# Embedded Interrogatives and Predicates That Embed Them

by

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Submitted to the Department of Linguistics and Philosophy

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## Abstract

This thesis deals with certain issues in the interpretation of embedded interrogatives, in particular, the role of the notion *answer* to a question in the interpretation of embedded interrogatives. Chapter 1 discusses a certain view about the interpretation of embedded interrogatives deriving from Hintikka (1976) and Berman (1991), and raises problems for the view that embedded interrogative complements of predicates like *know* are open sentences. I discuss the phenomenon of Quantificational Variability, viz., the fact that certain adverbs of quantification restrict the interpretation of structures containing interrogatives embedded under predicates like *know* in a way they do not for predicates like *knows*. I argue that the distinction between the two classes of predicates is not between factives and non-factives, but between those predicates that are true of questions and an agent only if their proposition-taking counterpart is true of the agent and some answer to the question. I also argue that certain predicates require their embedded interrogatives to be interpreted as whole answers rather than the way expected of the open sentence view.

In Chapter 2, I examine possible syntactic evidence for the claim that the interrogative complements of predicates like *know* and predicates like *wonder* are syntactically

distinct, and show that no such evidence is available in English. I examine the case of Spanish which has been proposed to maintain such a distinction, and again show that the relevant distinction is between speech-act and non-speech-act verbs, and so is not directly relevant to the issue of which predicates allow Quantificational Variability.

In Chapter 3, I develop an account of Quantificational Variability that highlights the ways in which answers to questions are relevant in interpreting embedded interrogatives. In order to do this, I first distinguish between two classes of adverbials of quantification, viz., adverbials of frequency and adverbials of quantity and precision, and show that only the latter are relevant to Quantificational Variability. I argue that *natural* answers to questions can be viewed as things with a Boolean part-structure, and develop a theory of quantification for atomic Boolean algebras modelled on Higginbotham's treatment of mass-quantification. Since *natural* answers have an atomic Boolean part-structure, this analysis, which is needed independently, can be extended to interrogatives.

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# Chapter 1

# Embedded Interrogatives as open sentences

## 1.1 Quantificational Variability in Embedded Interrogatives

In this chapter, I will discuss, in some detail, a view about the semantics of embedded interrogatives that stems from Hintikka (1976), recently revived by Berman (1990). On this view, embedded interrogatives have the logical form (using the term "logical form" in a loose sense) of open sentences, i.e., wh-phrases act as variables. The following sentence (1a) is interpreted as (1b):

(1) a. John knows who Bill saw.
b. $\forall x$[Bill saw $x$][John knows that Bill saw $x$].[1]

Wh-phrases, on this view, are thus similar to indefinites as analysed in classical Discourse Representation Theory ( Lewis (1975), Kamp (1981), Heim (1982) ). One of the motivations for analysing indefinites as variables, one might recall, is that indefinites apparently take their quantificational force from an overt adverb of quantification, if present, the default in the absence of an overt adverb of quantification being a genericity

[1] According to Hintikka, (1a) is really ambiguous, the other reading being existential, i.e. , $\exists x$[Bill saw $x$][John knows that Bill saw $x$]. Berman, on the other hand predicts that without an overt adverb of quantification, (1a) has only the reading in (1b). For details, see below.

operator. Thus, it has been claimed, e.g., in Lewis (1975), Kamp (1980), Heim (1982), Wilkinson (1991), that sentences like the following:

(2) a. A man rarely loves his enemies.
b. A man usually hates his enemies.
c. A man sometimes loves his enemies.
d. A man hates his enemies.

can mean (3a)-(3d) respectively[2]:

(3) a. Few $x$[man($x$)][$x$ loves $x$'s enemies].
b. Most $x$[man($x$)][$x$ hates $x$'s enemies].
c. $\exists x$[man($x$)][$x$ loves $x$'s enemies].
d. $Gn_x$[man($x$)][$x$ hates $x$'s enemies].

The quantificational force of the indefinite *a man* in these examples derives from the adverbs *rarely, usually, sometimes*, etc. This fact is an argument in favor of the analysis of indefinites as variables. Berman (1991), argues that interrogatives embedded under factive predicates like *know, remember, realize*, etc., show the same quantificational variability as indefinites show in the above examples. This is illustrated in examples like the following:

(4) a. Sue mostly remembers what she got for her birthday.
b. For the most part, Bill knows what they serve for breakfast at Tiffany's.
c. Mary largely realizes who cheats on the exam.
d. With few exceptions, John knows who likes Mary.
e. To a considerable extent, the operating manual lists what bugs might occur.

[2] In (3d), $Gn$ is the genericity operator, cf., Gerstner & Krifka (1987), that is taken to be an unselective binder.

f. The school paper recorded in part who made the dean's list.

g. The conductor seldom finds out who rides the train without paying.

In each of the above examples, the quantificational force of the embedded interrogative is derived from the adverb of quantification. So, according to Berman, (4b) can mean (5)[3]:

(5) MOST($x$)[they serve $x$ for breakfast at Tiffany's][Bill knows that they serve $x$ for breakfast at Tiffany's].

In the absence of an overt adverb of quantification, the sentence is interpreted with a default universal quantification. This phenomenon is called the Quantificational Variability Effect (QVE). According to Berman, QVE is observed only with verbs that are either factive or can be used factively, thus, examples like the following with *ask, wonder*, etc. do not show QVE:

(6) a. Sue mostly wonders what she got for her birthday.

b. For the most part, Bill asks what they serve for breakfast at Tiffany's.

c. With few exceptions, John inquired who likes Mary.

(6a), for example does not mean that most things that Sue got for her birthday are such that she wonders whether she got them; furthermore, (6b) and (6c) barely make sense.

This distinction between verbs of the *know*-class and those of the *wonder*-class is explained by assuming that adverbs of quantification can be treated as unselective quantifiers, in the tradition of Lewis (1975). Berman extends the Lewis-Kamp-Heim idea

[3]In the following examples capitalized quantifiers, e.g., MOST, are just the unselective variants of the corresponding selective quantifiers.

that indefinite NPs are free variables to wh-phrases. He proposes that structures involving adverbs of quantification have a tripartite logical form, including a quantifier, a restrictive term, and a nuclear scope. Thus, in a sentence like (4b), the quantifier is *for the most part*, which can bind any variable that is free in its restriction as well as the nuclear scope. The nuclear scope is the open sentence

(7) Bill knows that they serve $x$ for breakfast at Tiffany's.

The problem is to get the restrictive term. Berman's proposal is that the restrictive term can be derived by *presupposition accomodation*, a phenomenon observed at least as early as Stalnaker (1973), Karttunen (1974), and subsequently named so in Lewis (1978).[4] This is a way by which presuppositions are integrated into the discourse. As observed by Schubert & Pelletier (1989), presuppositions can be accomodated in the restrictive term of an adverb of quantification. E.g., a sentence like (8):

(8) A cat usually lands on its feet.

doesn't exactly mean that most cats land on their feet; nor that for most pairs of cats and times, the cat lands on its feet at that time; but rather that for most events/situations $e$ such that $e$ is an event of a cat dropping on the ground, $e$ is an event of the cat landing on its feet. The restrictive term is, then obtained by accomodating a presupposition of the clause "$e$ is an event of a cat landing on its feet", viz., that "$e$ is an event of the cat falling on the ground", which, in turn, is due to a lexical presupposition of the predicate *land*

[4]The older observations pertain to cases involving *global* accomodation. The extension to local accomodation is more recent, however.

*on*. In the case of interrogatives embedded under factive predicates, Berman argues that the restrictive term is the complement of the factive predicate, since factives presuppose their complements. Since (7) presupposes (9):

(9) they serve $x$ for breakfast at Tiffany's.

(9) is accomodated into the restrictive term of the quantifier *for the most part*, which for our purposes is the same as MOST, and so one gets the following logical form:

(10) MOST($x$)[they serve $x$ for breakfast at Tiffany's][Bill knows that they serve $x$ for breakfast at Tiffany's].

This explains QVE, since embedded interrogatives have no inherent quantificational force, being open sentences. Berman assumes that since factives are the only predicates that presuppose their complements, only factives show QVE. This assumption will be seen to be too strong.

As to the verbs/predicates of the *wonder*-class, Berman assumes that their complements are syntactically different from those of wh-complements of verbs of the *know*-class, in that they are CPs with a phonologically empty Q-morpheme that can unselectively bind all free variables in its scope, as in

(11) a. ...wonder[who saw what]
b. ...wonder[[$Q_{ij}$][$x_i$ saw $x_j$]

Whereas wh-complements of verbs of the *know*-class are propositions, the wh-complements of verbs of the *wonder*-class are *Questions*, i.e., sets of propositions as defined in Hamblin (1971). Thus, the complement of (11b) is interpreted as (12):

(12) $[Q_{ij}][x_i \text{ saw } x_j] = \{ p: \exists x_1, x_2[p = \text{that } x_1 \text{ saw } x_2] \}$.

The salient features of Berman's analysis can be summarized as follows:

(13) a. Embedded wh-complements are open sentences in certain environments, i.e., the same logical type as propositions.

b. Predicates of the *know*-class select propositions but not Questions.

c. A Q-morpheme combines with an open sentence to yield Question denotations.

d. Predicates of the *wonder*-class select Questions and not propositions.

e. Logical forms containing embedded wh-complements are interpreted after presupposition-accomodation, with factive predicates presupposing their complements.

There are some consequences of the above five propositions. In particular, let me mention the following two which are relevant for the discussion here:

(14) a. All factive predicates must be able to take embedded wh-complements.

b. No non-factive predicate can show QVE.

(14a) must be true on Berman's view because all factives can take propositional complements, in particular, open sentences which are LF-counterparts of embedded wh-complements, and presuppposition accomodation due to factivity guarantees that the LFs would be well-formed. (14b) is different. Berman adopts (14b), but it does not follow from any other feature of the theory proposed. Since the restrictive term of the adverbials of quantification in these cases is obtained by presupposition- accomodation, presuppositions trigerred by something other than a factive verb should also be able to play this role. I will show in a later section that presupposition-accomodation does indeed have a wider scope than assumed by Berman.

## 1.2 Not all factives embed interrogatives

The first obvious counterexample to (14a) is the verb *regret*, which is factive, but cannot take interrogative complements:

(15) a. * I regret whether John came to the party.
b. * I regret who John saw.
c. * I regret which man saw which woman.
d. * I regret that John came to the party.
e. * I regret what John saw. (free relative)[5]
f. * I regret who saw what.
g. * I regret what to do.
h. ?? I regret why he had to do do this.

Verbs like *resent* are similar to *regret* in this respect, in that they are factives but do not take embedded interrogatives, and this is unexpected on the theory being discussed. This will be discussed in greater detail in the next chapter, as it will be crucial in determing the selectional properties of predicates that allow interrogative complements.

## 1.3 (Some) Nonfactives show QVE

There are two classes of nonfactives that show QVE: (i) the first class consists of verbs like *guess, tell*, etc., that are nonfactive when they take indicative complements, but become factive when they embed interrogatives, as noted in Baker(1968); (ii) the second

[5] David Pesetsky (p.c.) points out examples like the following, where *regret* seems to be able to take embedded wh-complements:
(i) I regret when he went to the party.
at least in some idiolects, interpreted not as a free relative, but a true wh-complement. If that's true, it might weaken the point somewhat. But most wh-complements do seem to be disallowed as complements to *regret*.

class consists of predicates like *be certain (about), be convinced (about), agree (on),* etc., that remain nonfactive when they take embedded interrogatives. As examples of the first class, note the following examples:

(16) a. John partly guessed who came to the party.
b. John told Bill, in part, who came to the party.

Both of these examples show QVE, and furthermore the interrogative is interpreted factively, i.e., (16b), e.g., is interpreted as (17):

(17) $\exists x$[$x$ came to the party][John told Bill that $x$ came to the party]

It has sometimes been claimed, viz., in Kiparsky & Kiparsky (1970), Grimshaw (1977), etc., that these verbs are not really non-factive, but that they can be used factively as well as a non-factive. The fact that these verbs become factive when they embed interrogatives is taken as evidence by Berman that only factives allow accomodation of presuppositions.

A closer look, however, reveals that there are non-factives that remain non-factives when they embed interrogatives, and furthermore, show QVE. These are the predicates of the second class mentioned above. Consider the examples below:

(18) a. Bill was certain about whether John came to the party.
b. John was certain which man saw which woman.
c. John and Bill agree on whether to invite Mary.
d. John and Bill agree on which person to invite for which party.
e. I was sure of which person to invite for which party.
f. I informed John whether to invite Bill.

g. I informed John what to do.

h. Bill was right about what John did.

i. Bill was right about who saw what.

