person\ (k)\ (X)\ \&\ n' = |X|\ \&$ maximality

$play\ (k)\ (X)\ ]]] \rightarrow N' \leq N]\ \&$

$\forall n \leq N\ [$ distributivity

$\exists p\ [p\ (j)\ \&\ P'\ (p)\ \&\ p = \lambda i\ [\exists k\ [i \sim k\ \&\ \exists X\ [{*}person\ (k)\ (X)\ \&$

$n = |X|\ \&\ play\ (k)\ (X)]]]]]]]]]$

{{one person can play}, {one and two people can play},

{one and three people can play}, ...{two people can play}, ... ,

{two and four people can play}, ..., {two and four and six people can play}, ...}

2.3.5.1 Compositional analysis

The maximality condition is introduced by the determiner *how*:

(245) how $\approx\!> \lambda P\ \lambda S\ \lambda Q\ [\exists N\ [\forall N'\ [\forall n' \leq N'\ [\exists X\ [P\ (a)\ (X)\ \&\ S(j)\ (X)\ \&\ n' = |X|]] \rightarrow$
$N' \leq N]\ \&\ Q\ (X)]]$

Furthermore, like in B&R (1999) *x-many N* takes narrow scope. This assumption goes back to unpublished work by Karttunen who shows that if *how-many N* takes wide scope in a Karttunen-style semantics of questions the resulting translation does not account for the meaning of the question. The translation in (246a)

(246) how many students called?

a. $\#\lambda p\ [\exists n\ [\exists X\ [{*}student\ (a)\ (X)\ \&\ n = |X|\ \&\ p(a)\ \&$

$p = \lambda i\ [\forall x \in X\ [call\ (i)\ (x)]]]]]$

b. $\lambda p\ [\exists n\ [p(a)\ \&\ p = \lambda i\ [\exists X\ [student\ (a)\ (X)\ \&\ n = |X|\ \&\ \forall x \in X\ [call\ (i)\ (x)]]]]]$

denotes the set of propositions {p: there are n many students X such that p is true and p = all $x \in X$ called}. Thus, a proposition such as *Ann, Bill and Carl called* would be an answer to the question *how many students called?* The translation in (246b) denotes the set of propositions {p: there is a number n such that p is true and p = n students called} and accounts for the meaning of the question.

Beck (1996a) provides an argument for assuming that *how-many* phrases are reconstructed in syntax and not in semantics. Syntactic reconstruction allows for an explanation of negative island effects of *how-many* phrases in terms of violations of constraints on LF-movement, see Beck (1996a:200ff) and Beck (1996b) for details. Beck (1996a:133) discusses negative island effects of *how-many* phrases. E.g. the question

(247) wieviele Hunde hat Karl nicht gefüttert?

how many dogs has Karl not fed

how many dogs didn't Karl feed?

has only the reading in (248a) and not the reading in (248b):

(248) a. For which n: there are n dogs that Karl didn't feed.

b. For which n: it is not the case that Karl fed n dogs.

She also provides a situation that distinguishes the two readings. Suppose that there are five dogs alltogether and that Karl has fed three dogs, but that he has not fed the other two. If someone asked (247) the only possible true answer would be 'two', meaning: there are two dogs that karl didn't feed. It would not be possible to truthfully answer 'four', meaning: it is not the case that Karl fed four dogs. The interpretation in (248b) is not available because an LF-structure in which the negation intervenes between *wieviele*$_i$ and [t_i *Hunde]* is ruled out, see Beck (1996a:142).

(249) *[$_{CP}$wieviele$_i$ [$_{IP}$nicht [$_{IP}$ [t_i Hunde]$_k$ [Karl hat t_k gefüttert]

Summary:

I have shown that if *how-many* phrases introduce quantification over pluralities of degrees then degree questions denote sets containing all complete, possible answers to the question and Dayal's entailment-based answerhood operator can be used to account for uniqueness effects of singular wh-phrases and maximally informative answers. Also, wh-phrases can be translated into maximality conditions that determine maximal pluralities of degrees. This allows for a uniform analysis of questions in which all types of questions denote sets of sets of propositions.

2.3.6 Degree questions and QVE

Lahiri (to appear:197) observes that degree questions with downward and upward scalar predicates do not exhibit QVE. The following sentences are odd:

(250) a. ?*John knows for the most part how many books Jill read.
b. ?*John knows for the most part how many eggs are sufficient.

Degree questions with non-scalar predicates exhibit QVE:

(251) John knows for the most part how many players can play this game.

If this game can be played by 4, 6, 8, 9 and 20 players the above sentence is true if John knows that this game can be played by 4, 6 and 9 players. Lahiri (to appear) adopts B&R's (1999) analysis of degree questions. Questions with upward or downward scalar predicates do not allow QVE because the propositions in the question denotation do not qualify as the domain of an atomic Boolean Algebra. They are not logically independent of each other, i.e there is no world in which the proposition *Jill read one book* is false and the propositions *Jill read two books* or *Jill read three books* are true. Questions with non-scalar predicates allow QVE because the propositions that are element of the question denotation are logically independent. There are worlds in which the proposition *y-number* *of players can play this game* is false and any proposition of the form *x-number of players can play this game* with $x \neq y$ is true. Hence Lahiri's (to appear) analysis predicts that questions with non-scalar predicates allow QVE. However, since he adopts Heim's intersective answerhood operator, his analysis does not account for uniqueness effects of singular wh-phrases.

Let's start with QVE of questions with non-scalar predicates. The present analysis also accounts for QVE of questions with non-scalar predicates because the set denoted by '(Max-Ans(Q,C)) is the domain of an atomic Boolean Algebra.

(252) John knows for the most part how many people can play this game.
most^{+} ('(Max-Ans(Q, C)), λp [know (a) (j, p)])

Degree questions differ from *which*-questions in that the set determined by (Max-Ans(Q,C)) is not the set of atomic parts to the answer that makes C true. E.g. if Max-Ans(Q, C) equals the set of proposition {two people can play this game, four people can play this game, two and four people can play this game} then only the propositions *two people can play this game* and *four people can play this game* are atomic parts of the corresponding complete, possible answer *two and four people can play this game*. Hence, in order to test whether '(Max-Ans (Q,C)) is the domain of an atomic Boolean Algebra it is not possible to take (Max-Ans (Q,C)) as the set of atomic parts but atomic parts of the complete, possible answer have to be defined seperately. The set of atomic parts is determined by the following operator which states that every element of P that does not entail any other element of P is an atomic element of P.

(253) Atom (P) = $\{p: p \in P \ \& \ \neg\exists q \ [q \in P \ \& \ q \neq p \ \& \ q \supseteq p]\}$

As explicated in section 2.2.1.2, the set 'Q is the domain of an atomic Boolean Algebra, i.e. there is a 1-1 mapping from 'Q to Pow(Atom(Q)), if 'Q is closed under conjunction and every element of 'Q is the generalized intersection of a subset of Atom (Q). The function f defines the 1-1 mapping from elements of 'Q to elements of Pow(Atom (Q)): f (p) is the set S $\subseteq$ Atom (Q) such that p = $\cap$S.

The set '(Max-Ans (Q,C)) is closed under conjunction because of the definition of the '-operator. The following condition states that every element of Q is the generalized intersection of a subset of the set of atomic elements of Q:

(254) $\forall p \in Q \ [\exists S \subseteq \text{Atom}(Q) \ \& \ p = \cap S]$

Questions with non-scalar predicates allow QVE. E.g. if '(Max-Ans(Q,C)) equals {two people can play, four people can play, two and four people can play} it is the domain of an atomic Boolean Algebra. The set Atom ('(Max-Ans(Q,C))) equals {two people can play, four people can play} and every element of '(Max-Ans(Q,C)) is the generalized intersection of a subset of Atom ('(Max-Ans(Q,C))).

The above conditions also account for the fact that questions with downward scalar predicates do not allow QVE. If there are three students that called and if Q is the denotation of the question *how many students called?* and if C $\subseteq$ λp [p(a)], then '(Max-Ans(Q,C)) equals {one student called, one and two students called, one and two and three students called}. The set Atom ('(Max-Ans(Q,C))) has one element, namely the proposition *one student called* because it is the only proposition that does not entail any other proposition in the set. '(Max-Ans(Q,C)) is not the domain of an atomic Boolean Algebra because '(Max-Ans(Q,C)) does not fulfill the condition in (254). E.g. the proposition *one and two students called* is an element of '(Max-Ans(Q,C)) but it is not the generalized intersection of a subset of Atom ('(Max-Ans(Q,C))).[48]

If Q is the denotation of the question *how many eggs are sufficient?* then '(Max-Ans(Q,C)) is not the domain of an atomic Boolean Algebra either. If 20 is the maximal number of eggs that is considered in the context then Atom('(Max-Ans(Q,C))) equals {20 eggs are sufficient}. If three eggs are sufficient and C $\subseteq$ λp [p(a)] then the set '(Max-Ans(Q,C)) contains the proposition *three eggs are sufficient* which is not the generalized intersection of a subset of Atom('(Max-Ans(Q,C))).

[48]Lahiri's (to appear) condition of logical independence relies on a semantics of questions in which the denotation of *which*-questions and questions with non-scalar predicates defines sets of atomic propositions (which are logically independent of each other by definition) whereas the denotation of questions with upward and downward scalar predicates defines sets that also contain non-atomic propositions. Hence they are not logically independent of each other. Since in my analysis the denotation of questions with non-scalar predicates also defines sets that contain non-atomic propositions I cannot use Lahiri's condition of logical independence in order to determine which sets are domains of atomic Boolean Algebras.

2.4 QVE and strong exhaustiveness

Questions in QVE contexts provide an empirical argument against the assumption that strongly exhaustive readings derive from a question denotation that specifies the positive and negative extension of the main predicate. If there is a reading according to which the denotation of the question *who called* is identical to the denotation of the question *who did not call* then there should be a reading according to which the following two sentences are equivalent, however, such a reading does not exist.[49]

(255) a. John knows for the most part who called.
b. John knows for the most part who did not call.

Groenendijk & Stokhof (1993:17) claim that questions that exhibit QVE also have strongly exhaustive readings. However, unlike questions that do not exhibit QVE, strongly exhaustive readings of questions that exhibit QVE allow for some incorrect beliefs about the negative extension of the main predicate. They claim that the sentence

(256) John usually knows which girls sleep. (=48)

is true if John knows for most girls that sleep that they sleep and if his correct beliefs about whether or not a girl sleeps outnumber his incorrect beliefs about whether or not a

[49]Beck and Rullmann (1999) also mention this fact.

girl sleeps. Switching from *usually* to *for the most part* because Lahiri (1991) has shown that adverbs of frequency such as *usually* quantify over situations rather than parts of answers, G&S (1993) would assume that the sentence

(257) John knows for the most part who called.

is true in the following scenarios: 30 people called and John knows of 20 of them that they called and he also erroneously believes that some other two people called who actually did not call. The above sentence is also true if 30 people called and if John believes that 40 people called, including the 30 people that actually called. Hence he is mistaken about ten people. In both scenarios John has false beliefs about people that did not call. The sentence is not true if 30 people called and John believes that 70 people called, including all or some of the people that actually called. G&S (1993) put it this way:

(258) John knows for the most part which girls sleep.

a. of most girls who sleep, John knows that they are girls who sleep.

b. of few girls who don't sleep, John believes that they are girls who sleep.

In their analysis the weakly exhaustive reading accounts for the first entailment, the following expression accounts for both entailments except that G&S's derivation of it runs into a formal error.[50] (Notice that they switch from *know* to *tell*.)

(259) John usually tells which girls sleep.

$$MOST_x\ [[G(w)(x)\ \&\ S(w)(x)] \vee \exists w'\ [T_{j,w}\ (w')\ \&\ G(w')(x)\ \&\ S(w')(x)]]$$
$$[G(w)(x)\ \&\ S(w)(x)\ \&\ \forall w'\ [T_{j,w}\ (w')(x)\ \&\ S(w')(x)]]]$$

Thus the above sentence is true if most of the people that are girls and sleep in the actual world or that are such that in the actual world, John tells that they are girls and sleep are such that they are girls and sleep and John tells that they are girls and sleep.

If QVE is analysed as quantification over parts of answers as in Lahiri (1991, 2000, to appear) then the answers that adverbs of quantity quantify over are necessarily weakly exhaustive. This is so because the propositions that are atomic parts of the maximal relevant answer are necessarily weakly exhaustive. E.g. if John and Mary are the only individuals that called then the weakly exhaustive proposition *John called* is an atomic part of the maximal true answer to the question *who called?* but the strongly exhaustive proposition *John called and nobody else called* is not because it is not true in the actual world. If the atomic parts of an answer are weakly exhaustive, then the answer itself is also weakly exhaustive because it is the generalized intersection of its atomic parts. In the case at hand the intersection of the atomic parts of the (true) answer is the

[50]See section 2.1.3 for a discussion of G&S' (1993) analysis of QVE and why it runs into a formal error.

weakly exhaustive proposition *John and Mary called* and not the strongly exhaustive proposition *John and Mary called and nobody else called.* Hence a semantics of questions that defines atomic parts of answers in order to account for QVE necessarily defines weakly exhaustive question denotations. Thus Lahiri (1991) assumes that question denotations are weakly exhaustive. In order to account for strong exhaustiveness he defines an operator that turns weakly exhaustive question denotations into strongly exhaustive question denotations. But this operator cannot apply to questions in QVE contexts. Lahiri (to appear) does not provide an analysis of strong exhaustiveness in QVE contexts.

G&S's (1993) analysis of strongly exhaustive readings in QVE contexts can be mimiced in a semantics of questions that analyses QVE as quantification over plural propositions if the restriction of the adverb of quantification contains not not only propositions that are parts of the maximal answer that makes C true but also propositions that John believes and that are atomic parts of a possible answer to the question.

(260) John knows for the most part who called.

strongly exhaustive reading:

$most^{+}$ ['({p: p is a part of the maximal answer to the question that makes C true or p is an atomic part of a possible answer to the question and John believes p}]

[{p: p is a part of the maximal answer to the question that makes C true and John knows p}]

All_Atom (Q) defines the set of propositions that are atomic parts of any possible answer to Q:

(261) All_Atom (Q) = $\{p: \exists P\ [P \in Q\ \&\ p \in P\ \&\ \neg\exists q\ [q \in P\ \&\ q \neq p\ \&\ q \supseteq p]\}$

G&S's (1993) strongly exhaustive reading is captured by the following expression: (assuming that one's beliefs are closed under conjunction.)

(262) most^{+} ('(Max-Ans(Q, C) $\cup$ λp [believe (a) (j, p) & p $\in$ All_Atom (Q)]),
Max-Ans(Q,C) $\cap$ λp [know (a) (j, p)])

Strongly exhaustive readings are accounted for by a rule of adverbial binding that ensures that the restriction and nuclear scope of the adverb of quantity have the above values. Following Heim (1994) I assume that strongly exhaustive readings depend on the choice of the question-embedding predicate. In order to define a rule of adverbial binding that is sensitive to the question-embedding predicate I assume that the adverb of quantity adjoins to VP instead of to IP and that Interrogative raising adjoins the CP to VP instead of to IP .

(263)

```
              IP
           /      \
      DP_1          VP
       |          /      \
   John      CP_2          VP
               /  \          /     \
      who called    ADV           VP
                   /    \          /  \
           for the most part    t_1 knows t_2
```

The strongly exhaustive reading is accounted for by the following rule of adverbial binding:

(264) If ADV has the translation α^+ and κ dominates ADV and β, and furthermore, β has the translation λp [know (a) (x, p)], then

$$\lambda Q\ \alpha^+ \text{ ('(Max-Ans(Q, C)} \cup \lambda p \text{ [believe (a) (x, p) \& } p \in \text{ All\_Atom (Q)]),}$$
$$\text{Max-Ans(Q,C)} \cap \lambda p \text{ [know (a) (x, p)])}$$

is a translation of κ.

The present analysis also accounts for strongly exhaustive readings of embedded questions that do not exhibit QVE if Lewis' (1972) assumption is adopted that there is a silent universal quantifier. The following translation correctly rules out that John incorrectly believes that someone called who actually did not call.

(265) John knows who called.

all^{+} ('(Max-Ans(Q, C) $\cup$ λp [believe (a) (j, p) & p $\in$ All_Atom (Q)]),

Max-Ans(Q,C) $\cap$ λp [know (a) (j, p)])

Thus the above translation accounts for the following entailment which motivated G&S's (1982) strongly exhaustive question denotations:

(266) Only Bill called.

John believes that Bill and Suzy called.

$\Rightarrow$ John does not know who called.

Unlike G&S's (1982) analysis of strongly exhaustive de re readings the current analysis does not predict that the following sentences are equivalent:

(267) a. John knows who called.

b. John knows who didn't call.

They are not equivalent because if the adverb of quantity is the universal quantifier the strongly exhaustive reading of (267a) rules out that John has incorrect beliefs about propositions of the type *x called* whereas the strongly exhaustive reading of (267b) rules out that John has incorrect beliefs about propositions of the type *x didn't call*. Hence if Ann and Beth called and Carl did not call and John knows that Ann and Beth called but has no beliefs about whether or not any other people called the first sentence is true on the strongly exhaustive reading but the second sentence is false because John does not know that Carl did not call. Hence this version of strongly exhaustive readings accounts for Bromberger's example:

(268) Feynman knew in 1978 which elementary particles had been discovered in 1978.
≠> Feynman knew in 1978 which elementary particles had not been discovered in 1978.

Unlike G&S (1993) I claim that questions that exhibit QVE also have a 'strictly' strongly exhaustive reading that rules out that John has any incorrect beliefs about the negative extension of the question. This reading is more salient if the question-embedding predicate is a predicate that has to do with uncovering the truth such as *to uncover, to confess, to find out, ...*.

(269) a. John uncovered to a large extent who took bribes.
b. John confessed to a large extent who he had cheated in poker.
c. John found out to a large extend who had cheated on the exam.

The sentence in (269a) has a reading according to which it is not true if John uncovered for most people who took bribes that they had taken bribes but also falsely accuses some people of taking bribes that had not taken any bribes. Thus unlike the strongly exhaustive reading discussed by G&S (1993) the strictly strongly exhaustive reading of (269a) is not true if 30 people took bribes and John accuses 40 people of taking bribes even if the 40 people include the 30 people that actually took bribes. Hence on the strictly strongly exhaustive reading John can have incorrect beliefs about people that took brides but he cannot have incorrect beliefs about people that did not take bribes. In the framework of a semantics of questions in which QVE of embedded questions is analysed as quantification over plural propositions this means that John can have a limited amount of incorrect beliefs about propositions that are part of the maximal true answer but John cannot have incorrect beliefs about propositions that are atomic parts of possible answers to the question and not true in the actual world, i.e. he cannot incorrectly believe that Jones took bribes if Jones did not take bribes. The proposition *Jones took bribes* is an atomic part of a possible answer to the question *who took bribes?* but it is not a part of the maximal true answer to the question if Jones did not take bribes in the actual world. Strict strong exhaustiveness is accounted for if in addition to the truth conditions of the weakly exhaustive reading also the condition is true that all propositions p that are an atomic part of a possible answer to the question Q and that are believed by John are an atomic part of the maximal answer to the question Q that makes C true.

(270) $\forall p\ [p \in \text{All\_Atom}\ (Q)\ \&\ \text{believe}\ (a)\ (x\ ,p) \rightarrow p \in \text{Max-Ans}\ (Q, C)]$

Thus strongly exhaustive readings are accounted for if the weakly exhaustive reading is strengthened by an additional condition:

(271) John uncovered to a large extent who took bribes.

$most^{+}$ ('(Max-Ans (Q, C)), λp [uncover (j) (j, p)) &

$\forall$p [p $\in$ All_Atom (Q) & believe (a) (j,p) $\rightarrow$ p $\in$ Max-Ans (Q, C)]

If the adverb of quantity is the silent universal quantifier as in

(272) John uncovered who took bribes.

the strictly strongly exhaustive reading in

(273) all^{+} ('(Max-Ans (Q, C)), λp [uncover (j) (j, p)) &

$\forall$p [p $\in$ All_Atom (Q) & believe (a) (j,p) $\rightarrow$ p $\in$ Max-Ans (Q, C)]

is equivalent to the strongly exhaustive reading in:

(274) all^{+} ('(Max-Ans(Q, C) $\cup$ λp [believe (a) (j, p) & p $\in$ All_Atom (Q)]),

Max-Ans(Q,C) $\cap$ λp [uncover (a) (j, p)])

Assuming that strictly strongly exhaustive readings also depend on the question embedding predicate I propose that they are also accounted for by a rule of adverbial binding that is sensitive to the question-embedding predicate.

(275) If ADV has the translation α^+ and κ dominates ADV and β, and furthermore, β has the translation λp [uncover (a) (x,p)], then

$$\lambda Q\ \alpha^+ \ ('(\text{Max-Ans}\ (Q,C)),\ \lambda p\ [\text{uncover}\ (a)\ (x,p)])\ \ \&$$
$$\forall p\ [p \in \text{All\_Atom}\ (Q)\ \&\ \text{believe}\ (a)\ (x,p) \rightarrow p \in \text{Max-Ans}\ (Q, C)]$$

is a translation of κ.

The strictly strongly exhaustive reading also accounts for Bromberger's example.

2.5 Uniqueness effects of functional readings

Functional readings exhibit uniqueness effects. Answers that specify more than one function are infelicitous even if the functions express the same mapping in the actual world. E.g. even if it is the case that in the actual world the wine in front of every customer is the wine his boss recommended the following is infelicitous:

(276) There is one wine that no customer ordered and John knows which wine no customer ordered, namely the wine his boss recommended (#and the wine in front of him).

Hence functional answers name a pragmatically/contextually unique function. In most cases it is the function that specifies the reason why someone did something. E.g. the customers didn't order a certain wine because it was recommended by their boss.

Since the translation of the wh-phrase is in the scope of the minimality operator there is no answer in any world j unless there is a unique function that expresses the relevant mapping in j.

(277) which wine did no customer order?