The predicates of the above class contrast with verbs like *believe* and *think* which do not take interrogative complements at all. Moreover, the following examples demonstrate that these predicates show QVE:

(19) a. John is certain, for the most part, about who loves Mary.

b. John is convinced, in part, about who Mary's ex-lovers are.

c. John and Bill agree, for the most part, on who Mary's ex-lovers are.

d. Bill was mostly right about who saw what.

(19a) and (19d) roughly have the meaning associated with the following logical forms, respectively:

(20) a. most($x$)[John considers it likely that $x$ loves Mary][John is certain that $x$ loves Mary].

b. most($\langle x, y \rangle$)[Bill claimed(in some fashion) that $x$ saw $y$][Bill was right in claiming that $x$ saw $y$].[6]

As mentioned above, it is not an essential feature of the theory of embedded interrogatives being discussed here that only factives be able to contribute presuppositions for accomodation. As the examples show, non-factives can contribute lexical presuppositions, too. Thus, consider a predicate like *be certain (about)*. Suppose, contrary

[6]Notice that the predicate *be right (about)* is not factive, although veridical. Accordingly, the presupposition accomodated is not what one might expect if it were factive.

to Berman's specific claim that predicates like *be certain about* take Question wh-complements, that the wh-clause embedded under *be certain (about)* is an open sentence (in the general spirit of the Hintikka/Berman theory). Then the following logical form (21) is obtained:

(21) John is certain (about/that) $x$ loves Mary.

presupposes (22):

(22) John considers it likely that $x$ loves Mary.

By presupposition accomodation, (19a) would then be predicted to mean (23):

(23) MOST($x$)[John considers it likely that $x$ loves Mary][John is certain that $x$ loves Mary].

which seems to be the right result. Similarly, *to be right about p* presupposes *claiming, in some fashion, that p*, and so by the procedure illustrated above, (20b) follows. Thus, Berman's theory, extended so as to include presuppositions of lexical items other than factives, goes some way in explaining the presence of QVE in examples (19a)-(20b).

Matters can get more complicated, however. Consider the predicate *agree on*. As mentioned above, one can construct examples with *agree on* that exhibit QVE:

(24) John and Bill agree on who Mary's ex-lovers are, for the most part.

The relevant reading that is a result of QVE is the following:

(25) MOST($x$)[John or Bill believes that $x$ is an ex-lover of Mary][John and Bill agree that $x$ is an ex-lover of Mary].

Now blindly applying a Berman-style procedure might yield the reading in (25), but it gets problematic for more complicated cases involving *agree on*. If we assume an extension of the Berman-Hintikka theory (let us call it BH for short) to non-factive predicates that belong to the class under discussion, the embedded interrogative translates as '$x$ is an ex-lover of Mary', and the nuclear scope is 'John and Bill agree that $x$ is an ex-lover of Mary'. A first guess about its presupposition might be the open sentence 'John and Bill believe that $x$ is an ex-lover of Mary', and so one would get the following logical form:

(26) MOST($x$)[John and Bill believe that $x$ is an ex-lover of Mary][John and Bill agree that $x$ is an ex-lover of Mary].

(26) is interpreted as the trivial statement that John and Bill agree on most things they agree on (about the identity of Mary's ex-lovers). This probably means' that John and Bill agree that $x$ is Mary's ex-lover' doesn't really *presuppose* that 'John and Bill believe that $x$ is Mary's ex-lover', but rather *asserts* it, agreement on something being just having the same beliefs/opinions about the same. What is presupposed, one could argue, is the much weaker proposition that is a disjunction of beliefs of the individuals that are parts of the subject of *agree on*, in the above example, John and Bill. Construed this way, the presupposition of 'John and Bill agree that $x$ is Mary's ex-lover' is 'John believes that $x$ is Mary's ex-lover $\vee$ Bill believes that $x$ is Mary's ex-lover', which gets accomodated into the restrictive term of the adverb of quantification, yielding the logical form in (25), the right result in this case.

Once one turns to plural subjects of *agree on* that can have more than two atomic parts[7] in their extension, the situation gets even more complicated. Imagine a situation in which there are 20 FBI agents observing a meeting of five alleged subversives meeting in a building. They agree completely on who four of those five are, but disagree about the fifth, about whose identity they each have a different hypothesis. In this situation, it is certainly true to say the following:

(27) The FBI agents agree on who the people in the building are, for the most part.

The extension of BH outlined in the previous paragraph, however predicts that (27) should be false in this situation. In the logical form corresponding to (27), the nuclear scope is the open sentence 'The FBI agents agree that $x$ is in the building'. Following the remarks above, this should presuppose the sentence 'Some FBI agent believes that $x$ is in the building', which would get accomodated in the restriction of the adverbial, yielding the following logical form:

(28) MOST($x$)[Some FBI agent believes that $x$ is in the building][The FBI agents agree that $x$ is in the building].

Given that the FBI agents agree about the identity of four individuals, but disagree about 20, (28) will be false in this situation. This is clearly an undesirable result. The correct reading of (27) seems to be the following:

[7] Using the terminology of Link's or Landman's lattice-theoretic treatment of plurals, without necessarily being committed to one particular theory of plurals.

(29) $\forall x$[$x$ is an FBI agent][most($y$)][$x$ believes that $y$ is a person in the building][The FBI agents agree that $y$ is a person in the building]].

It is at first unclear how BH can be extended so as to derive the reading in (29) by presupposition accomodation, given that the restriction must have a free variable for FBI agents to be bound by a universal outside, but that variable($x$ in the e.g. (29)) cannot appear free in the nuclear scope[8].

One way of getting these readings, suggested to me by Irene Heim, is to relate the predicate *agree (on)* with its dyadic variant. On this view, (30a) is taken to mean (30b):

(30) a. The FBI agents agree that Bill is the murderer.

b. $\forall x$[$x$ is an FBI agent][the FBI agents other than $x$ agree with $x$ that Bill is the murderer].

More generally, statements like (31a) and (31b) are equivalent[9]:

---

[8]It has been suggested to me by Tim Stowell that the correct interpretation for (27) might be the following:

(i) MOST($\langle x, y\rangle$)[$x$ is an FBI agent and $x$ believes that $y$ is in the building]
[The FBI agents agree that $y$ is in the building].

But this cannot be true, because if half of the FBI agents had no beliefs whatsoever about who was in the building, while everything else were as before, (i) would come out true. Note that even if (i) were the right interpretation rather than (29), the problem of deriving the restriction from the nuclear scope would remain. Given that *agree on* is a symmetric predicate with dyadic variants ( $X$ agrees with $Y$ on $Z$), one might be tempted to think that (27) might have a reciprocal reading, i.e., the reading that any two FBI agents mostly agree on who the people in the building are, 'mostly agree' interpreted as in (25), using the straightforward extension of Berman's procedure mentioned above. Unfortunately, (27) cannot be interpreted that way. Suppose there were three FBI agents, 1, 2 and 3. 1 thinks that the people in the room are John and Bill, 2 thinks that the people in the room are Bill and Tom, and 3 thinks that the people in the room are John and Tom. On the putative pairwise reading, (27) should turn out to be true. But (27) is clearly false in such a situation. So the simple extension of BH cannot work this way.

[9]This assumes the theory of plurals in Link (1984). '*$\Pi$' is the relation 'is an atomic part of', $A - x$ is the complement of $x$ with respect to $A$. Thus if $A$ is the plural sum of the individuals that are the FBI agents in question, $A - x$ is the plural sum of the individuals that are the FBI agents, except $x$. In the discussion below, I will assume that the set-union of the set of elements of the same sort as the first argument of **believe** and **agree**, and the first and second arguments of **agree-with** (call it $D_h$) and a 0-element (call the union $D'_h$), is the domain of an atomic Boolean algebra with the usual operations of sum and complementation and a **0** and **1**-element, as seems reasonable given that believers, etc., are countable human individuals, probably finite. Let the set of atoms of $D_h$ be $D_a$. Furthermore, define the

(31) a. **agree**$(A, p)$, where $A$ is the denotation of a plural NP.

b. $\forall x[x^{*}\Pi A]$[**agree-with**$(A - x, x, p)$].

One might then stipulate that Berman's procedure applies to the predicate *agree with* rather than *agree*, i.e., (27), reproduced here as (32a), is taken to mean (32b)[10]:

(32) a. The FBI agents agree on who the men in the building are, for the most part.

b. $\forall x[x^{*}\Pi$ [**the FBI agents**]][the FBI agents other than $x$ agree with $x$ on who the people in the building are, for the most part].

The embedded interrogative, by BH, translates as (33):

(33) person$(y)\wedge y$ is in the building.

The nuclear scope of the adverb of quantification, then, is the following:

(34) [[**the FBI agents**]$-x$] agree with $x$ that [person$(y)\wedge y$ is in the building].

The presupposition of (34) is (35) :

(35) $x$ believes that [person$(y)\wedge y$ is in the building].

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mapping $\Psi : D'_h \rightarrow \wp(D_a)$ as follows:
(i) $\Psi(A)$=$\{$ $a$: $a$ is an atom $\wedge a \Pi A$ $\}$.
The first argument of **agree**, say $A$, is always plural, i.e., $||\Psi(A)|| \geq 2$. Consequently, in all the examples below, statements of the type
(ii) **agree**$(A, p)\leftrightarrow$ ...
are intended to be abbreviations for
(iii) $\forall A[||\Psi(A)|| \geq 2]$[**agree**$(A, p)\leftrightarrow$ ...].
unless otherwise mentioned. Furthermore, in all the formulas it is assumed that the plural individuals are not **0**. So statements like
(iv) **believe**$(A, p)\leftrightarrow$ ...
are intended to be abbreviations for
(v) $\forall A[A \neq \mathbf{0}]$[**believe**$(A, p)\leftrightarrow$ ...].

[10]In the following examples, [**the FBI agents**] is the sum of the denotation of individuals who are the FBI agents in question, in Link's terminology, $\sigma x$[**FBI-agents**$(x)$].

With presupposition accomodation, the nuclear scope of (32b) translates as (36)[11]:

(36) most($y$)[$x$ believes that [person($y$)$\wedge y$ is in the building]][[[**the FBI agents**]$-x$] agree with $x$ that [person($y$)$\wedge y$ is in the building]].

(32b) is thus rendered equivalent to (37):

(37) $\forall x[x^{*}\Pi$[**the FBI agents**]][most($y$)][$x$ believes that [person($y$)$\wedge y$ is in the building]][[[**the FBI agents**]$-x$] agree with $x$ that [person($y$)$\wedge y$ is in the building]].

(37) as it stands, is almost equivalent to (29). Their complete equivalence is guaranteed by the following axiom about the meaning of *agree (on)* and *agree with...(on)*, viz., (38)[12]:

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[11]Note that *most* binds $y$ but not $x$. This can be made to follow from the requirement that adverbials of quantification only bind elements that are moved at LF, either in Spec,CP or adjoined.

[12]The equivalence between (31a) and (31b) does not follow from (38). It is possible that the equivalence of (31a) and (31b) as well as the statement (38) can be made to follow from some more basic axiom about the meaning of *agree (on)* in terms of sameness of belief or opinion, i.e., axioms like:
(i) **agree**($A$, $p$)$\leftrightarrow \forall x[x^{*}\Pi A]$[**believe**($x$, $p$)]
(ii) **agree-with**($A$, $B$, $p$)$\leftrightarrow$[**believe**($A$, $p$)$\wedge$**believe**($B$, $p$)]
From (i) and (ii), and independent facts about the subject argument of **believe**, the equivalence between (31a) and (31b), as well as (38) follow. The required facts about **believe** are the following:
(iii) **believe**($A$, $p$)$\leftrightarrow \forall x[x^{*}\Pi A]$[**believe**($x$, $p$)]
(iv) **believe**($A$, $p$)$\wedge$**believe**($B$, $p$)$\leftrightarrow$**believe**($A \sqcup B$, $p$)
where "$\sqcup$" is the mereological sum-relation (actually, (iii) is a consequence of (iv) if the domain of **believe** is furthermore finite, as will be the case with realistic models for English.). From (i) and (iii), it follows that
(v) **agree**($A$, $p$)$\leftrightarrow$**believe**($A$, $p$)
Now,
(vi) $\forall x[x^{*}\Pi A]$[**agree-with**($A - x$, $x$, $p$)
(vii) $\leftrightarrow \forall x[x^{*}\Pi A]$[**believe**($A - x$, $p$)$\wedge$**believe**($x$, $p$)]
(viii) $\leftrightarrow \forall x[x^{*}\Pi A]$[**believe**($(A - x) \sqcup x$, $p$)] (by (iv))
Since $x^{*}\Pi A$, it follows that $x \Pi A$, and so $(A - x) \sqcup x = A$, and so (viii) is equivalent to (ix)
(ix) $\forall x[x^{*}\Pi A]$[**believe**($A$, $p$)]
Since $A$ is non-zero, $\exists x[x^{*}\Pi A]$, and so (ix) is equivalent to (x)
(x) **believe**($A$, $p$), and by (v),
(xi) $\leftrightarrow$**agree**($A$, $p$).
and so the equivalence between (31a) and (31b) follows. On the other hand, consider an arbitrary $x$ such that $x^{*}\Pi A$, and also that $A$ is non-atomic, i.e., $||\Psi(A)|| \geq 2$. Then
(xii) **agree-with**($A - x$, $x$, $p$)

(38) $\forall A[\|\Psi(A)\| \geq 2]\forall x[x^*\amalg A][\textbf{agree}(A, p)\leftrightarrow\textbf{agree-with}(A - x, x, p)]$.