$\lambda P\ [\exists j\ [P = \mu P'\ [\exists f\ [f =$

$\iota f_C'\ [\forall z\ [wine\ (a)\ (f'\ (z)\ (j))\ \&\ \neg\exists x\ [customer\ (a)\ (x\ (a))\ \&$ uniqueness

$order\ (j)\ (x\ (j),\ f'\ (x)\ (j))]]]\ \&$

$\exists p\ [P'\ (p)\ \&\ p\ (j)\ \&\ p = \lambda i\ [\neg\exists x\ [customer\ (a)\ (x\ (a))\ \&$

$order\ (i)\ (x\ (i),\ f\ (x)\ (i))]]]]]]]]$

The function f is of type <<s,e>,<s,e>>. The trace of the wh-phrase translates into f (x) (i) which is an expression of type e.

***2.6 Interrogatives embedded under* wonder**

Following Lahiri (1991) I assume that predicates such as *wonder* do not allow QVE because they do not take propositions but questions as arguments.

3. Chapter: Which elements allow pair list readings?

There is wide-spread agreement that questions with universal terms such as *every woman*, *each woman* allow pair list readings whereas questions with *no* do not allow pair list readings. There is less of an agreement whether questions with other elements allow pair list readings. Krifka (1992) and Srivastav (1992) argue that questions with plural definites do not allow pair list readings. Dayal (1996) claims that questions with numerals do not allow pair list readings either.

Since I adopt Pafel's (1999) minimality operator in order to define relevant answers the analysis predicts that not all elements allow pair list readings. This is so because if certain elements outscope the wh-phrase the minimal set of propositions in every world j is the empty set. In particular, the semantics of questions predicts that questions with *no* do not allow pair list readings because in this case the question denotes the empty set of sets of propositions. The analysis also accounts for the fact that questions with *most* do not allow pair list readings if it is taken into account that *most* is vague. It does not specify a precise cut-off point.

And the analysis predicts that questions with universal terms such as *every*, *each*, plural definites, *all* and *both* allow pair list readings. While this prediction is correct for questions with *every* and *each*, it is not correct for questions with plural definites, *all* or *both*. *Every* and *each* are inherently distributive whereas plural definites are not inherently distributive. *All* and *both* are not inherently distributive as Brisson (1998) has shown. Hence I follow Srivastav (1992) and assume that only inherently distributive elements allow pair list readings.

The minimality operator also predicts that if numerals are interpreted quantificationally questions as in *John knows which wine two customers ordered* only allow pair list readings if there are exactly two customers that ordered some wine. Since pair list readings of questions with numerals are not restricted to such contexts I analyse numerals as specific indefinites and adopt Reinhart's (1992, 1997) and Winter's (1997) choice-function analysis of specific indefinites. Contra Szabolcsi (1997) I show that questions with numerals allow pair list readings not only if they are embedded under extensional predicates such as *know* but also if they are embedded under intensional predicates such as *wonder* if a possessive pronoun is part of the numeral. Predicates such as *know* are factive. The factivity presupposition seems to facilitate a specific reading of the numerals. Predicates such as *wonder* are not factive. Possessive pronouns facilitate pair list readings, possibly because they are also presuppositional.

3.1 Previous accounts

3.1.1 Pair list readings and universal terms (Groenendijk & Stokhof 1983)

Groenendijk & Stokhof (1983:180) are the first to point out that not all scope bearing elements allow pair list readings. They point out that non-universal quantifiers such as *no*, *most, few* and *many* do not allow pair list readings:

(278) which woman does no man love?

John does not love Mary and Bill does nor love Suzy, ...

(279) which woman do most men love?

#John loves Mary, Bill loves Suzy, ...

(280) which woman do few men love?

#John loves Mary, Bill loves Suzy, ...

(281) which woman do many men love?

#John loves Mary, Bill loves Suzy, ...

They assume that only universal terms allow pair list readings but this does not follow from their analysis. Their analysis does not rule out quantification of non-universal terms into questions. In the following expression the quantifier *no* is quantified in:

(282) which woman does no man love?

= which woman does every man not love?

$\lambda i\ [\forall y\ [\text{man (a) (y)} \rightarrow \neg[\lambda x\ [\text{woman (a) (x) \& love (a) (y,x)}] =$

$\lambda x\ [\text{woman (i) (x) \& love (i) (y,x)}]]]]$

In a world in which there are three men Adam, Bill and Carl, and three women Mary Sue and Iva, and Adam loves Mary and Bill loves Sue and Carl loves Iva, the above expression denotes the following proposition: *Adam does not love Mary and Bill does not love Sue* *and Carl does not love Iva*. The proposition that is denoted by the question is necessarily false in the actual world. A question that does not have a true answer is strange, especially as a matrix question but this by itself does not rule out the above question denotation. Similarly, if the quantifier *two* is quantified in, the resulting question denotation is not appropriate to capture intuitions about what constitutes a possible answer to the question but the question has a well-formed denotation. E.g. the following question

(283) which woman do two men love?

$\lambda i\ [\exists_2 y\ [\text{man (a) (y)}\ \&\ [\lambda x\ [\text{woman (a) (x)}\ \&\ \text{love (a) (y,x)}] =$

$\lambda x\ [\text{woman (i) (y)}\ \&\ \text{love (i) (y,x)}]]]]$

denotes a proposition that is a disjunction of propositions: *[Adam loves Mary and Bill loves Sue] or [Adam loves Mary and Carl loves Iva] or [Bill loves Sue and Carl loves Iva]*. Thus the denotation does not account for the choice reading[51] of the question which would account for the fact that the question can be answered by any proposition that specifies for two men which woman they love, e.g. the proposition *Adam loves Mary and Bill loves Sue* would be a possible answer. But the above expression is well-formed and it has a denotation. Notice that G&S (1983) claim that quantifiers such as *two* do not allow

[51]Szabolcsi (1997:311) uses the term *choice reading* for pair list readings of questions with numerals because she uses the following paraphrase:

i. who did six dogs bite?
'for six dogs of your choice, who did they bite?'

pair list readings. This changes in chapter six of their dissertation. (G&S 1983 is chapter three of their dissertation.)

Groenendijk and Stokhof (1983):

universal terms	non-universal terms
every man, each man, the men, the two men, both men, all the men	no man, any man, few men, many men, most men, two men, at least two men, at most two men, exactly two men

Summing up, G&S (1983) make the empirical claim that only universal terms allow pair list readings but this does not follow from their analysis of questions with quantifiers.

3.1.2 The minimal non-empty witness set theory (Groenendijk & Stokhof 1984)

Groenendijk & Stokhof chapter six (1984:511ff) assume that quantifiers that have minimal non-empty witness sets allow pair list readings. The witness set of a generalized quantifier GQ is a subset of the set A that the generalized quantifier lives on, see Barwise & Cooper (1981:191). The property 'live on' has the following definition, see Barwise & Cooper (1981:178):

(284) A generalized quantifier GQ lives on a set A iff for any set B,

$$B \in GQ \Leftrightarrow B \cap A \in GQ.$$

(285) A witness set for GQ is a set W such that $W \subseteq A$ and GQ lives on A and $W \in GQ$.

Minimal witness sets W of a generalized quantifier GQ are witness sets of GQ that do not have any subsets that are also elements of the generalized quantifier:

(286) A minimal witness set for GQ is a set W such that $W \subseteq A$ and GQ lives on A and $W \in GQ$ and for no $W' \subset W$, $W' \in GQ$.

The generalized quantifier *every man* has a unique minimal witness set, namely the set of all men, the generalized quantifier *two men* has potentially many minimal witness sets, namely as many sets as there are sets of two men, downward monotone quantifiers such as *no* and *few* have the empty set as unique minimal witness set. Thus according to G&S (1984) not only universal quantifiers such as *every* and *each* but also non-universal quantifiers such as *two* allow pair list readings.

(287) Which wine did two customers order? pair list
Customer A ordered Bordeaux and customer B ordered Chardonnay.

G&S (1984) do not discuss questions with *most*. Questions with *most* do not allow pair list readings:

(288) Which wine did most customers order? no pair list

#Customer A ordered Bordeaux and customer B ordered Chardonnay.

G&S (1984) account for the lack of pair list readings with *most* if *most* is vague in the sense that it does not define a clear cut-off point, see section 3.2.2.

G&S (1984):

quantifiers that have minimal non-empty witness sets:	quantifiers that do not have minimal non-empty witness sets:
every man, each man, the men, all men, the two men, two men, at least two men, more than two men, exactly two men, both men,	no man, few men, at most two men, fewer than two men, (most men),(many men)

3.1.3 The unique minimal non-empty witness set theory (Chierchia 1991)

Chierchia (1991:82) assumes that all quantifiers that have a generator set allow pair list readings. Hence Chierchia (1991) claims that only universal terms allow pair list readings. Empirically this is the same claim that G&S (1983) made. Chierchia (1991) adopts Engdahl's (1986) functional analysis of pair list answers according to which pair list answers are the spell out of a functional answer. Pair list answers are possible if the quantifier provides a generator set. The list of the pair list answer is the extrinsic definition of the function that maps each element of the generator set into some value.

3.1.4 Questions with plural definites (Srivastav 1992, Krifka 1992, Dayal 1996)

Srivastav (1992) & Krifka (1992) - as a reaction to Pritchett (1990) - independently make the point that questions with plural definites do not allow pair list readings. Both point out that questions with plural definites only allow pair list answers if the wh-phrase is plural as in the following example taken from Krifka (1992:158):

(289) which movies did the boys rent last night?
John rented Wings of Desire, Peter rented City of Sadness and Carl rented Stranger than Paradise.

If the wh-phrase is singular as in the following example a pair list answer is not possible:

(290) which movie did the boys rent last night?
#John rented Wings of Desire, Peter rented City of Sadness and Carl rented Stranger than Paradise.

Both Srivastav and Krifka analyse the apparent pair list answer of questions with plural wh-phrases and plural definites as a spell out of a cumulative reading of the question. Dayal (1996:143) proposes that list answers of the form a_1 R b_1, ..., a_n R b_n to a question Q are accetable iff $a_1 + ... + a_n$ R $b_1 + ... + b_n$ is an answer to the question Q.

Additional evidence for their claim that questions with plural definites do not allow pair list readings comes from the fact that in genuine pair list answers the number feature of the wh-phrase determines whether each boy rented exactly one movie or more than one movie. If the wh-phrase is singular each boy rented exactly one movie:

(291) which movie did every boy rent?
John rented Wings of Desire and Peter rented City of Sadness (*and Stranger than Paradise).

If the wh-phrase is plural each boy rented more than one movie:

(292) which movies did every boy rent?
John rented Wings of Desire and Full Moon over Paris and Peter rented City of Sadness *(and Stranger than Paradise).

In cumulative readings the set of boys is mapped into the set of movies. Hence any boy can rent one or more movies even though the wh-phrase is plural:

(293) which movies did the boys rent?
John rented Wings of Desire and Peter rented City of Sadness and Stranger than Paradise.

Srivastav (1992) adopts Chierchia's (1991) analysis of pair list readings according to which pair list readings are a spell out of a functional answer and they are restricted to elements that have a generator set. She assumes that plural definites denote pluralities and that the generator set of plural definites contains exactly one element, namely the plurality denoted by the definite. If the generator set contains only one element the pair list answer is indistinguishable from the individual answer because the pair list answer contains only one mapping. Hence Srivastav makes the implicit assumption that it is not possible to insert a distributivity operator in order to get a pair list reading. I come back to this point in section 3.2.4.

In Krifka (1992:158) plural definites do not allow pair list readings because they are not quantificational. They are interpreted in situ. Krifka assumes that only quantificational NPs undergo QR. He also tacitly assumes a scope analysis of pair list readings in which the non-wh-quantifier outscopes the wh-phrase.

Dayal (1996:120 fn 31) like Srivastav (1992) assumes that plural definites do not allow pair list readings. However, the explanation has changed a little. Dayal (1996) adopts a version of the minimal-witness theory in order to account for the restrictions on pair list readings. According to any variety of the witness set theory only quantificational elements allow pair list readings because only quantifiers have witness sets. Plural definites do not allow pair list readings because Dayal (1996) does not analyse them as quantifiers.

In order to rule out pair list readings of questions with quantifiers such as *most* and *many* Dayal (1996) assumes that only quantifiers that have unique minimal non-empty witness sets allow pair list readings. Hence only universal quantifiers allow pair list readings. Numerals such as *two* do not allow pair list readings either because they do not have unique minimal witness sets. Dayal (1996:120 fn 31) assumes that numerals - like definites - only allow pair list answers that are the spell out of a cumulative reading.

Hence she predicts that questions with numerals only allow pair list answers if the wh-phrase is plural.

(294) which movies did two boys rent?
John rented Wings of Desire and Peter rented City of Sadness and Stranger than Paradise. cumulative reading

If the wh-phrase is singular pair list answers are ruled out:

(295) which movie did two boys rent?
#John rented Wings of Desire and Peter rented City of Sadness.
no pair list reading

Dayal (1996:143 fn 48) points out that her analysis accounts for the fact that questions with *both* do not allow pair list answers:

(296) which movie did both boys rent?
#John rented Wings of Desire and Peter rented City of Sadness.
no pair list answer

On the assumption that *both* is the distributive version of *the two* pair list readings with *both* and singular wh-phrases are ruled out because *both* is not a quantifier and the notion of witness set does not apply. Questions with *both* also do not allow pair list answers that are a spell out of a cumulative reading:

(297) which movies did both boys rent?
#John rented Wings of Desire and Peter rented City of Sadness and Stranger than Paradise. no pair list answer

This follows from Dayal's (1996:143) assumption that *both* is inherently distributive. All possible individual answers to (297) are such that each of the two boys saw the same set of movies. The possible answers can be paraphrased as follows: There exists a set of movies X such that each of the two boys saw X. Hence a possible individual answer is: b1 saw m1, m2 and m3 and b2 saw m1, m2 and m3. This answer cannot be spelled out as a list of the form: b1 saw m1 and b2 saw m2 and m3.

However, Brisson (1996, 1998) argues that *both* is not inherently distributive. She points out that while it is true that floating *both* does not combine with all collective predicates, there are some collective predicates that floating *both* combines with:

(298) a. *John and Mary are both a happy couple.
b. *John and Mary are both married. (on the *each other* reading)
c. Les and Lee both collided.

Brisson (1996, 1998) assumes that *both* is purely presuppositional. *both* carries the following presupposition:[52]

(299) An expression of the form Y *both* Z (where Y is a conjoined NP of the form (a + b) and Z is a VP) presupposes Z (a) $\vee$ Z (b).

E.g. the sentence *Mary and Sally are both tall* presupposes that *tall (m)* $\vee$ *tall (s)* and asserts that *tall (m) & tall (s)*. She adopts Stalnacker's (1973, 1978) view that assertions shrink the context set. This is the case here. (298a) is illicit because there is no context that presupposes happy.couple (j) $\vee$ happy.couple (m). In order to account for (298c) Brisson (1996, 1998) points out that *collide* has an asymmetrical transitive paraphrase and that there are contexts that entail the following paraphrase: *collide.into.les (p)* $\vee$ *collide.into.pete (l)*. And asserting *collide (l+p)* shrinks the context set. (298b) also has a transitive paraphrase, but it is symmetrical: *married.to.Mary (j)* $\vee$ *married.to.John (m)*. Any world in which the first disjunct is true is also such that the second disjunct is true. Hence asserting that *marry (j+m)* does not shrink context set. Support for her view stems from the fact that *both* combines with symmetrical predicates if they are made asymmetrical:

(300) John and Mary both willingly married. (on the *each other* reading)

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[52]A similar proposal about the presupposition associated with *both* was made by Edmondson (1978).

Brisson (1998:231) distinguishes two senses of prenominal *both*. There is conjunction *both* which is inherently distributive and does not combine with any kind of collective predicates:

(301) Both John and Mary answered the phone.

*Both John and Mary collided.

Hence Dayal's (1996) explanation why *both* does not allow pair list answers if the wh-phrase is plural does not hold up.

Dayal (1996) does not discuss *all*. Her analysis predicts that *all* - like *both* - does not allow pair list readings if *all* is non-quantificational as Brisson (1997) proposes.[53] And indeed questions with *all* and singular wh-phrases do not allow pair list readings:

(302) which movie did all the boys rent?

#John rented Wings of Desire and Peter rented City of Sadness

no pair list answer

However, Brisson (1997) also points out that *all* - like *both* - is not necessarily distributive. It can combine with collective predicates such as *gather*:[54]

However, other than Brisson (1996) he also takes *both* to be distributive.

[53] Brisson (1997) claims that questions with *all* do not allow pair list readings.

[54] *All* does not combine with all collective predicates.

i. *The boys are all a big group.

Brisson (1997) adopts Taub's (1989) generalization that the collective predicates that allow *all* are activities or accomplishments whereas the collective predicates that do not allow *all* are states or achievements.

(303) All the students gathered in the hallway.

Hence Dayal (1996) predicts that *all* allows pair list answers that are the spell out of a cumulative reading which does not seem to be the case:

(304) which movies did all the boys rent?

?*John rented Wings of Desire and Peter rented City of Sadness and Stranger than Paradise. no pair list answer

Dayal (1996):

quantifiers that have a unique minimal non-empty witness set:	quantifiers that do not have a unique minimal non-empty witness set or non quantificational elements:
every man each man	no man, few men, most men all the men (cumulative reading?) both men (*cumulative reading) the men (cumulative reading) these men (cumulative reading) two men (cumulative reading) at least two men (cumulative reading) at most two men (cumulative reading)

While there is no explanation why there is this correlation Brisson's analysis of *all* in terms of pragmatic strengthening correctly predicts that only the first class of predicates allows pragmatic strengthening:

ii. The boys -- in fact all the boys -- gathered in the hallway.

iii. *The boys -- in fact the entire lot of them -- are a big group.

Summing up: Dayal (1996) predicts that elements that are not universal quantifiers such as plural definites and numerals only allow pair list answers that are a spell out of cumulative readings. Hence they only allow pair list answers if they are not inherently distributive and if the wh-phrase is plural.

3.1.5 The non-empty witness set theory (Szabolcsi 1997)

Szabolcsi (1997) makes two points. One point is that modified numerals allow pair list readings and since some of them have minimal witness sets and some of them do not have minimal witness sets the property of having a minimal witness set does not define the class of elements that allow pair list readings. Szabolcsi (1997) unfortunately uses *who* which is not marked for number and which allows cumulative readings on its plural interpretation. She sets up the following context: people try to find out how dangerous each neighborhood dog is, and they make lists about which dog has bitten who. Then they get together and compare notes. According to Szabolcsi pair list readings have the following distribution:

(305) a. I found out who three dogs bit.

b. I did a lot better! I found out who more than five dogs bit.

c. John is not here but I have glanced over his list, and I estimate that he found out who more than five but certainly fewer than ten dogs bit.

d. And I know that Judy found out who exactly four dogs bit.

e. ?Bill was very lazy. he only found out who at most three dogs bit.

f. *Mary is even worse: she found out who no dog bit.

g. Don't worry; I think we now know who every dog bit.

three, more than five and *every* are monotone increasing, *at most three* is monotone decreasing (for some unknown reason the *only* is needed to get the pair list reading), and *more than five but certainly fewer than ten* and *exactly four* are non-monotonic. Szabolcsi concludes from this that the only quantifier that does not allow pair list readings is *no*. *no* has the empty set as unique witness set. Szabolcsi (1997) restricts pair list readings to quantifiers that have non-empty witness sets. [55]

[55]Szabolcsi (1997) also modifies the semantics of questions such that it accounts for non-monotonic quantifiers. I will ignore non-monotonic quantifiers because they pose additional problems that are beyond the topic of semantics of questions.

Szabolcsi (1997):

quantifiers that have a non-empty witness set	quantifiers that do not have a non-empty witness set
every man, each man, two men, at least two men, at most two men, exactly two men, the men, most men, few men, all men, both men	no man

discussion:

Szabolcsi (1997) uses *who* which is not marked for number. Her point that monotone decreasing and non-monotonic quantifiers allow pair list readings does not go through with singular *which*-phrases:

(306) which wine did less than three customers order? ?* pl

Which wine did exactly three customers order? ?* pl

Szabolcsi's (1997) second point is that the choice of question-embedding predicate also determines which elements allow pair list readings. According to Szabolcsi (1997:321) questions embedded under extensional predicates such as *find out* and *know* allow pair list readings with any quantifier that has a non-empty witness set whereas matrix questions and questions embedded under intensional predicates such as *wonder* only allow pair list readings with universal quantifiers:

(307)	a. John wonders which boy every dog bit.	pair list	(=27)
	b. John wonders which boy more than two dogs bit.	??pair list	

(308)	a. which boy did every dog bite?	%pair list[56]	(=23)
	b. which boy did more than two dogs bite?	*pair list	(=24)

Szabolcsi (1997) adopts Groenendijk & Stokhof's (1984:chapter six) semantics of questions. They point out that universal quantifiers can be quantified into questions of type <s,t> whereas questions with non-universal quantifiers have to be of higher types in order to account for the choice reading.

discussion:

Contrary to what Szabolcsi (1997) claims there are questions that are embedded under intensional predicates and that allow pair list readings with numerals. The pair list reading becomes more readily available if the numeral contains a bound pronoun:

(309)	a. John wonders which grade two students got in semantics.	??pair list
	b. John wonders which grade two of his students got in semantics.	pair list

[56]The % sign means that not every informant got a pair list answer. This judgement holds for all pair list answers with singular wh-phrases.

3.1.6 Pair list readings and speech acts (Krifka 1999)

Krifka (1999) makes the same empirical claims as Szabolcsi (1997). The novelty of his approach is that pair list readings of matrix questions and questions embedded under intensional predicates are analysed as conjunctions of question speech acts. Universal quantifiers can move out of speech acts because they can be interpreted as conjunction of speech acts:

(310) which dish did every boy make?
[[every boy]$_i$ [QUEST [which dish t_i made]]]
which dish did Al make and
which dish did Bill make and
which dish did Carl make?

Non-universal quantifiers cannot move out of speech acts because they cannot be interpreted in terms of speech act conjunction alone. They require disjunction as well and Krifka provides evidence that speech act disjunction is not possible.[57]

(311) which dish did two boys make?
which dish did Al make and which dish did Bill make or
which dish did Bill make and which dish did Carl make or
which dish did Al make and which dish did Carl make?

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[57] Krifka ms. points out that baptisms and curses can not be disjoined:
i. I hereby baptize you John, or i hereby baptize YOU Mary. (=42)

Intensional verbs do not allow pair list readings of non-universal quantifiers because quantifier raising is cyclic and the quantifier must be interpretable at every landing site. However, it is not interpretable in the intermediate trace position.