(38) makes (37) equivalent to (39):

(39) $\forall x[x^*\amalg$[the FBI agents]][most($y$)][$x$ believes that [person($y$)$\wedge y$ is in the building]][The FBI agents agree that [person($y$)$\wedge y$ is in the building]].

which is equivalent to (29).

While most of the above is relatively straightforward if one assumes BH, the most non-trivial step is the claim that (32a) means (32b), i.e., *to mostly agree* means *for each person to mostly agree with the others*. This ensures that *most* has narrow scope with respect to the universal quantifier that quantifies over the atomic parts of the subject NP-denotation. This step does not follow from anything else about the meaning of *agree (on)*. What the examples with *agree on* show is, that while presupposition accomodation is probably involved in these cases, the precise readings that are a result of QVE are highly sensitive to details of the lexical semantics of individual verbs/predicates.

## 1.4 Predicates of Surprise

In the previous section, I presented evidence that QVE is a broader phenomenon than recognised in Berman (1990), and suggested how the general approach of BH may be

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(xiii) $\leftrightarrow$[**believe**($A - x$, $p$)$\wedge$**believe**($x$, $p$)] (by (ii))
(xiv) $\leftrightarrow$[**believe**(($A - x$) $\sqcup x$, $p$)] (by (iv))
(xv) $\leftrightarrow$[**believe**($A$, $p$)] (since $(A - x) \sqcup x = A$)
(xvi) $\leftrightarrow$[**agree**($A$, $p$)] (by (v))
It therefore follows that
(xvii) $\forall A[\|\Psi(A)\| \geq 2]\forall x[x^*\amalg A][\textbf{agree}(A, p)\leftrightarrow\textbf{agree-with}(A - x, x, p)]$. which is (38).

As a word of caution, note that according to (ii), **agree-with**($A$, $B$, $p$) and **agree-with**($B$, $A$, $p$) have identical truth-conditions. They, however, have different presuppositions. The former presupposes that **believe**($B$, $p$), whereas the latter presupposes that **believe**($A$, $p$).

preserved, at least for a wide variety of cases, while extending the empirical coverage of the theory beyond the case of factive predicates. This section aims to provide some deeper challenges for BH. Here I will simply present the problem, and postpone the business of outlining a solution for chapters 3 and 4.

There is a class of predicates in English which is a subclass of the class of emotive predicates, discussed, e.g., in Elliott (1974), Grimshaw (1977), like *be surprising, be amazing*, etc. One finds some argument in the literature concerning whether they take embedded interrogatives or not. Now while it is true that they do not take *whether*-complements and wh-infinitives, they certainly can take multiple interrogatives with *which*-phrases.

(40) a. * It is amazing whether John went to the party.
b. * It is amazing what to do.
c. It is amazing what John did.
d. It is surprising who came to the party.
e. ? It is amazing who does what.
f. It is amazing which men love which women.

Elliott and Grimshaw have concluded from examples like (40a)-(40f) that these predicates do not select questions, but what they call embedded exclamations. Note that not only does this fail to explain why (40e) (though slightly marginal), (40f) are good, but also, as Elliott and Grimshaw note, this also really fails to explain why (40d) is good, given the fact that embedded who-complements cannot be a matrix exclamation:

(41) * Who came to the party !

They conclude that there are more types of embedded exclamations than matrix exclamations, but that is highly suspicious. I will conclude, then, given (40e)-(40f), that these predicates do indeed take wh-complements that do not have to be exclamatives but rather he. interrogatives.[13] The fact that these predicates do not take wh-infinitival complements is not an argument against their selected wh-complements being interrogatives, given that there exist predicates like *depend on*, which undoubtedly take embedded interrogatives but do not embed wh-infinitival interrogatives, at least as the second argument:

(42) a. ?? What to do depends on where to be.
b. What to do depends on who comes.
c. ?? Who comes to Boston depends on how to get there from LA.
d. ? How to go to Boston depends on how to go to NY.

So whatever the reason for infinitival interrogatives being disallowed as complements of the predicates of surprise, that does not constitute an argument against wh-clause complements of these predicates being interrogatives.

One property of these predicates is that they do not distribute over parts of a conjunction. So from (43a), (43b) and (43c) do not follow:

(43) a. It is surprising that ($p$ & $q$).
b. It is surprising that $p$ & It is surprising that $q$.
c. It is surprising that $p$.

[13] I will not have anything to say about the semantic type of embedded exclamatives here. The issue here is not whether these predicates take embedded exclamatives or not, but rather whether all wh-complements of these predicates are exclamatives or not.

This is because while the fact that two propositions are simultaneously true may be surprising, it may not be surprising for each of them to be individually true. This property shows up in embedded wh-complements too. So if Mary and John came to the party, and it is surprising that they both came to the party, but it is not surprising that Mary came to the party or that John came to the party, it is true to utter (40d). BH, on the other hand, predicts that (40d) should be false, for on that account the logical form for (40d) is (44):

(44) $\forall x$[$x$ came to the party][it is surprising that $x$ came to the party].

by the usual principles.

There are a few ways one could respond to the above argument[14]. It is possible to argue that statements like (43c) are never made out of context, and so the truth of (43c) is really dependent on whether (45) is true:

(45) It is surprising that $p$, given the context, and nature of things.

On this view, then, while it is true that (43a) entails neither (43b) nor (43c), (43a) does entail (46):

(46) It is surprising that $p$ or It is surprising that $q$ (given the context, etc.).

It is unclear how viewing the matter this way will help in getting the right interpretations for embedded interrogatives. It is beyond dispute that (40d) does not have the same truth-conditions as (44). For it to be surprising who came to the party, it does not have

[14]Irene Heim, p.c.

to be the case that the coming to the party of each of those who came to the party was surprising. Given that (43a) entails (46), one might try the following logical form:

(47) $\exists x$[$x$ came to the party][it is surprising that $x$ came to the party (given the context $x$ is in)].

But if (47) were the logical form, BH would have to claim that the default adverbial of quantification in these cases is not universal, but existential. This might be a throwback on the old position of Hintikka's that sentences with embedded interrogatives are always ambiguous, but accepting that position takes away much of the explanatory power of Berman's modification of Hintikka's theory. It would be much more desirable to derive the fact, if it is indeed one, that the default in these cases is existential rather than universal.

Furthermore, it is unclear that (40d) and (47) are equivalent to begin with. Suppose the party was given by someone moderately famous, and attended by many celebreties, so that it is not surprising, for any of those that came to the party considered in isolation, that they came to the party. However, what may be surprising is that he managed to bring together such large numbers of celebreties on a particular day. In such a situation, it is certainly true to say (40d). But it is not at all clear that (47) is true in this situation, even with the clause about 'given the context $x$' built in. This is because for each person that came to the party, it is not the case that his/her coming to the party is surprising, even given the context, rather, the *entire context* is surprising. So (47) is not true in this situation. As expected, (44) does not have be true either, given that (40d) is perfectly compatible with some people coming to the party whose coming is not the least bit

surprising, the host's relatives, for example.

What this means is that if an open sentence analysis of interrogatives has to be maintained for these examples, the default in these cases cannot be either existential nor universal. In fact, the example just discussed suggests that an open sentence analysis of interrogative complements of these predicates is impossible, since what is surprising or amazing is the *entire answer* to the question complement[15].

One alternative proposal that might be worth considering, assuming a general BH-type approach is the view that variables be allowed to range over plural objects, á la Link *et al*, a variant of the proposal in Zaefferer (1983). Consider the following example again:

(48) It is amazing who came to the party.

According to BH, (48) is interpreted as (49)

(49) $\forall x$[$x$ came to the party][it is amazing that $x$ came to the party].

What is new is that the variable $x$ can now take not only atoms as values, but also arbitrary finite sums of atoms. In a situation where there are two men $a$ and $b$ who came to the party and their coming to the party is surprising, taken together but not individually, (50a) and (50b) are false but (50c) is true:

(50) a. It is amazing that $a$ came to the party.
b. It is amazing that $b$ came to the party.
c. It is amazing that $a \oplus b$ came to the party.

[15]I am here anticipating notions like *questions, answers*, etc. which have not been discussed yet.

(49) is still false, because both $a$ and $b$ came to the party, but it is not amazing that $a$ came to the party. the interpretation of (48) must then be (51):

(51) $\exists x$[$x$ came to the party][it is amazing that $x$ came to the party].

This certainly accords with the intuition, but then the question is why the default is existential in this case. Moreover, allowing quantification over non-atoms leads to other problems as well, e.g., with quantifiers like *most*. Thus if there are three men $a$, $b$ and $c$, and $a$ and $b$ snore but $c$ doesn't, then the sentences in (52a) are true whereas those in (52b) are false:

(52) a. snore($a$), snore($b$), snore($a \oplus b$).
b. snore($c$), snore($a \oplus c$), snore($b \oplus c$), snore($a \oplus b \oplus c$).

If quantification over non-atoms is allowed, (53a), interpreted as (53b) would turn out to be false in the above-mentioned situation, given (52a)-(52b):

(53) a. Most men snore.
b. most($x$)[men($x$)][snore($x$)].

There is a different way of looking at quantification which solves this problem, a variant for count nouns of the proposal for quantification with mass terms developed in Higginbotham (1991a.) (see Chapter 3 for greater details.). On this approach, open sentences like the one in (53b) are interpreted not as sets but as maximal sums. Quantifiers like *all, some, most*, etc. are functions from ordered pairs of individuals to truth-values. First let me introduce the following definitions:

(54) a. $\sigma x[P(x)] = \sup\{X : P(X)\}$.

b. $\mu(A) = \|\{b : AT(b) \wedge b \leq A\}\|$

I.e., $\sigma x[P(x)]$ is the maximal element that satisfies the predicate $P$, and $\mu(A)$ is the number of atomic parts of $A$. With this apparatus, (53b) is interpreted as:

(55) most ($\sigma x$[men($x$)], $\sigma x$[snore($x$)]).

Furthermore, quantifiers like *all*, *some*, *most*, etc. are defined as follows[16]:

(56) a. All ($A$, $B$)=1 iff $A \leq B$, or alternatively $\mu(A \otimes \overline{B}) = 0$.

b. Some ($A$, $B$)=1 iff $\mu(A \otimes B) \neq 0$.

c. Most ($A$, $B$)=1 iff $\mu(A \otimes B) > \mu(A \otimes \overline{B})$.

d. Many ($A$, $B$)=1 iff $\mu(A \otimes B) \geq n$, for some contextually specified $n$.

and so on. Sticking to example (53b), and the situation mentioned there, note that $\sigma x$[men($x$)] $= a \oplus b \oplus c$, and $\sigma x$[snore($x$)] $= a \oplus b$. Therefore, $\sigma x$[men($x$)] $\otimes$ $\sigma x$[snore($x$)] $= a \oplus b$, and $\sigma x$[men($x$)] $\otimes \overline{\sigma x[\text{snore}(x)]} = c$, and thus (53b) is true in this situation by (56).

This redefining of quantification solves the problem noted earlier with quantifiers like *most*, but also allows one to maintain that the default quantification in cases of interrogatives embedded under predicates like *it is amazing* is universal rather than existential. Take (49) again, in the situation described above, viz., when $a$ and $b$, and they alone, came to the party, and furthermore, it is amazing that $a \oplus b$ came to the party, but it is not amazing that $a$ came to the party, nor is it amazing that $b$ came to the party. In

[16]In what follows $\oplus$ and $\otimes$ are the sum and product operations respectively over the Boolean Algebra of individuals, corresponding to set union and intersection for sets.

this situation, $\sigma x$[$x$ came to the party]= $a \oplus b$, and $\sigma x$[it is amazing that $x$ came to the party]= $a \oplus b$,and so by the definition of All in (56), (49) is true, as expected.