(312) [[most boys]$_i$ [Doris wonders[t_i [QUEST [which dish t_i made]]]]]

Questions embedded under extensional predicates do not denote speech acts but question radicals. Therefore the quantifier can move out of the interrogative:

(313) Doris knows which dish most boys made.
Doris knows [most boys [which dish t made]]
most boys [Doris knows [t [which dish t made]]]

discussion:

The empirical points that I made against Szabolcsi's (1997) proposal also hold for Krifka. In particular, I claim that pair list readings of questions embedded under intensional predicates are not restricted to universal quantifers. Hence restricting pair list readings to questions with universal terms is empirically not adequate and the notion of speech act conjunction does not make a relevant distinction. Notice also that it is hard to modify

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ii. You are an idiot, or you are a fool! (=43)

Krifka's proposal such that it accounts for pair list readings of non-universal quantifiers unless one allows speech act disjunction. Since Krifka provides empirical evidence against speech act disjunction this modification is not viable.

3.1.7 The minimality operator and kinds of propositions (Pafel 1999)

Pafel's minimality operator - which is independently motivated, it is needed to determine relevant answers in a semantics of questions in which answers can be plural propositions - restricts the set of elements that allow pair list answers. In particular Pafel's minimality operator predicts that universal quantifiers, plural definites and NPs with *both* and *all* allow pair list readings because if those elements outscope the wh-phrase the resulting question denotation is potentially non-empty. Hence - unlike any variety of the witness-set theories - Pafel's minimality operator does not distinguish between quantificational and non-quantificational elements. The minimality operator analysis correctly predicts that questions with *no* do not allow pair list readings because the resulting translation of the question denotes the empty proposition $\varnothing_{<s,t>}$. (I assume in analogy to the subset relation that the empty proposition is a subpart of any proposition.) The following expression denotes the empty proposition:

(314) which novel did no critic review?

$\mu p\ [\neg\exists x\ [critic\ (a)\ (x)\ \&$

$\exists y\ [novel\ (a)\ (y)\ \&\ \ review\ (a)\ (x,y)\ \&$ factivity

$\forall y'\ [novel\ (a)\ (y')\ \&\ review\ (x,y') \rightarrow y' \leq y]\ \&$

maximality

$\lambda i\ [review\ (i)\ (x,y)]\ \leq p]]]$

Pafel (1999:283) points out that if a numeral quantifier outscopes the wh-phrase as in (315) the translation of the question denotes nil if four critics reviewed some novel.

(315) which novel did three critics review?

$\mu p\ [\exists X\ [*critic\ (a)\ (X)\ \&\ three\ (X)\ \&$

$\forall x\ [atom\ (x,\ X,\ \lambda x'\ [critic\ (a)\ (x')]) \rightarrow$

$\exists y\ [novel\ (a)\ (y)\ \&\ \ review\ (a)\ (x,y)\ \&$ factivity

$\forall y'\ [novel\ (a)\ (y')\ \&\ review\ (x,y') \rightarrow y' \leq y]\ \&$

maximality

$\lambda i\ [review\ (i)\ (x,y)]\ \leq p]]]]$

The reason is that there is no minimal proposition that is a true answer to the question. In order to account for pair list readings of questions with numeral quantifiers Pafel (1999:291ff) proposes that some questions denote kinds of propositions. Pafel (1999:293) assumes that interrogatives denote the smallest kind such that for all x, x instantiates the kind if x is ϕ.

(316) $\sigma k\ [\forall x\ [x \text{ Inst } k \leftrightarrow \phi\ (x)]]$ (=78)

= the kind which is 'smallest' with respect to ϕ.

Inst means instantiation and relates kinds to their instances, see Krifka et al. (1995). $Two_v\ (x, <\phi(v)>)$ is true iff $f_v(x,<\phi(v)>) = 2$. f is a function that assigns to each plurality relative to a concept or open proposition $\phi(v)$ the number of its individuals. Pafel (1999:293) assumes that the embedded interrogative in (317) describes the kind @ every instance of which is a plurality of at least two propositions of the form *x lives at y*, x being a unicorn and y being a place.

(317) I wonder where two unicorns live. (=80)

$\sigma k\ [\forall p\ [p \text{ Inst } k \leftrightarrow \exists X\ [Two_v\ (X, <{}^{*}unicorn(v)>)\ \&$

$\forall x\ [atom\ (x, X, \lambda x'\ [unicorn\ (a)\ (x')]) \rightarrow$ distributivity

$\exists y\ [{}^{*}place\ (a)\ (y)\ \&\ live\ (a)\ (x,y)\ \&$ factivity

$\forall y'\ [place\ (a)\ (y')\ \&\ live\ (a)\ (x,y') \rightarrow y' \leq y]\ \&$ maximality

$\lambda i\ [live\ (i)\ (x,y)] \leq p]]]]]$

Pafel (1999:294) - like G&S (1982) and Chierchia (1993) - assumes that questions with monotone decreasing quantifiers do not allow pair list readings. Pair list readings of questions with monotone decreasing quantifiers are ruled out because they result in 'funny' kinds. Pafel (1999:294) illustrates this with the following example:

(318) a.?? Ich möchte wissen was nicht jeder Kritiker für einen Roman rezensiert hat.

I would like to know what kind of novel not every critic reviewed.

b. [[nicht jeder Kritiker]$_i$ [[was für einen Roman]$_j$ [t_i hat t_j rezensiert]]]

c. $\sigma k\ [\forall p\ [p \text{ INST } k \leftrightarrow \neg\forall x\ [x \ {*}{\leq}\ a \oplus b \oplus c \oplus d]\ \&$ (=81c)

$\exists y\ [\text{Kind-of-novel } (a)\ (y)\ \&\ \text{Reviewed } (a)\ (x, y)\ \&$

$\forall y'\ [\text{Kind-of-novel } (a)\ (y')\ \&\ \text{Reviewed } (a)\ (x,y') \rightarrow y' \leq y]\ \&$

$\lambda i\ [\text{Reviewed } (i)\ (x,y)] \leq p]]$

(a, b, and c are the critics of the actual world).

According to Pafel (1999:294) (81c)

> "describes a kind that has each thing as an instance except the pluralities consisting at least of the propositions of the form 'x reviewed y', x being one of our four critics and y being the kind of novel x reviewed. Assuming that the embedded clause is supposed to denote 'propositional entities' (i.e. propositions or kinds of propositions), the missing restriction to pluralities of propositions might account for the unacceptability of (81c))."

I do not know what Pafel means by 'missing restriction to pluralities of propositions'. Maybe one could say that the the kind that is denoted by (81c) is not a 'natural' kind and therefore the question denotation in (81c) is illicit. The term 'natural' has also been used in the functional analysis of pair list readings in order to rule out certain functions that are not natural.

Pafel (1999:294 fn39) points out that Beck (1996) provides an alternative analysis for why (81c) is ungrammatical. Notice that the question contains a *was-für* split.

According to Beck (1996) the *was-für* split is blocked by intervening negation which is the case in (81c). However, Beck's theory does not explain why negative quantifiers such as *nobody* do not allow pair list readings if the wh-phrase is not a *was-für* construction:

(319) Ich möchte wissen wieviele Romane kein Kritiker rezensiert hat.
I want to know how many novels no critic has reviewed.

Pafel (1999:260 fn6) does not agree with Szabolcsi's (1997) claim that pair list readings of questions with non-universal quantifiers depend on the question embedding predicate. He claims that even if the question embedding predicate is extensional the embedded question does not necessarily allow pair list readings. Pafel claims that if the wh-phrase is a singular *which*-phrase it cannot be outscoped by any quantifier: [58]

(320) Fritz weiß welchen Jungen mehr als zwei Hunde gebissen haben. no pl
Fritz knows which boy more than two dogs bit.

Pafel (1999:293) also provides an example of a question embedded under the intensional predicate *wonder* that allows pair list readings with a non-universal quantifier, however, the wh-phrase is *where* which is not specified for number. Hence the apparent pair list reading could be the spell out of a cumulative reading. Pafel (1999) does not discuss Krifka (1992) or Srivastav (1992).

(321) I wonder where two unicorns live. pl ok (=80)

Pafel (1997, 1999) assumes that the availability of pair list readings follows from a general theory of scope that determines which elements can outscope which elements. Hence pair list readings depend not only on the properties of the non-wh-quantifier but also on the properties of the wh-phrase. Some of his data will be discussed in the next section.

Pafel (1997:109ff) provides a multi-factor analysis of scope relations. He proposes that scope relations depend on the interaction of several factors such as syntactic constellation, grammatical function, thematic properties, distributivity, focus, lexical discourse binding, structural discourse binding, attraction of negation. Pafel assigns a weight to each criterion and computes the set of possible scope relations according to those weights.

discussion:

While I agree that - descriptively speaking - several factors play a role in determining how readily questions allow pair list readings I do not adopt an extra device that computes scope relations. Instead I find it more desirable to develop a theory in which these factors

[58]Notice that the non-universal quantifier is a modified numeral. I assume that unmodified numerals allow pair list readings whereas modified numerals don't.

fall out of the syntactic and semantic analysis of the elements that are part of the question.

Summary:

There are two strategies to define which elements allow pair list readings. One strategy is to define the class of elements that allow pair list readings by naming a property that all the elements that allow pair list readings have in common. Any theory that uses the notion of witness sets is such a theory. E.g. G&S (1982) and Chierchia (1993) claim that only quantifiers that have minimal non-empty witness sets allow pair list readings, Dayal (1996) claims that only quantifiers that have unique minimal non-empty witness sets allow pair list readings. The other approach is that the question denotation itself is such that it allows only pair list readings with certain elements. E.g. Pafel's (1999) minimality operator predicts that questions with *no* do not allow pair list readings. In the following I persue the second approach.

3.2 Pair list readings and minimality

Since I adopt Pafel's minimality operator in order to define relevant answers my analysis makes the prediction that questions with *every*, *each*, plural definites, *all* and *both* allow pair list readings whereas questions with *no* do not. In order to account for the fact that questions with plural definites, *all* and *both* do not allow pair list readings I follow

Srivastav (1992) and assume that this has to do with the fact that they are not inherently distributive.

Questions with *most* do not allow pair list readings because *most* is vague, i.e. it does not define a specific cut-off point. Questions with numerals allow pair list readings if the numeral has a specific interpretation and translates into a choice function.

3.2.1 Questions with *no*

The semantics of questions developed in the last chapter predicts that questions with *no* do not allow pair list readings. If *no* outscopes the wh-phrase as in the following translation:

(322) which wine did no customer order?

$$\lambda P\ [\exists j\ [P = \mu P'\ [\neg\exists x\ [\text{customer (a) (x)}\ \&\ \exists y\ [\text{wine (a) (y)}\ \&$$
$$\forall y'\ [\text{wine (a) (y')}\ \&\ \text{order (j) (x,y')} \rightarrow y' \leq y]\ \&$$
$$\exists p\ [P'(p)\ \&\ p\ (j)\ \&\ p = \lambda i\ [\text{order (i) (x, y)}]]]]]]]$$

the resultiong expression denotes the empty set of sets of propositions $\varnothing_{<<<s,t>,t>,t>}$.

3.2.2 Questions with *most*

Krifka (1999) and Pafel (1999) are the only authors who claim that questions with *most* allow pair list readings. E.g. Pafel claims that *how many*-phrases can be outscoped by *most*. (He makes these claims for German but I take the liberty to transfer them to English, because I think the data is the same.)

(323) we know how many novels most critics will review. pair list (=82a)

How-many phrases are plural. The pair list answer is the spell out of a vague reading: Most critics will review between ten and twenty novels, i.e. critic A will review ten novels, critic B will review fifteen novels and critic C will review twenty novels.

Pafel (1999:266) also claims that questions with the *was-für* split allow pair list readings with *most* and that the pair list reading is in fact the only reading:

(324) was haben eigentlich die meisten für eine Note bekommen?
what have actually the most for a grade received
what grade have most received?

Pafel claims that if there are six students s1 to s6 and they have the grades indicated by the following list:

(325)

s1	s2	s3	s4	s5	s6
A	A	B	B	C	D

a possible answer to the question in (324) is: *most students got an A or a B*. However, this answer does not specify a list, a pair list answer would be: s1 got an A, s2 got an A, s3 got a B and s4 got a B. This type of answer is much harder to get. If one takes into consideration that *was-fü*r phrases denote kinds and that As and Bs are instances of the same kind, namely the kind of 'good grade', Pafel's answer seems to spell out instances of a kind. Hence Pafel's apparent pair list answer is more likely to be a spell out of the individual answer *most students got a good grade*. Questions with singular *which*-phrases provide a better testing ground for determining whether questions with *most* allow pair list answers.

The present analysis predicts that the question *which wine did most customers order* allows a pair list reading if not every customer but only the majority of the customers ordered some wine:

(326) which wine did most customers order?

$\lambda P\ [\exists j\ [P = \mu P'\ [most\ [\lambda x\ [customer\ (a)\ (x)]]\ [\lambda x\ [\exists y\ [wine\ (a)\ (y)\ \&$

$\forall y'\ [wine\ (a)\ (y')\ \&\ order\ (j)\ (x,y') \rightarrow y' \leq y]\ \&$

$\exists p\ [P'(p)\ \&\ p\ (j)\ \&\ p = \lambda i\ [order\ (i)\ (x, y)]]]]]]]]$

However, even if the context makes explicit that only the majority of customers ordered some wine, a pair list reading is not available:

(327) a. Yesterday (only) eleven out of twenty customers ordered some wine.
--Oh, really? which wine did most customers order? *??pl

b. Yesterday the majority of customers ordered some wine.
--Oh, really? which wine did most customers order? *??pl

In the following I assume that questions with *most* do not allow pair list readings. This is accounted for if *most* is vague in the sense that it does not define a specific cut-off point. E.g. if 1001 out of 2000 people do not like pickles, is it appropriate to say that most people do not like pickles?

3.2.3 Questions with plural definites

Srivastav (1992), Krifka (1992) and Dayal (1996) claim that questions with plural definites and singular wh-phrases do not allow pair list answers. Krifka (1992) uses the predicate *rent-a-movie* to make this point:

(328) which movie did the boys rent?
?*John rented Wings of Desire and Peter rented City of Sadness.

While I agree that pair list readings of questions with plural definites are hard to get in the above example I am not sure that they are totally ruled out. Consider the following example that Roger Schwarzschild has pointed out to me:

(329) which grade the students got depended on which state capital they named.

The above sentence has a reading according to which the students got different grades depending on which state capital they named. Hence the question in subject position allows a pair list reading. One difference between *every* and plural definites is that *every* is inherently distributive. It cannot combine with collective predicates such as *gather*. Plural definites are not inherently distributive. They can combine with *gather*:

(330) a. *Every student gathered in the hallway.

b. The students gathered in the hallway.

Pair list readings arise if the element that outscopes the wh-phrase has a distributive reading. Thus, plural definites only allow a pair list reading if they have a distributive reading. While I do not have an explanation why the distributive reading is virtually impossible in (328), the sentence in (329) shows that distributive readings are possible in certain contexts. Pair list answers with plural definites and singular wh-phrases are also marginally possible if the context makes a distributive reading salient:

(331) A: During the summer break every boy watches a movie in his room every night.

B: Oh, really? which movie did the boys watch yesterday?

A: ??John watched Wings of Desire and Peter watched City of Sadness.

A semantics of questions that uses the minimality operator in order to determine relevant answers predicts that universal terms such as *every* NPs and plural definites allow pair list readings if they allow distributive readings.

3.2.4 Questions with *each, all* and *both*

Questions with *each* allow pair list readings whereas questions with *both* and *all* do not allow pair list readings.

(332) which movie did each of the the boys rent?/which movie did the boys each rent?

John rented Wings of Desire and Peter rented City of Sadness.

(333) which movie did all the boys rent?/which movie did the boys all rent?

?*John rented Wings of Desire and Peter rented City of Sadness.

(334) which movie did both boys rent?/which movie did the boys both rent?

?*John rented Wings of Desire and Peter rented City of Sadness.

Again, there is a correlation between inherent distributivity and availability of pair list readings. Brisson (1997, 1997, 1998) argues that *all* and *both* are not inherently distributive, see section 3.1.4. [59] *Each* is inherently distributive:

(335) *The boys each gathered in the hallway.

*Each of the boys gathered in the hallway.

Pair list readings of questions with elements that are not inherently distributive depend on whether or not there is a distributivity operator between the CP-adjoind QP and the *which*-phrase in SpecCP.

(336) which grade did the students get?

CP

/ \

QP_i CP

| / \

the students Dist CP

/ \

DP_j C'

| / \

which grade C IP

|

t_i get t_j

[59]Pair list readings with *both* and *all* do not improve much if they are embedded under *depend on*:

i. which grade the students all got depended on which capital they named.

ii. which grade the students both got depended on which capital they named.

I do not have a theory that determines under what circumstances a distributivity operator can be inserted. To assume that the distributivity operator can only adjoin to VP is too restrictive in many ways. It does not account for the pair list reading in (329), it also does not account for distributive readings of objects that outscope subjects in declarative clauses:

(337) A doctor prescribed the medications.
[[the medications]$_i$ [Dist [a doctor prescribed t$_i$]]]

In section 3.2.5 we will see that pair list readings of numerals are another case that has to be accounted for by a theory that determines under what circumstances distributivity operators can be inserted.[60]

I adopt Schwarzschild's (1996) analysis of distributivity. It accounts for the context-sensitivity of distributive readings. In Schwarzschild distributive and collective readings involve the partitivity operator Part. Part does not quantify over NP denotations but over a context variable that is called Cover. This makes it possible to account for the context-sensitivity of distributive readings. It also allows to account for distribution over subpluralities. E.g. the sentence

(338) the boys watched a movie.

has a distributive reading according to which it is true if each boy watched a movie, it also has a collective reading according to which it is true if all the boys watched the same movie together and it has a third reading which is true if the boys split up into several groups and each group watched a movie together. On the third reading the distributivity operator does not quantify over the atomic parts of the plurality denoted by *the boys*. Instead it quantifies over subpluralities of the plurality denoted by *the boys*. Schwarzschild's (1996) Cover-variable provides the appropriate partitions that the distributivity operator quantifies over. Covers also account for the context-sensitivity of the distributive, collective or subplurality reading because Covers are restricted by the context. Formally, Covers are sets of non-empty sets of individuals. In Schwarzschild (1996) pluralities are sets of individuals. The singleton set of individuals is equal to the individual: {x} = x. This is called Quine's innovation. Schwarzschild (1996:6) directly interprets expressions of English with respect to a domain D and a domain D^*. D is a set of individuals and D^* is a set that contains any non-empty subset of D. Let's assume the following domain:

(339) D = {a, b, c, d}

and let's assume that *the boys* has the following denotation:

[60]My explanation for why plural definites do not allow pair list readings is the same as Srivastav's (1992) explanation: They are not inherently distributive and it is not possible to insert a D-operator.

(340) €the boys,^{g} = {a,b,c}

The following are possible Covers:

(341) I = {{a}, {b}, {c}, {d}}

J = {{a, b, c}, {d}}

K={{a, b}, {c}, {d}}

L = {{a}, {b, c, d}}

The distributivity operator Part has the following definition: (Schwarzschild 1996:72)

(342) Let α and β be variables whose values are object language expressions of type <e,t> and let u, v be variables whose values are entities in D*. For all α, β, u:

u $\in$ €Part (β) (α) , if and only if $\forall$v [(v $\in$ €β, & v $\subseteq$ u) $\rightarrow$ v $\in$ €α,]

Thus if β is the Cover and if α is the VP-denotation and u is the NP-denotation then the sentence *the boys watched a movie* has the following translation:[61]

(343) (Part (Cov) (watched a movie))(the boys)

[61]Schwarzschild (1996) assumes that VPs have singularities and pluralities in their extension.

If Cov = I then the distributive reading of the sentence emerges, if Cov = J then the collective reading emerges and if Cov = K then distribution over subpluralities emerges. Notice that L is also a possible Cover. If Cov = L then the sentence is true if only one boy watched a movie. Schwarzschild (1996:77) calls this a pathological Cover and assumes that it is pragmatically ruled out.[62] The set of possible Covers COV is restricted by the domain of discourse DISC:

(344) Context-sensitive Cover:

$\text{Cov} \in [\text{COV} \cap \text{DISC}]$

This accounts for the context-sensitivity of distributive readings. If the distributive Cover I is the only one that is compatible with the context then a distributive reading emerges. Since I adopt Link's (1983) lattice-theoretic analysis of pluralities and since I assume indirect interpretation of English I have to modify Schwarzschild's definitions slightly. In a lattice theoretic analysis of pluralities Covers are sets of possibly non-atomic individuals:

(345) I = {a, b, c, d}

J = {{a+b+c, d}

K= {a+b, c, d}

L = {a, b+c+d}

---

[62]Schwarzschild (1996) does not restrict Covers to subsets of the NP-denotation in order to account for cases in which *the boys built a raft* is true even though one out of twenty boys did not participate in raft-building.

Let's assume that *the boys* denotes the following non-atomic individual:

(346) $\text{€}\iota X\ [{}^{\text{«}}\text{boy (a) (X)}],^{g} = a+b+c$

In indirect interpretation, the Part-operator takes expressions of the intermediate language as arguments. Since in a lattice theoretic approach pluralities denote non-atomic individuals instead of sets of individuals the statement $v \subseteq u$ is replaced by $v \leq u$:

(347) Let α and β be expressions of type <e,t> and let u, v be expressions of type e.
For all α, β, u:
$u \in \text{€}\text{Part}\ (\beta)\ (\alpha)$, if and only if $\forall v\ [(v \in \text{€}\beta, \ \&\ v \leq u) \rightarrow v \in \text{€}\alpha,]$

(348) $\text{€}(\text{Part (Cov)}\ (\lambda x\ [{}^{*}\text{watched\_a\_movie (a) (x)}]))(\iota X\ [{}^{\text{«}}\text{boy (a) (X)}]),^{g}$

We are now in a position to account for pair list readings of questions with plural definites:[63]

---

[63] Schwarzschild (1996:73) assumes that Part is introduced by plural VPs.

(349) which wine did the customers order?