While this reformulation solves the two problems mentioned earlier, it is absolutely unclear how this can be extended to cases with multiple interrogatives, and in fact the most natural extension of the above formulation seems to fail for these cases. Consider the example

(57) It is amazing which men love which women.

Given that the default is the unselectively binding universal, according to BH, the most natural extension of the remarks in the previous paragraphs would be to interpret (57) as (58):

(58) All ($\sigma\langle x, y\rangle$[men($x$)$\wedge$women($y$)$\wedge x$ love $y$],
$\sigma\langle x, y\rangle$[it is amazing that [men($x$)$\wedge$women($y$)$\wedge x$ love $y$]]).

Consider now the situation in which there are two men $a$ and $b$, and two women $c$ and $d$ and $a$ loves $c$ and $b$ loves $d$. Moreover, these two facts are not amazing in themselves but what is amazing is the pattern of the man-woman lover-lovee pairs (i.e., that $a$ loves $c$ and $b$ loves $d$ and not the other way around.). In this situation, the intuition is that (57) should come out true. For this situation, $\sigma\langle x, y\rangle$[men($x$)$\wedge$women($y$)$\wedge x$ love $y$]= $\langle a, c\rangle \oplus \langle b, d\rangle$. However, since it is not true that it is amazing that $a$ loves $c$ or that $b$ loves $d$ or that $a \oplus b$ love $c \oplus d$ (the last one is simply false, assuming that the predicate *love* is distributive with respect to both subject and object), $\sigma\langle x, y\rangle$[it is amazing that[men($x$)$\wedge$women($y$)$\wedge x$ love $y$]]=$\mathbf{0}$.[17] Consequently, (58) is simply false in this

[17] $\mathbf{0}$ is the zero-element of the Boolean algebra of individuals.

situation.

It is hard to imagine any other way of dealing with multiple interrogatives embedded under predicates like *be surprising, be amazing*, etc. What is needed for these cases is some notion of *answer* such that one can talk about an entire answer, and the BH treatment of embedded interrogatives does not give that. As the last case demonstrates, what one needs is a sum-operation that can form sums ( maybe set-union or conjunction) of propositions (in the above case, *that a loves c* and *that b loves d.*) rather than individuals, which one might need for other purposes, but don't achieve anything in these cases. In a later section, I will suggest how one can make sense of these facts by assuming a different perspective on embedded interrogatives.

## 1.5 Predicates of Relevance

There is another class of predicates which are worth mentioning at this point, viz., what one might broadly characterize as predicates of relevance. These are predicates like *be important, matter, be relevant*, etc. These predicates can take the entire range of embedded interrogatives[18], as shown in the examples below:

(59) a. It will be relevant whether (or not) John comes to the party.
b. It will be relevant who comes to the party.
c. It will be relevant which man goes to which place.
d. It will be important whether or not John came.
e. It will be important who becomes the president of the US.
f. It will be important what funds are alloted to which state.

[18]Except wh-infinitives, more on this later.

g. It surely matters whether or not John comes.

h. It surely matters who becomes president of the US.

i. It doesn't matter at all who does what.

What is peculiar about these predicates is the fact that the default quantifier is not universal. Certainly (59b), e.g., does not mean (60):

(60) $\forall x$[$x$ comes to the party][It will be relevant that $x$ comes to the party].

In order for the answer to a question to be relevant for something, it is sufficient that some subset of the answer be relevant. For example, suppose a crime has been committed and John is a prime suspect for being the perpetrator of the crime. If John's coming to the party entails that he could not be at the scene of the crime, then it would be true to say that it is relevant (for our purposes: in this case the purpose being finding the perpetrator of the aforementioned crime) who came to the party. This is perfectly consistent with the fact that the coming or not coming of many other individuals to the party is irrelevant for our purposes, since they may not be suspects. In other words, th following seems to be the default interpretation for (59b) rather than (60):

(61) $\exists x$[$x$ comes to the party][It will be relevant that $x$ comes to the party].

Notice that on Berman's theory the default is the universal quantifier, generally. While Berman does entertain the possibility that the default can be existential sometimes, e.g., with embedded wh-infinitivals, as pointed out by Hintikka, the above example shows that the default can be existential even when the embedded interrogative is tensed rather

than infinitival. This would mean that whether the default is universal or existential depends on the embedding predicate in question. It would certainly be desirable to be able to predict when the default is universal and when existential from the semantics of interrogatives in combination with independent facts about the semantics of the embedding predicates, and neither Hintikka's theory nor Berman's version of it is able to do this in an obvious fashion.

Furthermore, a predicate like *be important* which belongs to this class has the property discussed for the predicate *be surprised* mentioned in the last section, namely, that the default is neither universal nor existential, nor anything in particular. Thus, (62a) cannot be paraphrased either as (62b) or as (62c):

(62) a. It is important who came to the party.
b. $\forall x$[$x$ comes to the party][It is important that $x$ comes to the party].
c. $\exists x$[$x$ comes to the party][It is important that $x$ comes to the party].

Just like for *be surprising*, what is important is the entire answer to the question *Who came to the party?*, and this can be the result of some part of the answer being important (for the purpose) in question, or the combination of the coming of various people rather than each one of them individually. This is even clearer in case of a predicate like *be sufficient (for x's purposes)*, in those dialects that permit this predicate to embed interrogatives, e.g., the one described in Grimshaw (1977). Thus, again as before, (63a) can mean neither (63b) nor (63c) :

a. It is sufficient (for our purposes) who came to the party.
b. $\forall x$[$x$ comes to the party][It is sufficient (for our purposes) that $x$ comes to the party].

c. $\exists x$[$x$ comes to the party][It is sufficient (for our purposes) that $x$ comes to the party].

Again, what is sufficient is the entire answer, and neither some part nor each part of the answer need be sufficient in itself.

To sum up, BH is inadequate for these predicates of relevance for two reasons. Firstly, it can't even describe the correct equivalence between structures containing the interrogative and the corresponding structures with *that*-clauses, as in case of predicates like *be important, be sufficient*. Secondly, when it is able to do this, as with *be relevant*, it is not able to give the equivalence in a principled way. In the last chapter of the thesis, I will give meaning postulates for these predicates that will make it possible to derive the default in cases where there is a default, and also explain why there is no default when there is none.

I must mention in passing that the readings given above for structures containing predicates of relevance with interrogative objects, is only one of the possible readings. Structures containing these predicates with interrogative objects are most naturally interpreted generically, and so (64a) has the reading in (64b) as its most natural reading:

(64) a. It is relevant who will come to the party.

b. $\forall w$[$p$ is the complete answer to *Who will come to the party* in world $w$][It is relevant in $w$ that $p$].

It is clear, however, that unlike predicates like *depend on, control*, etc., these predicates are not inherently generic, possibly related to the fact that these predicate select Questions as well as propositions.

## 1.6 Default Universal and Genericity

One point that I would like to make about Berman's theory is that there is a certain discrepancy between the extension of the semantics of indefinites to embedded interrogatives and the actual readings. Consider example (2d), reproduced here as (65a), and its interpretation (65b):

(65) a. A man hates his enemies.
b. $Gn_x$[man($x$)][$x$ hates $x$'s enemies].

It is clear that in the absence of any adverb of quantification, a sentence like (65a) is interpreted as in (65b), rather than something like (66):

(66) $\forall x$[man($x$)][$x$ hates $x$'s enemies].

It is well-known from Carlson (1977), and the earlier philosophical literature, that genericity is not the same as universal quantification. In fact, as emphasised there it is virtually impossible to translate it in terms of other known quantifiers like *most, all normal*, etc. Furthermore, generics are reports of a certain kind of generalisations, and cannot be reports of accidental generalisations, and so on. So, sentences like (65a) become deviant with specific time-reference, at least the generic reading is no longer available:

(67) * A man hated his enemies at 2:00 PM yesterday.

Specific time reference precludes the statement of a generalization in cases like (67), and so (67) is deviant. Sentences containing embedded interrogatives, however, can be interpreted episodically, and so (68a) and (68b) are both acceptable:

(68) a. John realises what Bill had done.

b. Gazing at the valley, at 2:00 PM vesterday, John realised what Bill had done.

In other words, the default in the case of embedded interrogatives is a real universal quantifier rather than a generic operator. Given that wh-phrases are assumed to be indefinites, it is surprising that the default in structures containing normal indefinites should be different from those containing wh-phrases, even given the syntactic differences between the position of wh-phrases and real indefinites at LF that Berman assumes. Notice that sentences like (68b) can be used generically, at least with a slight change in the embedded tense:

(69) John realises what Bill does.

This suggests that genericity has a different source from that of the default universal that one finds so often in the examples involving embedded interrogatives.

One point I would make about BH in passing is that it shares the property, with some other semantic theories of questions like Karttunen's, that the following two sentences are rendered equivalent:

(70) a. Which philosophers are Frenchmen?

b. Which Frenchmen are philosophers?

This is because both (71a) and (71b) receive the interpretation in (71c):

(71) a. John knows which philosophers are Frenchmen.

b. John knows which Frenchmen are philosophers.

c. $\forall x$[French($x$)$\wedge$philosopher($x$)][John knows that( French($x$)$\wedge$philosopher($x$))].

More accurate interpretations of (71a) and (71b) should be the following, respectively, or perhaps (72c) and (72d):

(72) a. $\forall x$[philosopher($x$)][John knows whether French($x$)].
b. $\forall x$[French($x$)][John knows whether philosopher($x$)].
c. $\forall x$[philosopher($x$)$\wedge$French($x$)][John knows that French($x$)].
d. $\forall x$[philosopher($x$)$\wedge$French($x$)][John knows that philosopher($x$)].

The general semantics assumed by BH cannot, however, yield these readings, unless one assumes some kind of extra operations.

## 1.7 Embedded Interrogatives and Unselective Binding

The last point to be made about BH, or rather Berman's version of Hintikka's theory, concerns one crucial assumption, viz., that some structures containing embedded interrogatives involve unselective binding. This comes from Lewis (1975), who analyzed adverbs of quantification as unselective binders, i.e., quantifiers binding all variables in their scope. To take an example involving indefinites, this would mean that (73a) is interpreted as (73b):

(73) a. If a man owns a donkey, he usually beats it.
b. most($\langle x, y \rangle$)[man($x$)$\wedge$donkey($y$)$\wedge$own($x$,$y$)][beat($x$,$y$)].

For Berman, multiple interrogatives embedded under predicates like *know* also involve unselective binding. Thus, (74a) is interpreted as (74b):

(74) a. John usually knows who likes who.

b. most($\langle x, y \rangle$)[$x$ likes $y$][John knows that $x$ likes $y$].

Now it is known that the view that indefinites are unselectively bound gives rise to the so-called proportion problem at least when the binding quantifier is, e.g., the quantifier head of a relative clause, as in (75a) whose interpretation is not quite the one in the expected (75b):

(75) a. Most men who own a donkey beat them.

b. most($\langle x, y \rangle$)[man($x$)$\wedge$donkey($y$)$\wedge$own($x$,$y$)][beat($x$,$y$)].

This is because if, e.g., of 10 men that own donkeys, 1 man owns 20 donkeys and the others 1 each, and the one who owns 20 donkeys beats all of them whereas the others don't beat their respective donkeys, (75b) is true, whereas (75a) is intuitively felt to be false. There are various attempts in the literature to deal with this problem, and I won't go into them here. Now one might ask whether similar problems arise in case of embedded multiple interrogatives. While I haven't found an exact analogue of the proportion problem with these cases, there are reasons to question the assumption that the interpretation of these structures involves unselective binding.

Recall that according to Hintikka, all interrogatives embedded under predicates like *know* are ambiguous between a universal and an existential reading. The existential reading is particularly salient in examples involving wh-infinitivals. Thus the most natural interpretation of (76a) is (76b) rather than (76c):

(76) a. John knows where to get gas.

b. $\exists x$[one can get gas at $x$][John knows that one can get gas at $x$].

c. $\forall x$[one can get gas at $x$][John knows that one can get gas at $x$].