CP:1
/ \
U:2 CP:3
/ \
QP_i:4 CP:5
| / \
the customers PART:6 CP:7
/ \
DP_j:8 C':9
| / \
which wine C:10 IP:11
|
t_i order t_j

The translation of PART introduces the Part-operator and the context-sensitive variable Cov. P is of type <e,t> and Q is of type e.

(350) PART ≈> $\lambda P\ \lambda Q\ [(\text{Part}\ (\text{Cov})\ (P))\ (Q)]$ <<e,t>, <e,t>>

(351) which wine did the customers order?

$\lambda P\ [\exists j\ [P = \mu P'\ [(\text{Part}\ (\text{Cov})\ (\lambda x\ [\exists y\ [\text{wine}\ (a)\ (y)\ \&$

$\forall y'\ [\text{wine}\ (a)\ (y')\ \&\ \text{order}\ (j)\ (x,y') \rightarrow y' \leq y]\ \&$ maximality

$\exists p\ [P'(p)\ \&\ p\ (j)\ \&\ p = \lambda i\ [\text{order}\ (i)\ (x, y)]]]]])) (\iota X\ [\text{“customer}\ (a)\ (X)])]]]$

3.2.5 Questions with numerals

If numerals are interpreted as quantifiers the the semantics of questions that has been developed in the last chapter predicts that a question such as *which wine did ten customers order* has a true answer in worlds in which exactly ten customers ordered some wine. In the following translation the numeral *ten* outscopes the wh-phrase:[64]

(352) which wine did ten customers order?

$\lambda P\ [\exists j\ [P = \mu P'\ [\text{ten}\ (\lambda X\ [^{\wedge}\text{customer (a) (X)},$

$\quad \lambda x\ [\exists y\ [\text{wine (a) (y)}\ \&$

$\qquad \forall y'\ [\text{wine (a) (y')}\ \&\ \text{order (j) (x,y')} \rightarrow y' \leq y]\ \&$ maximality

$\qquad\quad \exists p\ [P'(p)\ \&\ p\ (j)\ \&\ p = \lambda i\ [\text{order (i) (x, y)}]]]]])]]]$

The above question translation - like Pafel's (1999) corresponding question translation - incorrectly predicts that the question does not have a maximal true answer in worlds in which more than ten customers ordered some wine. However, this is empirically incorrect. There are contexts in which the above question allows a pair list answer even though the context makes explicit that more than ten customers ordered some wine. Consider the following context that makes explicit that more than ten customers ordered some drink:

---

[64]Since numerals are not inherently distributive I adopt a non-distributive definition of numerals. ϕ determines the atomic parts of a plurality:

(353) Peter knows which drink twenty customers ordered and
John knows which drink ten customers ordered.

Even though the context makes explicit that more than ten customers ordered some drink a pair list answer with the numeral *ten* is possible. Hence the quantificational analysis of numerals does not account for all contexts in which questions with numerals allow pair list readings.

Pafel (1999) introduces kinds of propositions in order to account for the remaining cases. However, it is not necessary to introduce new entities into the semantics of questions. Pair list readings of questions with numerals are accounted for if numerals are interpreted as choice functions as in Reinhart (1992,1997) and Winter (1997). Under the choice function analysis a question such as *which wine did ten customers order?* has a true answer even if more than ten customers ordered some wine. The assumption that numerals that allow pair list readings are specific indefinites also offers an explanation for the observation that questions embedded under extentional predicates more easily allow pair list readings than questions embedded under intensional predicates or matrix questions.[65] Extensional predicates such as *know, find out* are also factive. The factivity presupposition makes a specific reading more readily available. E.g. the sentence

(354) John knows which grade two students got in Semantics. pl

---

i. ψ (A) = {a: atom (a) & a $\leq$ A}
ii. *numeral* (A, B) = 1 iff $|\phi(A) \cap \phi(B)| \geq$ *numeral*

presupposes that there are two students that got some grade. This allows to infer that there are two specific students for who John knows which grade they got. Intensional predicates such as *wonder* are not factive. They allow pair list readings more readily if a pronoun is added:

(355) a. John wondered which grade two students got in Semantics. ?*pl

b. John wondered which grade two of his students got in Semantics. ?pl

If the possessive pronoun is coreferent with *John* it is easier to infer that John has two specific students in mind for who he wonders what grade they got in Semantics than if there is no coreferent pronoun.

Matrix questions do not easily allow pair list readings with numerals because even if the questioner has two specific students in mind it is hard for the answerer to guess which ones the questioner has in mind:[66]

(356) which grade did two students get in semantics? ?*pair list

---

[65]This observation is a modification of Szabolsci's (1997) observation that questions embedded under extensional predicates allow pair list readings whereas questions embedded under intensional predicates and matrix questions do not allow pair list readings, see section 3.1.5.

[66]Since only embedded questions with numerals allow pair list readings an alternative explanation could be that pair list readings arise if the numeral takes matrix scope:

i. John knows which grade two students got in semantics.
[[two students]$_i$ [John knows which grade t_i got in semantics]

QVE of questions with numerals provides an argument that the numeral can adjoin to the embedded CP, see section 3.2.5.3:

3.2.5.1 Specific indefinites and choice functions

In order to account for pair list readings of questions with numerals I adopt Reinhart's (1992, 1997) proposal that indefinites translate into choice functions.[67]

Reinhart (1992, 1997) proposes that indefinites translate into choice functions in order to account for specific indefinites. Specific indefinites are indefinites that seemingly take scope from outside an island for movement. The indefinite *three relatives* in the sentence

(357) If three relatives of mine die, I inherit a house.

is a specific indefinite on the reading that can be paraphrased as *there are three relatives of mine such that if they die I inherit a house*. Since conditionals are islands for movement, movement out of the conditional would violate some island constraint.

If indefinites are translated into free variables that are existentially bound at VP-level or at text level as in Heim (1982) then there is no island violation, however, the truth conditions of the following expression are not correct. They are too weak:

(358) if three relatives of mine die I inherit a house.

$\exists X$ [[relative of mine (X) & three (X) & $\forall x \leq X$ [die (x)]] $\rightarrow$ I inherit a house]

---

ii. John knows for the most part which grade twenty students got in semantics.
John knows for the most part [[twenty students]$_i$ which grade t_i got in semantics]

The expression in (358) incorrectly predicts that the sentence is true in a world in which I have three relatives and they die and I do not inherit a house. This is so because if X is assigned something that is not a relative of mine such as Donald Duck, the antecedens of the conditional is false and hence the conditional is true. If the indefinite moves out of the conditional the following expression is a possible translation.

(359) [three relatives of mine]$_1$ [if x_1 dies I inherit a house]

$\exists X$ [relative of mine (X) & three (X) & [$\forall x \leq X$ [die (x)] $\rightarrow$ I inherit a house]]

The expression in (359) is not trivially true like (358). However, movement out of the conditional is an island violation. Furthermore, the movement analysis makes incorrect semantic predictions. As Ruys (1992) has pointed out, the movement analysis makes the incorrect prediction that a distributivity operator can be inserted between the moved indefinite and the conditional.[68] This leads to an interpretation in which the distributivity operator has wide scope over the conditional:

(360) [three relatives of mine]$_1$ D [if x_1 dies I inherit a house]

$\exists X$ [relative of mine (X) & three (X) & $\forall x \leq X$ [die (x) $\rightarrow$ I inherit a house]]

[67]Reinhart (1997:383) leaves it open whether indefinites only translate into choice functions or whether they are quantificational in some cases.

[68]Ruys assumes that the distributivity operator can be inserted anywhere at LF.

The translation in (360) incorrectly predicts that the sentence is true in a world in which I have three relatives and one of them dies and I inherit a house.

As Ruys (1992) and Reinhart (1997:380) point out, if indefinites are translated into inherently distributive generalized quantifiers and move out of the antecedent of the conditional in order to take widest scope the wide scope distributivity reading is the only one that is generated. The following translation does not account for the truth conditions of the sentence:

(361) [three relatives of mine]$_1$ [if x_1 dies I inherit a house]

three [λx [relative of mine (x)]] [λx [x dies $\rightarrow$ I inherit a house]]

Reinhart (1992) proposes translating indefinites into choice functions in order to account for specific indefinites. Reinhart's (1997:372) choice functions are functions from a non-empty set to a member of that set.

If indefinites are translated into choice functions and the choice function is existentially bound at text level, the specific reading is accounted for without moving the indefinite out of the conditional. The indefinite *three relatives* denotes a set of plural individuals. Each member of the set is a plural individual with three atomic parts such that each part is a relative of mine.

(362) [if three relatives of mine die] [I inherit a house]

$\exists$f [CH(f) & [die (f (λX [relative of mine (X) & three (X)])) $\rightarrow$ I inherit a house]]

Notice that wide scope distributivity is also correctly ruled out because if a D-operator is inserted in front of the conditional it cannot quantify over relatives because the translation of the indefinite is inside the conditional:

(363) D [if three relatives of mine die] [I inherit a house]

$\exists$f [CH(f) & D [die (f (λX [relative of mine (X) & three (X)])) $\rightarrow$ I inherit a house]]

Winter (1997:434) points out that Reinhart's definition of choice functions runs into the empty restriction problem. Reinhart's definition of choice functions is the following (see Winter 1997:434) (Here sets are restricted to sets of individuals.)

(364) Choice functions (preliminary):

$CH =_{def} \lambda f_{<<e,t>, e>} [\forall_{P<e,t>} [P \neq \varnothing \rightarrow P (f (P))]]$

The definition incorrectly predicts that the following sentence is true if there are no women but if there is one individual that smiled:

(365) Some woman smiled.

$\exists$f [CH (f) & smile (f (λx [woman (x)]))]

The definition of the choice function does not specify what the value of the choice function is if it applies to the empty set. Assuming that choice functions are total functions the above definition of choice functions does not rule out that choice functions map empty sets of individuals into some individual. Thus if there is one individual that smiled and the choice function maps the empty set of individuals into that one individual that smiles the above expression is true. In order to avoid the empty restriction problem Winter (1997:436) proposes that choice functions do not map sets of individuals into individuals but that they map sets of individuals into sets of sets of individuals. Every individual of type e can be mapped onto the set of its properties $\lambda P\ [P(a)]$.

(366) Choice function (preliminary):

$$CH =_{def} \lambda f_{<<e,t>,<<e,t>,\ t>>}\ [\forall_{P<e,t>}\ [P \neq \varnothing \rightarrow \exists x_e\ [P\ (x)\ \&\ f\ (P) = \lambda_{A<e,t>}\ [A(x)]]\ \&\ f\ (\varnothing_{<e,t>}) = \varnothing_{<<e,t>,\ t>}]$$

The definition of the choice function states that the choice function maps the empty set of individuals into the empty set of sets of individuals.

Since Schwarzschild's (1996) Part-operator takes NPs of type e as arguments I adopt the definition of choice functions under which choice functions range over elements of type e. In order to account for the empty restriction problem I assume that choice functions map empty sets into empty individuals and that the domain of discourse contains empty individuals.

Winter (1997:444) points out that extensional choice functions do not account for indefinites that contain an anaphor that is bound by a quantifier:

(367) Every man$_i$ loves a woman he$_i$ knows.