Now in cases involving multiple wh-infinitivals, one would expect exactly two readings for a sentence like (77a) if one were to assume unselective binding, viz., the readings in (77b) and (77c):

(77) a. John knows where to go when.

b. $\forall(\langle x, y\rangle)$[place($x$)$\wedge$time($y$)$\wedge$one can go to $x$ at $y$][John knows that one can go to $x$ at $y$].

c. $\exists(\langle x, y\rangle)$[place($x$)$\wedge$time($y$)$\wedge$one can go to $x$ at $y$][John knows that one can go to $x$ at $y$].

The reading in (77c) is, in fact never available, as far as I can tell. Unselective binding rules out various intermediate readings, e.g., (78a) and (78b):

(78) a. $\forall x \exists y$[place($x$)$\wedge$time($y$)$\wedge$one can go to $x$ at $y$][John knows that one can go to $x$ at $y$].

b. $\forall y \exists x$[place($x$)$\wedge$time($y$)$\wedge$one can go to $x$ at $y$][John knows that one can go to $x$ at $y$].

It seems to me, however, that, these intermediate readings are indeed available. Thus, if John has some specific places to go to, and needs to find some suitable time to go to those places, then (77a) is true if and only if (78a) is. Similarly, if John has a pre-given set of times, say, vacation times, and needs to find places to go to at those times, then (77a) is true if and only if (78b) is. The readings can, in fact, be disambiguated by stressing *where* or *when* differently. Thus, (79a) and (79b) (with boldface indicating greater stress) correspond most naturally to the readings (78a) and (78b) respectively:

(79) a. John knows where to go when.

b. John knows where to go when.

The general point is that unselective binding is too restrictive and that structures with embedded interrogatives have more readings than expected if one assumed unselective binding.

## 1.8 Summary of the present work

Having reviewed in some detail the view of the semantics of (embedded) interrogatives as presented in Hintikka (1976) and its modification due to Berman (1990), I will proceed to deal with other aspects of the syntax and semantics of embedded interrogatives. In the next chapter, I deal with problems having to do with the syntax of embedded interrogatives, arguing that predicates of the *know*-class and those of the *wonder*-class both s-select Questions. One result of this is that in no language should there be any syntactic difference between these two classes of predicates. One apparent counterexample, viz., Spanish, is presented in some detail and accounted for. In the following chapter, I reanalyse QVE, giving reasons for favoring the alternative. In this last chapter, I discuss the predicates of *relevance* mentioned above, and explain their properties, viz., how expressions involving these predicates with interrogative complements are to be interpreted, and why they have the properties mentioned in the previous sections of this chapter.

# Chapter 2

# Selection of Interrogative Complements

## 2.1 Introduction

In this chapter, I will discuss some syntactic issues concerning interrogative complements. It was observed before that interrogative complements embedded under predicates of the *know*-type are interpretated in a special way in that whereas (80a) is interpreted as (80b), no corresponding translation exists for (80c):

(80) a. John knows who Mary saw.

b. John knows some proposition *p* that answers the question "Who did Mary see?"

c. John wonders who Mary saw.

The question then arises what semantic category these predicates select for, given that predicates of the *know*-type interpret interrogative complements, as propositions rather than Questions, in a certain sense. There are two major proposals in the literature: on one view espoused, e.g., by Berman(1990), Groenendijk & Stokhof(1981), and others, predicates of the *know*-class select propositions rather than Questions, whereas predicates of the *wonder*-class select Questions alone. On the other view espoused, e.g., by

Karttunen(1977), Grimshaw(1979), etc., predicates of the *know*-type select propositions as well as Questions, predicates of the *wonder*-type select Questions but not propositions. There are differences among proponents of each of the two views, given that they come from very different syntactic frameworks. In this chapter, I will provide some evidence that under the syntactic assumptions made in the principles-and-parameters framework, the second view is supported.

## 2.2 S-selection and C-selection

It is a standard assumption in a wide variety of syntactic frameworks that the lexicon includes information about the syntactic and semantic type of the complement a verb or a predicate may take: strict subcategorisation restrictions and selectional restrictions, following Chomsky(1965). A version of this theory that is of interest to us can be found in Grimshaw(1977). According to this theory, verbs and predicates select for the semantic type of the complement they take (s-selection), as well as the syntactic category of the complement (c-selection)[1]. Following, in part, certain observations of Baker (1968, 1970), Grimshaw argues that the theory of s-selection allows predicates to select complements categorized as Q (question), P (proposition), etc[2]. The major observation of

[1] Versions of this view can be found in theoretical frameworks not discussed here, e.g., LFG, Categorial Grammar, HPSG, etc.

[2] The term "semantic type" is used rather loosely in Grimshaw (1979), and includes exclamations, etc. In my discussion below, I use semantic type to mean logical type, something along the lines of Montague's type theory. It is unclear what the logical type of "exclamations" is, for example, one could offer arguments for them being propositions, or maybe even questions. If I am right then, in restricting s-selection to selection for logical type, one would expect predicates to not be subcategorized for exclamations, but would rather follow from other properties. This is a task that I won't attempt here, however. It is clear that propositions and questions have different logical types, and so it is legitimate to talk about s-selection for P and Q.

Grimshaw's was that semantic types and syntactic categories are not in one-to-one correspondence. Thus, while questions as well as propositions are realized as CPs, they can also be realized as NPs ("concealed" questions, "concealed" propositions, etc.), or nothing (null complement anaphora, for details, see below). Thus, the predicate *ask* selects Q, and this requirement is satisfied in all three of the following examples:

(81) a. John asked me $[_{CP}$ what the time was].
b. John asked me $[_{NP}$ the time].
c. John wanted to know what the time was, so I asked [$\phi$].

In (81a), Q is realized as a syntactic CP. In (81b), Q is realized as a syntactic NP. In (81c), there is no argument in syntactic structure, but is filled at some later, more abstract level of representation, before interpretation. Given the fact that not any NP can function as a concealed question, for reasons independent of selection, e.g., the NP *the book* can never be interpreted as *what the book is*, it is not surprising that the following sentence is judged as grammatical:

(82) * John asked him the book.

This observation shows that s-selection is essential, and that only c-selection will not do. Given that s-selection is necessary, one might wonder whether information about c-selection is needed as well. Grimshaw argues that it is, given the fact that there exist verbs like *wonder* which s-select questions, but do not take concealed NP questions:

(83) a. John wondered $[_{CP}$ what the time was].
b. * John wondered $[_{NP}$ the time].
c. Bill inquired $[_{CP}$ how old I was].

d. * Bill inquired [$_{NP}$ my age].

Similar remarks also hold for verbs or predicates that s-select propositions: while some of them can take NP-complements, some of them cannot. Thus, as the following examples show, predicates like *assume* take NP-complements, predicates like *pretend* don't, even though both predicates s-select propositions[3]:

(84) a. I'll assume [$_{CP}$ that he is intelligent].
b. I'll assume [$_{NP}$ his intelligence].
c. I'll pretend [$_{CP}$ that he is intelligent].
d. * I'll pretend [$_{NP}$ his intelligence].

Grimshaw accounts for these distinctions among predicates that s-select the same semantic type by assuming that predicates not only s-select semantic types, but also subcategorize for syntactic categories like NP or CP[4]. I.e., predicates like *ask*, *wonder*, etc., in addition to having entries like <__ Q> in their lexical representation, also have subcategorization frames like the following type:

(85) a. [_{ NP, CP} ].
b. [_ CP].
c. [_ NP].
d. [_{ $\phi$ }].

Thus, predicates *ask* and *wonder* both s-select questions, i.e., have <__ Q> as their selectional frame. But whereas *ask* has (85a) as its subcategorization frame, the subcategorization frame of *wonder* is (85b). Similarly, both *assume* and *pretend* have <__ P>

[3] I am glossing over the distinctions that have been proposed between events, propositions, and facts. It might be that this point is made irrelevant if these three entities are distinguished, but I don't know the consequences at this point.

[4] *S'* in the old system.

as their selectional frame, but whereas *assume* has (85a) as its subcategorization frame, *pretend* has (85b) as its subcategorization frame, as so the facts in (83) and (84) follow.

A shortcoming of this approach which was noted by Grimshaw(1979) and addressed in Grimshaw(1981) is that at least in English, predicates that s-select questions or propositions never have the subcategorization frames (85c) or (85d). Since it is not likely to be an accidental gap, an explanation is called for. Grimshaw's suggestion in Grimshaw(1981) is that whereas it is in general *not* predictable whether a predicate that s-selects questions allows NP-complements or not, it is a fact that every semantic type has associated with it a certain syntactic category that can be called its Canonical Structural Realization (CSR). E.g., the CSR of the semantic type Q is CP, and so that every predicate that s-selects Q must subcategorize for CP. Whether it subcategorizes for NPs or not is non-redundant information that must be present in the lexicon. This modification still requires that there be syntactic subcategorisation, but that part of the information about subcategorization be derivable from a general principle like the following:

(86) Context Principle
If a predicate s-selects a semantic category C, then it c-selects (subcategorizes) CSR(C).

Given that in English, CSR(P, Q) = CP, it must be the case that predicates that s-select questions and propositions also subcategorize for CPs, although they may or may not subcategorize for NPs. So the gap noted by Grimshaw follows. Given that facts about syntactic subcategorization, alias c-selection can at least partly be predicted from facts about s-selection and facts about CSRs in the specific language in question, the next

question to ask would be if c-selection is totally predictable from independent facts. Pesetsky(1982) suggests that this is indeed so, at least for these cases, crucially relying on Case theory. Pesetsky, citing examples from Ken Hale observes that there are predicates that s-select propositions but cannot take sentential complements, all examples involving predicates that contain prepositions that do not allow sentential complements, as in the following examples:

(87) a. We assume [$_{CP}$ that unemployment will rise in the 80's].
b. We assume [$_{NP}$ that rising unemployment in the 80's].

(88) a. We noted [$_{CP}$ that we were departing on Thursday instead of Friday].
b. We noted [$_{NP}$ our departure on Thursday instead of Friday].

(89) a. * We approve (of) [$_{CP}$ that unemployment will rise in the 80's].
b. We approve *(of) [$_{NP}$ rising unemployment in the 80's].

(90) a. * We paid attention (to) [$_{CP}$ that we were departing on Thursday instead of Friday].
b. We paid attention *(to) [$_{NP}$ our departure on Thursday instead of Friday].

Given that CSR(P)=CP, one would expect that all these predicates should be able to take CP complements[5]. It is clear from te examples, though, why the predicates in (89) and (90) do not take sentential complements: they all contain prepositions like *of* and *to* that do not allow sentential complements, probably as a consequence of something like Stowell(1981)'s Case Resistance Principle. What this means is that NP is also a CSR for propositions. Whether a predicate takes CP and/or NP complements that are interpreted as propositions, then depends upon whether they assign Case or not, and also whether

[5] As noted above, I am glossing over the distinction between facts and propositions

they contain constituents that allow CP complents or not (on independent, syntactic grounds). Pesetsky suggests that the same explanation carries over to predicates that s-select questions. As noted above, predicates like *ask* allow NP complements whereas predicates like *wonder* do not allow NP complements. Suppose that predicates like *ask* are Case assigners whereas predicates like *wonder* are not. It would follow that the former should allow NP complements, but that the latter do not, as is the case. Pesetsky provides further evidence that this is indeed the case.

Firstly, adjectives in English cannot assign case, and correspondingly adjectival predicates that s-select Q cannot take concealed questions unless there exists some other way of assigning Case, usually a dummy (or not-so-dummy) preposition, as in the following examples with *be uncertain* show:

(91) a. John is uncertain $[_{CP}$ what time it is].
b. * John is uncertain $[_{NP}$ the time].
c. John is uncertain about $[_{NP}$ the time].

Secondly, predicates like *wonder* that do not take concealed questions nevertheless allow concealed questions if preceded by a preposition, as attested in the following examples:

(92) a. John wonders $[_{CP}$ what time it is].
b. * John wonders $[_{NP}$ the time].
c. John wonders about $[_{NP}$ the time][6].

(93) a. John doesn't care /give a damn $[_{CP}$ what time it is].

[6]This sentence has other readings as well, but the point is that the concealed question reading is available.

b. * John doesn't care /give a damn [$_{NP}$ the time].

c. John doesn't care /give a damn about [$_{NP}$ the time].

Thirdly, it is a fact about English (as opposed to languages like Dutch, German, Sanskrit, Bangla, etc.) that predicates that do not assign Case do not passivize. So English intransitives, e.g., do not passivize:

(94) a. John ran.

b. * It was run by John.

Notice that whereas CPs can appear in caseless positions, NPs cannot. This explains the following contrast :

(95) a. It was asked [$_{CP}$ what time it was].

b. * It was asked [$_{NP}$ the time].

Since *ask* is a Case-assigner, it can passivize even though its passive form does not allow the concealed question. Predicates like *wonder*, on the other hand do not passivize at all, even with the question-complement in situ, differentiating them from the examples in (95):

(96) a. * It is not cared what time it is.

b. * It was inquired who tried to kill the Pope.

c. * It has been wondered what John did at the seminary.

d. * It wasn't given a damn what time it was.

Given Case theory, it seems then that subcategorization frames are predictable from facts about the language in question, viz., the CSRs of semantic types. We assume, then, following Pesetsky that syntactic subcategorization is not a primitive of the theory, but

something deducible. Keeping this in mind, we return in the following section to the original problem mentioned in the introduction, viz., the question of whether predicates of the *know*-class and those of the *wonder*-class both s-select questions or not. We will examine one proposal about the semantics of questions that is based on the assumption that predicates of the *know*-class s-select propositions but not questions whereas predicates of the *wonder*-class s-select questions, and one based on the proposal that questions and propositions belong to the same, or depending on the version, the same family, of semantic types. The latter is the proposal in Groenendijk & Stokhof(1981) (and subsequent work by them) and the former is Berman(1991). We note problems specific to either approach, and also note that both proposals contradict the requirement that c-selection be derivable in a given language from s-selection, CSRs and independent facts of syntactic theory.

## 2.3 Berman(1990)

### 2.3.1 Essential Features

As discussed earlier, Berman's theory is based on the assumption that predicates of the *know*-class s-select propositions, whereas predicates of the *wonder*-class s-select questions, the latter denoting Hamblin sets. For Berman, most predicates that take *that*-complements as well as *wh*-complements and are factive, belong to the *know*-class of predicates[7]. Predicates that take *wh*-complements and are not factive are included in

[7]Berman excludes predicates like *be relevant, matter, be important*, etc. from this class and includes them in the *wonder*-class.

the *wonder*-class irrespective of whether they take *that*-complements or not. As noted earlier, the latter position is not an essential feature of Berman's theory, as predicates like *be certain (about), agree (on)*, etc. show QVE and should be classified under the *know*-class predicates. What is relevant for my purposes here is what Berman's theory has to say about the distribution of embedded interrogatives.

The essential elements of Berman's theory, mentioned earlier, that are relevant here are the following:

(97) a. Predicates of the *know*-class select propositions but not questions.
b. A Q-morpheme combines with an open sentence to yield question denotations.
c. Predicates of the *wonder*-class select questions and not propositions.

One consequence of (97a)-(97c) is that *ceteris paribus*, all factive predicates should be able to take interrogative wh-complements. Their factivity guarantees that the presuppositions of the nuclear scope can be accomodated and structures containing a factive predicate should be interpretable and well-formed. This, of course, is on the assumption that predicates do not subcategorize for features like a +wh COMP, as argued for in Grimshaw(1979). A second consequence of Berman's analysis is that since questions and propositions have different syntactic realizations: the former being realized with a Q-morpheme in the COMP-position and the latter lacking such a morpheme, it should follow that syntactic phenomena that distinguish syntactic entities (surface ar deep) must also distinguish the *wh*-complement of predicates like *know* from *wh*-complements of predicates like *wonder*. In the following two sections, I will challenge both of these consequences of Berman's analysis.

### 2.3.2 Factivity and the ability to take Interrogative complements

Factive predicates in large numbers take interrogative complements as one can see from the examples in Chapter 1, so, e.g., predicates like *know, realize, list, record, find out*, etc., all allow *wh*-complements that, on Berman's theory, are interpreted as propositions rather than questions. There are two classes of factives predicates that are potential problems for Berman's theory.

The first involves predicates like *regret and resent* that don't seem to allow interrogative complements, probably more clearly in case of *resent* than in case of *regret*, as the following examples show:

(98) a. * I resent whether (or not) John came to the party.
b. * I resent who John saw.
c. * I resent which man saw which woman.
d. I resent (it) that John came to the party.
e. I resent what Bill did. (free relative)
f. * I resent who saw what.
g. * I resent what to do.

The examples in (98) show that a predicate like *resent* cannot take *wh*-complements that are not free relatives. The corresponding examples with *regret* are slightly less clear, but the general point holds, I think, viz. that factivity by itself does not guarantee the ability to take interrogative *wh*-complements.

Given that this is so, one might wonder what this means for a theory of selection. One way out of this problem is to postulate some kind of syntactic subcategorization, say, for a +wh COMP. On this view, factive predicates like *know* and *realize* will be

assumed to subcategorize for a +wh COMP, whereas *resent* and probably *regret*, will subcategorize for a -wh COMP. This proposal, however, goes counter to the attempt mentioned in the last section to derive syntactic subcategorization from s-selection, because +/-wh is a syntactic feature that is presumably independent of the semantic type of the clause it is the head of[8]. Even if one were to ignore that requirement, the question of what the exact content of this feature is needs to be raised. It is worth mentioning in this connection that a +wh COMP was postulated in Baker (1968)[9], Bresnan (1970, 1972), and used extensively in Chomsky (1973). However, as was pointed out in Grimshaw (1977), once one assumes a theory of s-selection, the old use of +/-wh COMP becomes redundant, i.e., whether a +wh COMP headed a clause or not becomes predictable from the semantic type of the clause it heads. This means that the new use of the +/-wh COMP must be substantially different from the old one. Given that it is a purely syntactic feature, it presumably has some syntactic reflex. It can't be that a +wh COMP is filled by a wh-phrase at S-Structure, since that is not true of languages without syntactic wh-movement. Furthermore, most current versions of GB-theory assume that wh-movement is to the specifier of CP rather than COMP, and is also assumed by Berman. Suppose this problem was averted somehow, viz., by some mechanism that passed features of the specifier to the head of a phrase. Another, more plausible way of identifying a +wh COMP would be the requirement that its specifier be filled with a wh-phrase at LF rather than S-Structure.

[8] At least it is not supposed to distinguish propositions from questions.

[9] The Q-morpheme, á la Baker

An additional problem remains, however. Note that given that predicates can s-select propositions as well as questions, and at the same time subcategorize for +/-wh COMP, one would expect that there exist four classes of predicates:

(99) a. Predicates that s-select propositions, +wh: *know, realize, agree (on), be certain (about)*
b. Predicates that s-select propositions, -wh: *resent, regret, believe, assume*
c. Predicates that s-select questions, +wh: *wonder, ask, investigate*
d. Predicates that s-select questions, -wh: ?

As seen from the list, there are no predicates in English that s-select propositions but subcategorize for -wh COMP. A partial answer to this question can be given: since a question is realized syntactically as a clause, the specifier of whose head COMP is a phonologically empty Q-morpheme, it is required that the Q-morpheme bind some variables in its scope. Berman's theory guarantees that these free-variables come only from wh-phrases rather than the more run-of-the-mill indefinites, and that ensures that a clause that the Q-morpheme has in its scope must be headed by a +wh COMP. This explanation works, however, only upto a point. It does *not* explain why there is no English predicate, say, wönder, in English with the property that (100a) mean (100b):

(100) a. John wönders Bill came to the party.
b. John wönders, "Did Bill came to the party?"

This is so because in yes-no questions, there are, presumably, no variables for the Q-morpheme to bind. In short, the solution just sketched leads to redundancies, besides making syntactic subcategorization unpredictable from general facts about a given language. Furthermore, there is no evidence for an independent feature of +wh COMP

besides the need to distinguish factive predicates that take *wh*-complements from those that don't.

The second class of examples involves predicates like *be relevant, be important, be sufficient (for x's purposes), matter*, etc., which are factive and take *wh*-complements, but according to Berman, are interpreted as propositions rather than questions. Given their factivity, there is no reason why they should not be interpretable as propositions. There is a further problem with these examples, viz., that even recourse to syntactic subcategorization for something like a +wh COMP will not help, because these predicates select questions, whose syntactic realization presumably includes CPs headed by a +wh COMP. Of course, one might question the assumption that the *wh*-complements of these predicates are never interpretable as propositions. The counterfactual element that probably exists in some of these predicates might obscure the judgements, but some of these are clearly not interpreted in Berman's way. Thus (101a) means neither (101b) nor (101c):

(101) a. It is sufficient for our purposes who Bill saw.
b. $\forall x$[Bill saw $x$][it is sufficient that Bill saw $x$].
c. $\exists x$[Bill saw $x$][it is suficient that Bill saw $x$].

Of course, that in itself does not show that the *wh*-complement in (101a) is not interpreted as a proposition, after all, (101c) can be argued to mean (102):

(102) It is sufficient for our purposes that $p$, where $p$ is the complete true answer to the question "Who did Bill see?"

This might be compatible with a theory that rejected Berman's semantics but insisted that *be sufficient*, nevertheless selects propositions, but it is unclear what the relationship between factivity and the distribution of *wh*-complements would be, on that theory. Note that the statement about the interpretation of (101a), as it appears in (102), crucially assumes that the *wh*-complement in (101a) is a question. In a later part of this chapter[10], I will discuss why the strategy of assuming that predicates like *be sufficient* select propositions but not questions has other problems.

### 2.3.3 Question clauses and propositional *wh*-clauses

Recall that on Berman's theory, *wh*-complements of predicates like *know* and *wonder* differ syntactically as well as semantically. The former are propositions, the latter are questions. The latter are realized as clauses with a Q-morpheme in the specifier of CP, the former aren't. In this section, I will use two syntactic phenomena that can be used to determine whether this syntactic distinction between the two cases can be maintained, viz., Right Node Raising (RNR), and Null Complement Anaphora. My conclusion will be negative in either case.

#### Right Node Raising

Under the assumption that *wh*-complements embedded under *wonder*-class predicates have a Q-morpheme, whereas those under *know*-class predicates don't, one would expect RNR to distinguish the two types of clauses. As the following examples show,

[10]See the section on Groenendijk & Stokhof.

RNR treats both classes of complements as identical:

(103) a. John asked, and Bill knew, what went on at the party.
b. John knew, but nevertheless asked Bill, why he was sad.
c. John wondered, but Bill had realized long ago, who the murderer was.
d. John wondered, but Bill was certain, which men love which women.

This is contrary to one's expectations, if one expects the two classes of clauses to be syntactically distinct.

### Null Complement Anaphora

Null Complement Anaphora (NCA) was discussed in Grimshaw (1977). It was noted in Grimshaw (1977) that sentential complements can be dropped if they match up with the semantic type of an antecedent complement clause. If it doesn't match up with an antecedent of the same semantic type, the result is ill-formed. Consider the following discourse[11]:

(104) a. Question: Did John leave?
b. Response: I don't know.
c. Response: Ask Bill.
d. Response: I wonder.
e. Question: Who left?
f. Response: I don't know.
g. Response: Ask Bill.
h. Response: I wonder.

Note that the responses are interpreted as if they have the antecedent clause in the object position, as in the following:

[11]Most examples in this section are from Grimshaw (1977).

(105) a. I don't know whether John left.
b. I don't know who left.
c. I wonder who left.
d. I wonder whether John left.
e. Ask Bill who left.
f. Ask Bill whether John left.

Furthermore, predicates that cannot take embedded interrogatives are not well-formed in discourses like (104), with a question antecedent and a response with the complement clause deleted:

(106) Question: Did John leave?
Who left?
Response: #It's too bad.
#I agree.
#I'm flabbergasted.
#I'm surprised.

The reason why these samples of discourse are ill-formed is that the predicates in the response examples do not allow interrogative complements:

(107) a. * It's too bad whether John left/who left.
b. * I agree whether John left/who left.
c. * I'm flabbergasted whether John left/who left.
d. * I'm surprised whether John left/who left.

Note that the complement can be dropped in the very same predicates if the antecedent is a declarative:

(108) Statement: John is telling lies again.
Response : It's too bad.
I agree.
I'm flabbergasted.
I'm surprised.

As expected, predicates that do not take interrogative complements cannot drop their complements in discourses like (108), as the following examples show:

(109) a. John is lying again.
b. #Ask Bill.
c. #I wondered.
d. #I inquired.

This is because the following are not well-formed:

(110) a. * Ask Bill that John is lying again.
b. * I wondered that Bill is lying again.
c. * I inquired that Bill is lying again.

Grimshaw (1977) calls this phenomenon Null Complement Anaphora (NCA). Grimshaw also notes that there are predicates that don't allow NCA at all, even in discourse where their selectional constraints are satisfied. These predicates include *divulge, disclose, predict, be apparent, announced*, etc.[12]. The following examples show this:

(111) Question: Has the mayor resigned?
What did the mayor decide to do?
Response: *John wouldn't divulge.
*John wouldn't disclose.
*Predict.
*It's apparent.
*They haven't announced yet.