$\#\exists f\ [CH\ (f)\ \&\ \forall x\ [man\ (x) \rightarrow love\ (x,\ f\ (\lambda y\ [woman\ (y)\ \&\ know\ (x,\ y)])))]]$

The above expression incorrectly predicts that the sentence is false in the following situation: John and Bill are the only men and they know exactly the same women, namely Mary and Sue. Suppose further that John only loves Mary and Bill only loves Sue. The sentence is intuitively true but the expression is false. Since John and Bill know the same set of women, the choice function assigns one member of this set to the set of women that John and Bill know. Hence the formula is only true if John and Bill love the same woman.

Winter (1997:444) points out that intensional choice functions ICH solve the above problem. ICHs take intensions of sets of individuals as arguments. Thus the argument of the choice function is not the set of women that John (or Bill) knows in the actual world but a function from worlds into the set of women that John (or Bill) knows. Winter (1997:444) adopts Reinhart's (1997:394) definition of intensional choice functions:[69]

[69]Kratzer (1998) uses Skolem functions in order to account for anaphoric binding of pronouns inside indefinites. However, as Winter (1997) points out, Skolem functions are not necessary if intensional choice functions are adopted.

(368) Intensional Choice Function (final definition):

$ICH =_{def} \lambda f_{<<s,<e,t>>,e>} [\forall_{P<s,<e,t>>} [P \neq \varnothing_{<s,<e,t>>} \rightarrow P (a) (f (P))] \&$
$f (\varnothing_{<s,<e,t>>}) = \varnothing_{e}]$

Thus even if John and Bill know the same set of women in the actual world it is unlikely that they know the same set of women in every world and hence the intension of the set of women that John knows and the intension of the set of women that Bill knows is not identical and the intensional choice function can map both intensions into different individuals. And hence John and Bill can love different women even if they know the same set of women in the actual world.

(369) $\exists f [ICH (f) \& \forall x [man (x) \rightarrow love (x, f (\lambda i [\lambda y [woman (i) (y) \&$
$know (i) (x, y)]]))]]$

For brevity I define f_{ICH} as an intensional choice function:

(370) $f_{ICH} \in \lambda f_{<<s,<e,t>>,e>} [\forall_{P<s,<e,t>>} [P \neq \varnothing_{<s,<e,t>>} \rightarrow P (a) (f (P))] \& f (\varnothing_{<s,<e,t>>}) =$
$\varnothing_{e}]$

With this definition in place we can analyse pair list readings of numerals.

3.2.5.2 Pair list readings of questions with specific indefinites

Unlike Winter (1997) and Reinhart (1992, 1997) I do not assume that intensional choice functions are bound at text level. I follow Kratzer (1998) and assume that choice functions are contextually determined. This makes the analysis of matrix questions easier. Matrix questions are not of type t and therefore existential closure at text level is only possible if Karttunen's performative verb hypothesis is adopted and matrix questions are embedded under silent performative verbs.

Unlike the specific indefinites in conditionals the numerals in questions with pair list readings have to move even if they are interpreted as choice functions because - unlike the specific indefinites in conditionals - the indefinites in pair list readings exhibit wide scope distributivity. They have to move to a position that c-commands the wh-phrase in order to account for the fact that the numeral distributes over the wh-phrase. [70] Hence adopting a choice function analysis for numerals does not make movement of the numeral unnecessary. Numerals in pair list readings are analysed as choice functions because choice functions denote contextually determined unique individuals that fulfill the cardinality requirement of the numeral. Any NP that denotes a unique individual can outscope the wh-phrase in a Hamblin-style semantics of questions that employs the minimality operator in order to define relevant answers to a question. The choice function analysis also has the wellcome property that it is compatible with Schwarzschild's

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[70] I leave it as a topic for future research to explain why specific indefinites - which are not inherently distributive - more readily allow distributive readings if they outscope wh-phrases than plural definites, see section 3.2.3.

context-sensitive analysis of distributivity. His distributivity operator Part assumes that NPs denote objects of type e. In order to account for the context-sensitivity of pair list readings with numerals the distributivity operator PART is inserted between the numeral and the wh-phrase. PART introduces Schwarzschild's (1996) Part-operator and the context sensitive variable Cov, see section 3.2.4. Distributive Covers Cov account for the pair list reading.

(371) which wine did two customers order?

[[two customers]$_i$ PART [[which wine]$_j$ [t_i order t_j]]]

λP [$\exists$j [P = μP' [(Part (Cov) (λx [$\exists$y [wine (a) (y) &

$\forall$y' [wine (a) (y') & order (j) (x, y') $\rightarrow$ y' $\leq$ y] &

$\exists$p [P' (p) & p (j) & p = λi [order (i) (x, y)]]]]]))

(f_{ICH} (λk [λX [$^{\wedge}$customer (k) (X) & two (X)]]))]]]

The above question translation correctly predicts that the question has a true answer even if more than two customers ordered some wine in the actual world. Following Kratzer (1998) I assume that the variable f_{ICH} is specified by the context. If numerals introduce intensional choice functions the domain of the intensional choice function consists of intensions of sets of pluralities and the range of the f_{ICH} consists of pluralities. In the case at hand f_{ICH} maps the intension of the set of pluralities that have two atomic subparts that are customers into a plurality that has two atomic parts that are customers.

Following Winter (1997:448, 451) I assume that choice functions are introduced into the translation by a type shifting operator that type-shifts expressions of type

<s,<e,t>> to expressions of type <<s,<e,t>>,e>. Winter assumes that the type shifitng operator is lexicalized as an empty determiner. Numerals are interpreted as adjectival modifiers.

```
( 372)         DP:1
              /      \
            D:2       D':3
             |       /    \
             ∅     AP:4   NP:5
                    |       |
                   two    customers
```

5: “customer (a) (X) t

5': λX [“customer (a) (X)] <e,t>

4: two (X) & P (X) t

4': λP [two (X) & P (X)] <<e,t>,t>

3: two (X) & “customer (a) (X) t

3': λk [λX [two (X) & “customer (k) (X)]] <s,<e,t>>

2: λP [f_{ICH} (P)]

<<s,<e,t>>,e>

1: f_{ICH} (λk [λX [two (X) & “customer (k) (X)]]) e

Questions with *no* do not allow pair list readings even if *no* is analysed as an indefinite that denotes an individual that has zero atomic parts:

(373) which wine did no customer order?

$$\lambda P\ [\exists j\ [P = \mu P'\ [(\text{Part}\ (\text{Cov})\ (\lambda x\ [\exists y\ [\text{wine}\ (a)\ (y)\ \&$$
$$\forall y'\ [\text{wine}\ (a)\ (y')\ \&\ \text{order}\ (j)\ (x, y') \rightarrow y' \leq y]\ \&$$
$$\exists p\ [P'\ (p)\ \&\ p\ (j)\ \&\ p = \lambda i\ [\text{order}\ (i)\ (x, y)]]]]]))$$
$$(f_{ICH}\ (\lambda k\ [\lambda X\ [\text{customer}\ (k)\ (X)\ \&\ \text{zero}\ (X)]]))]]]$$

The choice function in the above translation takes $\varnothing_{<s,<e,t>>}$ as argument and denotes the empty individual $\varnothing_e$. Assuming that the empty individual is element of the cover Cov, the question denotes the empty set of sets of propositions because the empty individual is not element of the second argument of Part. Intensional choice functions account for the bound pronoun in the following sentence:

(374) Every instructor$_i$ knew which grade two of his$_i$ students got in semantics.

$$\forall z\ [\text{instructor}\ (a)\ (z) \rightarrow \text{all}^{+}\ ('(\text{Max-Ans}($$
$$\lambda P\ [\exists j\ [P = \mu P'\ [(\text{Part}\ (\text{Cov})\ (\lambda x\ [\exists y\ [\text{grade}\ (a)\ (y)\ \&$$
$$\forall y'\ [\text{grade}\ (a)\ (y')\ \&\ \text{get\_in\_semantics}\ (j)\ (x, y') \rightarrow y' \leq y]\ \&$$
$$\exists p\ [P'\ (p)\ \&\ p\ (j)\ \&\ p = \lambda i\ [\text{get-in-semantics}\ (i)\ (x, y)]]]]]))$$
$$(f_{ICH}\ (\lambda k\ [\lambda X\ [{}^{\wedge}\text{student}\ (k)\ (X)\ \&\ \text{instructor}\ (k)\ (z,X)\ \&\ \text{two}\ (X)]]))]]],$$
$$\lambda p\ [p\ (a)])),\ \lambda p\ [\text{know}\ (a)\ (z, p)])]$$

3.2.5.3 QVE of pair list readings of questions with specific indefinites

Unlike Chierchia (1993) and Lahiri (to appear) I claim that questions with numerals allow QVE. Rather than being unavailable these readings are odd in out of the blue contexts. They are possible if the number specified bu the numerals sets a goal and the goal is only partially achieved. Imagine a game in which a family is supposed to find out which dish certain celebrities like best. The family splits the task amongst each other. The youngest in the family - John - is sent out to find out for ten celebrities what their favorite dish is, the oldest - Mary - is sent out to find out for twenty celebrities what their favorite dish is. If they are only partially successful one can say:

(375) a. John found out, for the most part, which dish ten celebrities like best and

b. Mary found out, for the most part, which dish twenty celebrities liked best.

c. $most^{+}$ ('(Max-Ans(

λP [$\exists j$ [P = $\mu P'$ [(Part (Cov) (λx [$\exists y$ [dish (a) (y) &

$\forall y'$ [dish (a) (y') & like-best (j) (x, y') $\rightarrow$ y' $\leq$ y] &

$\exists p$ [P' (p) & p (j) & p = λi [like-best (i) (x, y)]]]]]))

(f_{ICH} (λk [λX [$^{\text{“}}$celebrity (k) (X) & twenty (X)]]))]]], λp [p (a)])),

λp [find-out (a) (m, p)])

3.2.5.4 Questions with modified numerals

Unlike Szabolcsi (1997) I claim that questions with modified numerals do not allow pair list readings. This holds independent of whether they are matrix questions or embedded questions:

(376) a. Which wine did more than three customers order? * pl
b. John wondered which wine more than three customers ordered. *pl
c. John knows which wine more than three customers ordered. *pl

(377) a. Which wine did less than three customers order? * pl
b. John wondered which wine less than three customers ordered. *pl
c. John knows which wine less than three customers ordered. *pl

Modified numerals do not have the properties of specific indefinites. They cannot scope out of conditionals:

(378) a. if more than three relatives of mine die, I inherit a house.
b. if less than three relatives of mine survive, I inherit a house.

The above sentences do not have a reading according to which they are true if a specific plurality that consists of more/less than three relatives of mine dies/survives, I inherit a house. Reinhart (1997:384) assumes that modified numerals cannot translate into choice functions. Quoting Kamp & Reyle (1993) she assumes that modified numerals only have a quantificational interpretation. Thus, the lack of pair list readings of questions with *more than n* and *less than n* can receive the same explanation as the lack of pair list readings with *most*. Since these quantifiers are vague, i.e. they do not define a precise cut-off point, the question denotes the empty set of sets of propositions if the non-wh-quantifier outscopes the wh-phrase. A remaining recalcitrant problem is *exactly n*: Questions with *exactly n* also do not allow pair list readings:

(379) a. Which wine did exactly three customers order? * pl

b. John wondered which wine exactly three customers ordered. *pl

c. John knows which wine exactly three customers ordered. *pl

However, *exactly n* is not vague. Thus the above questions should allow pair list readings if exactly three customers ordered some wine.

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