(111) contrasts with the fact that the following are well-formed:

(112) a. John wouldn't disclose whether the mayor has resigned.
b. John wouldn't divulge whether the mayor has resigned.

[12]There is considerable idiolect variation on these examples. Many people allow NCA with some of these predicates.

c. Predict whether the mayor has resigned.

d. They haven't announced yet whether the mayor has resigned.

Furthermore, according to Grimshaw, whether or not a predicate allows NCA or not does not depend on whether the complement is declarative or interrogative. E.g., the predicates in (111) also allow declarative complements, and discouse situations involving NCA are unacceptable even if the antecedent is a declarative:

(113) Statement: Guess what, John is telling lies again.
Response : * Oh, John wouldn't divulge.
* Oh, John wouldn't disclose.
* Yeah, I'd predicted.
* It's apparent.
* Why didn't they announce?

A further property of NCA is that it is conditioned by the semantic type of the antecedent rather than its syntactic category. It was noted earlier in the chapter that many verbs and predicates do not allow concealed question complements, i.e., NP complements that are semantically questions[13]. Examples of such predicates are *inquire, not care, wonder, not sure, not give a damn*, etc. Note the contrast below:

(114) a. I asked him the time.

b. I know the time.

c. * I inquired the time.

d. * I don't care the time.

e. * I wonder the time.

f. * I'm not sure the time.

g. * I don't give a damn the time.

[13]According to Berman, questions or propositions, depending on the predicate that has them as complements.

If the antecedent is a concealed question, however, NCA is possible with these predicates even though they don't allow concealed question complements. Thus, although the discourse situations in (115) are bad, (116) is perfectly acceptable:

(115) a. * Bill asked me the time, so I inquired the time.
b. * Bill claimed to want to know the reasons for my decision, but he didn't really care the reasons for my decisions.
c. * I didn't know the reasons for John's capricious behavior, but I wondered the reasons for his capricious behavior.
d. * Mary asked me the time, but I wasn't sure the time.

The corresponding NCA examples are fine:

(116) a. Bill asked me the time, so I inquired.
b. Bill claimed to want to know the reasons for my decision, but he didn't really care.
c. I didn't know the reasons for John's capricious behavior, but I wondered.
d. Mary asked me the time, but I wasn't sure.

What this shows is that the "understood element" in these cases does not have to be identical in syntactic structure to its antecedent, but must be "identical in meaning", in particular, belong to the same semantic type. What is of interest to us is that on the theory of Berman, wh-complements of *wonder* and those of *know* differ in syntactic structure as well as semantic type. One would expect then that NCA should distinguish the two types. But that is not the case, as the following examples show:

(117) a. Bill asked me what the time was, but I didn't know.
b. If you don't know what to do, ask.
c. I realized who I would have to see in Montreal, but I inquired anyhow.

Note that the antecedent could be a question clause, and the understood null complement a proposition (according to Berman), or the other way round, viz., the antecedent being a propositional wh-clause and the understood null complement a question. It is unclear how the view that holds that the wh-complements of the two classes of predicates are semantically different, describe the phenomenon of NCA. One can come up with ad-hoc explanations but even they can only work up to a point. Grimshaw notes that There is a small class of predicates, in which they include *be (im)possible, be (im)probable, be doubtful*, and to which one can also add *be certain*, that have the property that they can appear in a discourse with understood null complements that have as their antecedent a yes-no question:

(118) Question: Did John leave?
Response: It's (im)possible.
It's highly (im)probable.
It's doubtful.
I am almost certain.

Now the responses in the above example are interpreted as follows:

(119) a. It is (im)possible that John left.
b. It is highly improbable that John left.
c. It's doubtful that John left.
d. I am almost certain that John left.

Moreover, this restricted kind of NCA is not possible with constituent questions, as seen in the following example, where a wh-question is followed by ill-formed responses:

(120) Question: Who left?
Response: #It's (im)possible.
#It's highly improbable.
#It's doubtful.
#I am almost certain.

Now in a Berman-type theory, as well as many other versions of principles and parameters, the chief distinction between the D-Structures of *Did John leave?* and *John left* is that the former contains a Q-morpheme in Spec of CP[14]. The tree for the latter is, thus, contained in the tree of the former. While Grimshaw does not draw this conclusion, it could be argued that since the D-Structure tree for a yes-no question contains as its subtree a constituent that is interpreted as a proposition, NCA should be possible, at least for some predicates. Of course it leaves unexplained why only some predicates show this kind of NCA but not others. On the other hand it explains why constituent questions cannot be antecedents for the null complement of these predicates (e.g. (120)). This is because the D-Structure of *Who left?*, e.g., has no subtree that is interpretable as a proposition. Note also that this kind of anaphora shows up with predicates like *believe* which do not allow null complements, but rather use anaphoric elements like *so*:

(121) Question: Did John leave?
Response: I believe so.
I (don't) think so.
I had assumed so.

The above responses are interpreted as follows:

(122) a. I believe that John left.
b. I (don't) think that John left.

As expected, discourses of this type with constituent question antecedents are ill-formed:

(123) Question: Who left?
Response: #I believe so.
#I (don't) think so.

[14]Or COMP, depending upon the version.

Coming back to the original point, anyone advocating the view that the wh-complements of *know* and *wonder* are semantically different, could offer half an explanation for NCA involving these predicates. Given that the D-Structure tree for a question wh-complement contains the D-Structure tree for a propositional wh-complement, it follows that a question antecedent should allow a null complement of a predicate that can take a propositional wh-complement, as below:

(124) Bill asked me what the time was, but I didn't know.

On the other hand, even this cannot explain why NCA can also go the other way, i.e. why the following is as well-formed as the previous example:

(125) I knew what time it was, but I asked anyhow.

In other words, the facts from NCA go against the view that these two types of wh-complements are distinct syntactically and/or semantically.

### 2.3.4 Conclusions

From the evidence reviewed, we see then that there is no syntactic evidence to show that wh-complements embedded under *know* and *wonder* are distinct. Furthermore, the particular instantiation of this idea in Berman (1991) has other problems that require postulation of syntactic features that predicates need to subcategorize. This goes counter to the attempt to derive c-selection from s-selection and independent facts of the language, combined with general principles of syntax. And in this particular case, it lacks independent motivation beyond the immediate problem at hand.

## 2.4 Polarity and Embedded Wh-Complements

Another version of the view that wh-complements embedded under *know* are syntactically distinct from those embedded under *wonder* appears in Munsat (1987). He argues that the former contain a complementizer WH-THAT whereas the latter contain a complementizer WH-Q. Since his account is not coupled with a detailed semantic analysis of interrogatives, I will restrict my attention to one kind of evidence adduced in favor of this distinction, viz., that from Negative Polarity. The claim in this paper is that in certain contexts involving embedded wh-complements, NPIs are fine under the scope of *wonder*-class predicates but not under the scope of *know*-class predicates. The data are not so clear, though. Munsat's examples involve the following contrasts:

(126) a. * I know how he ever did it.
b. I wonder how he ever did it.
c. I don't know how he ever did it.
d. * I know why anyone bothers to listen to him.
e. I wonder why anyone bothers to listen to him.
f. I don't know why anyone bothers to listen to him.

Now while the above data are uncontroversial, it is not clear what the badness of (126a) and (126d) are to be attributed to. These examples get slightly better with a verb like *realize*, for example:

(127) a. ?? I realize why anyone would bother to listen to him.
b. ?? I now realize how he ever did a thing like that.
c. * I realize that anyone would bother to listen to him.
d. * I now realize that he ever did a thing like that.

*Realize* is a *know*-class predicate, but seems to be able to allow NPIs marginally in their embedded how- and why-complements. Moreover, predicates belonging to either class allow NPIs in their embedded *whether*-complements:

(128) a. John always knows whether anyone is here.
b. John always wonders whether anyone is here.
c. * John always knows that anyone is here.
d. John does know whether Bill ever went to the party.
e. John wonders whether Bill ever went to the party.
f. * John does know that Bill ever went to the party.

So again no matter what is responsible for the contrast in (126), it doesn't seem to be a straightforward prohibition against NPIs in wh-complements embedded under predicates of the *know*-class.

## 2.5 Groenendijk & Stokhof (1981, 1989)

Groenendijk & Stokhof assume a syntactic theory that is an extension of Montague's syntax, and so is substantially different from the syntactic theory presupposed in the present work, but the relevant topic, viz., selection for semantic types and syntactic categories and the relation between the two, is a matter of common concern, and what Groenendijk & Stokhof have to say about these matters is easily translatable into our framework. As I mentioned earlier, I defined *know*-class predicates as those for which statements like (80a) are interpreted as in (80b), repeated here:

(129) a. John knows who Mary saw.
b. John knows some *p* that answers the question "Who saw Mary?"

Groenendijk & Stokhof, on the other hand, propose a different classification of predicates that take embedded interrogatives, and the difference is relevant to our discussion. They distinguish between what they call *extensional* and *intensional* predicates, the former including predicates like *know, tell, discover, realize*, etc. and the latter including predicates like *ask, wonder, guess, be certain (about), be important, depend on, matter, make a difference*, etc. As they note, the terms *intensional* and *extensional*, as they use it, is slightly misleading, since all the above-mentioned predicates are intensional. Let me call G&S's *extensional* predicates *core-extensional*, following Zimmermann (1985)'s review of their paper. Core-extensional predicates consist of predicates like *believe* that take only that-clauses and predicates like *know, tell*, etc. that in relating agents to questions relate them to their *true* answers. G&S's intensional predicates include those predicates like *wonder* that take only wh-complements and those predicates like *guess, be certain*, etc., that in relating agents to questions do not relate them to their true answers.

According to G&S (1981), interrogatives denote functions from the set of possible worlds to propositions, the value of the function at each possible world being the complete true answer to the question at that world. E.g., the denotation of the question in (130a) is the expression in (130b), and the denotation of (131a) is (131b)[15]:

(130) a. "Who walks?"

b. $\lambda i \lambda j[\lambda x[\mathbf{walk}(i)(x)] = \lambda x[\mathbf{walk}(j)(x)]]$.

(131) a. "Did it rain?"

[15] In the following examples, $i$ and $j$ range over possible worlds, and the formulation is in Ty2, a system where variables can range over possible worlds.

b. $\lambda i \lambda j$[**rain**($i$)= **rain**($j$)]. (ignoring tense)

Groenendijk & Stokhof (1981) proposes, in addition, that questions and propositions as they occur in embedded contexts have the same type, i.e., they are also functions taking possible worlds as argument and yielding sets of possible worlds as their value. They differ from questions in that they are index-independent, i.e., they are constant functions and so the following condition holds:

(132) $\forall i \forall j[f(i) = f(j)]$.

Thus the denotation of *John walks*, according to G&S (1981) is the following propositional concept:

(133) $\lambda i \lambda j$[**walk**($j$)(**john**)].

This is a function that maps every possible world to the (classical) proposition **walk**(**john**).

G&S give a couple of arguments in favor of assigning the same logical type to propositions and questions. Their first argument is that if they have different types, then, given standard type theory, the same predicate cannot take both question and propositional complements. Thus, e.g., Karttunen (1977) is forced to assume the existence of two predicates *know* (and *tell, realize*, etc.), one, viz., $know_{IV/Q}$ which selects questions, and another, $know_{IV/t}$, which selects propositions, and the meanings of the two are related by means of meaning postulates. But for each one of these predicate pairs, there is a strong intuition that they are one and the same, and the procedure mentioned just multiplies lexical items where no complication is needed. The problem is solved

if one assumes that questions and propositions have the same semantic types, because then there is no need to postulate two lexical items.

Their second argument is that wh-complements can be coordinated, as the following examples show :

(134) a. John knows that Peter has left for Paris, and also whether Mary has followed him.

b. Alex told Susan that someone was waiting for her, but not who it was.

Since they can be coordinated, they must be of the same type.

Now neither argument is very strong, and rest on specific assumptions that one doesn't have strong reasons to adhere to. Thus, if one assumes the rather restricted type-theory of Chierchia (1984), according to which arguments are individuals that belong to one or other sort, there is no specific reason why a lexical item should not be able to take arguments which denote individuals drawn from a variety of sorts. E.g., if $e_p$ is the sort of individual correlates of propositions, and if $e_Q$ is the sort of individual correlates of questions, a predicate like *know* can simply be of type $\overline{< e_{p \cup Q}, < e, p >>}$. The fact that wh-complements and propositions can be coordinated is certainly compatible with the theory of type-shifting proposed, e.g., in Partee&Rooth (1984), where it is shown how conjuncts belonging to different basic types can be coordinated by shift the type(s) of one or more conjuncts. In fact, that is exactly what G&S propose in their later paper.

Moreover, an obvious problem is that this approach, *ceteris paribus*, allows any propositional attitude predicate to take propositional as well as question complements.

They recognize this problem, and say, "Of course, there are also verbs such as wonder, which take only wh-complements, and verbs such as believe, which take only that-complements. The relevant facts can be easily accounted for by means of syntactic subcategorization or, preferably, in lexical semantics. by means of meaning postulates"(pp. 94). It seems that they dislike the syntactic subcategorization option, and since there is a principled reason for doing so (see section 1), the only other option is meaning postulates. Presumably, what they have in mind are statements like the following:

(135) a. $\forall i \forall x \forall r$[**believe**$(i)(x,r) \rightarrow \forall j \forall k[x(j) = x(k)]]$.

b. $\forall i \forall x \forall r$[**wonder**$(i)(x,r) \rightarrow [\forall j \forall k[x(j) \neq x(k) \rightarrow x(j) \cap x(k) = \phi] \wedge \forall j[x(j) \neq \phi] \wedge \forall i[i \in x(i)] \wedge \bigcup_{i \in I} x(i) = I]]]$.

The idea is that the complement of *believe* is an index-independent propositional concept, i.e., a function that maps each possible world to a proposition in the classical sense (each possible possible world is mapped to the same proposition), whereas the complement of *wonder* is a function whose domain is the set of possible worlds and whose range is a partition on the set of indices, i.e., a question [16]. While I don't see any specific problems with this approach, and is in some respects close to the view I will outline later, I do have an objection that might be more aesthetic than substantial, and that is that on this view, problems of well-formedness seem to become problems of truth. Note that if statements like (135a) and (135b) are taken to be the basis of selectional restrictions, then sentences like *John wonders that Bill came to the party* and *Mary believes*

[16] With the additional condition that each world is mapped to a proposition that contains it. This captures the fact that each world is mapped to a proposition that is the complete true answer to the question in that world.

*who came to the party* are not ill-formed but simply false in all models. I think this is a conceptual problem that cannot be avoided on this view.

Groenendijk & Stokhof (1989) includes a modification of this view, a modification that doesn't change the semantics of interrogatives very much, but has very different different things to say about selection. There, they argue that core-extensional predicates have the same semantic type as those that take propositions as the second argument. Thus, *know* and *believe* have the same semantic type, viz., $<< s,t >,< e,t >>$, in other words they both s-select propositions. Predicates that are not core-extensional but allow wh-complements like *wonder*, etc., are of a higher type, viz., $<< s,< s,t >> ,< e,t >>$. It is argued that wh-complements start with the lowest type, viz., that of propositions, but are "lifted" in type to the denotations given above by means of operations described in Partee & Rooth(1983). This departs from the earlier proposal in G&S (1981) that core-extensional predicates took questions as their second argument, but were reduced to a propositional argument by means of a meaning postulate. They envisage a system of rules that guarantees that (136a) will be true in a world $a$ if and only if (136b) is true:

(136) a. John knows who walks.

b. **know(john,** $\lambda i[\lambda x[$**walk**$(i)(x)]=\lambda x[$**walk**$(a)(x)]]$).

It is unclear how this proposal can be made to work, since G&S do not give the details of the rules that can achieve this result. Let us assume, for the sake of argument that this is possible and see if G&S have arguments that favor this position. They give further details of type-lifting operations needed to account for coordination, etc. The

major problem with this approach is with those "intensional" predicates like *be certain, agree on predict, guess, conjecture*, etc., that take that-complements as well as wh-complements. Since the lowest possible type type for them is the same as *know*, they should be able to be interpreted as in (136a)-(136b). There is also no principled reason why *believe* should not be able to take wh-complements, in the same manner. Note that even if one forces oneself to postulating a syntactic *+wh* feature, that might prevent *believe* from taking a wh-complement, but is of no help in the other cases. Note that the modification of Berman's theory suggested in chapter 1, which shares with G&S (1989) the view that wh-clauses embedded under predicates like *know* are propositions (not propositional concepts, even index-independent ones), does a far better job in explaining the distribution of embedded wh-complements than G&S (1989), even though I believe there are problems with the former, discussed there.

## 2.6 Predicates that s-select Questions

We saw in the previous sections that predicates like *know* as well as predicates like *wonder* should be taken to s-select Questions, rather than the former s-selecting propositions and the latter Questions. Now it is true that interrogative complements of *know*-class predicates are interpreted in a special way, (related to the fact that these predicates also s-select propositions), viz., that these predicates are true of an agent and an interrogative complement only if they are also true of the agent and an answer to the question that the interrogative complement denotes, i.e., the following is true:

(137) $V_{IV/Q}(x, Q) \rightarrow \exists p[V_{IV/t}(x, p) \wedge p$ is a partial answer to $Q]$.

The condition (137) holds of all *know*-class predicates.

## 2.7 Spanish Interrogatives and Complement Selection

### 2.7.1 Introduction

I argued in the previous sections that predicates of the *know*-type as well as predicates of the *wonder*-type both s-select Questions. The argument was not based on purely semantic considerations, but based on the fact that certain generalizations about complement-selection and syntax-semantics correspondences are lost under the assumption that *know*-class predicates select propositions but not questions, as in Berman (1990), or the variant in Groenendijk & Stokhof (1989). Given this fact, it must be the case that there should be no language where the interrogative complements of predicates like *ask, wonder*, etc. have a different syntactic realization from the interrogative complements of predicates like *know, reveal*, etc. This seems to be the case with English. There are also languages like Mohawk, some West African languages like Vata, where embedded interrogatives are syntactically rather different from matrix interrogatives, but which do not distinguish predicates of the *know*-class from those of the *wonder*-class. In this section, I will discuss the case of Spanish, where it has been argued by Suñer (1989) that the two classes of predicates are associated with different features (syntactic and semantic), resulting in different selectional properties. I will argue that the difference between *ask* and *know* in this language stems not from any difference between proposition-

selecting and question-selecting predicates, but from the fact that this language systematically distinguishes speech-act verbs and predicates from other propositional attitude verbs/predicates. I show that there are predicates which are semantically from the *wonder*-class but are not speech-act verbs and correspondingly behave like *know*-class predicates in the relevant respect. Furthermore, I argue that the perspective I have adopted here explains some puzzles noted and left unresolved in Suñer (1989).

### 2.7.2 Predicates of Communication in Spanish

It is an old observation in traditional grammars of Spanish as well as in relatively recent work on the generative grammar of Spanish, e.g., Rivero (1978), Plann (1982), that the complementizer *que* may sometimes precede a *wh*-phrase, and, according to Rivero, are "connected in a very general way with verbs of saying". The following examples from Rivero (1980) illustrate this in part:

(138) a. Te preguntan que para qué quieres el préstamo.
you ask:3p that for what want:2s the loan
'They ask you what you want the loan for.'

b. Murmuró que con quién podía ir.
murmured:3s that with whom could:3s go
'He asked, by murmuring, who could he go with.'

c. Pensó que cuáles serían adecuados.
thought:3s that which ones would be appropriate
'He wondered which ones would be appropriate.'

d. Repitió que qué libros querían comprar.
repeated:3s that which books wanted:3p buy
'He asked again which books they wanted to buy.'

In contrast, verbs and predicates like *know* do not allow the *que* before embedded interrogatives, as in the following examples:

(139) a. El detective sabe (*que) quién la mató
the detective know:3s (*that) who her killed:3s
'The detective knows who killed her.'

b. Elena se enteró de (*que) por qué no la habían invitado
Elena found out:3s (*that) for what not her had:3p invited
a la fiesta.
to the party
'Elena found out why they had not invited her to the party.'

c. Jaime adivinó (*que) cuál era la respuesta correcta.
James guessed (*that) which was the response correct
'James guessed which one was the correct response.'

Plann's generalization from these data is that the interrogatives embedded under the *que* in (138) are correlates of direct questions. In other words, *que* can precede an embedded interrogative if and only if (with some, possibly principled, exceptions) the structure obtained by substituting the direct question correlate for the embedded interrogative is well-formed. The contrast can be seen in the examples (140) and (141) below:

(140) a. Te preguntan, "¿Para qué quieres el préstamo?"
'They ask you, "What do you want the loan for?" '

b. Murmuró, "¿Con quién puedo ir?"
'He murmured, "Who can I go with?" '

c. Pensó, "¿Cuales serían adecuados?"
'She thought, "Which ones would be adequate?" '

d. Repitió, "¿Qué libros quieren comprar?"
She asked again, "Which books do they want to buy?" '

(141) a. * El detective sabe, "¿Quién la mató?"

b. * Elena entero de, "¿Por qué no me han invitado a la fiesta?"

c. * Jaime adivinó, "¿Cuál es la respuesta correcta?"

This picture, of course is a slightly simplified one. As observed in Plann (1982), and then more systematically in Suñer (1989), the *que* that precedes an embedded interrogative may be optional or obligatory depending upon the embedding predicate. Suñer

provides a classification of propositional attitude verbs and predicates according to the kind of interrogative clauses and indicative clauses they can take as complements. On her scheme, there are five classes of such predicates.

The first class consists of predicates like *creer* 'to believe', and *pensar* 'to think'[17], which take only declarative complements, but do not take interrogative complements at all, as the following examples show:

(142) a. Creo que quedan diez días para las vacaciones.
believe:1s that remain:3p ten days for the holidays
'I believe that there remain ten days for the holidays.'

b. * Creo cuántos días quedan para las vacaciones.
believe:1s how many days remain:3p for the holidays
'* I believe how many days remain for the holidays.'

The second class consists of predicates like *preguntar(se)* 'to ask/wonder'. These verbs take only interrogative complements to the exclusion of declarative complements, and correspond exactly to English *ask* and *wonder*:

(143) a. Pepe preguntó (que) cuántos países habíamos recorrido.
Pepe asked:3s (that) how many countries had:1p visited
'Pepe asked how many countrie we had visited.'

b. * Pepe preguntó que habíamos recorrido ocho países.
Pepe asked:3s that had:1p visited eight countries
'* Pepe asked that we had visited eight countries.'

For this class of verbs, the complementizer *que* that precedes the embedded interrogative is optional.

[17]This refers to Suñer's dialect. In some dialects, *pensar* can also mean 'to wonder', and so would belong to the next class to be described.

The third class consists of manner of speaking verbs such as *gemir* 'to groan', *sollozar* 'to whimper', *contestar* 'to answer', etc., that can take interrogative as well as declarative clauses:

(144) a. Sollozó que cinco píldoras debía tragar.
whimpered:3s that five pills had:3s to take
'S/he whimpered that s/he had to swallow five pills.'

b. Sollozó que cuántas píldoras debía tragar.
whimpered:3s that how many pills had:3s to take
'S/he asked, whimpering, how many pills s/he had to swallow.'

c. * Sollozó cuántas píldoras debía tragar.
whimpered how many pills had:3s to take
'She whimpered how many pills she had to swallow.'

For this class of verbs and predicates, the *que* that precedes the embedded interrogative is obligatory. Furthermore, the embedded interrogative in (144b) is interpreted like the interrogative complement of *wonder* rather than like the interrogative complement of *know*. So in the above examples, if the person in question had to swallow five pills, and (144a) is true, it is still possible that (144b) is false (though (144c) would be true, if it were grammatical).

The fourth class contains predicates such as *saber* 'to know', *decidir* 'to decide', *explicar* 'to explain', *averiguar* 'to find out', *contar* 'to tell', *relatar* 'to relate', *referir* 'to tell'. This class of predicates can take interrogative complements as well as declarative complements:

(145) a. Sabían que yo iba darles una prueba el martes.
knew:3p that I went:1s give them a test the Tuesday
'They knew that I was going to give them a test on Tuesday.'

b. Sabían cuándo iba yo darles una prueba.
knew:3p when went:1s I give them a test
'They knew when I was going to give them a test.'

c. * Sabían que cuándo iba yo darles una prueba.
knew:3p that when went:1s I give them a test
'They knew when I was going to give them a test.'

This corresponds to the English *know*-class predicates, and these are interpreted as such. So if I was going to give them a test on Sunday, and (145a) is true, (145b) is automatically true. Furthermore, the interrogative complement of these predicates cannot be preceded by *que*.

The fifth class of predicates consists of predicates like *decir* 'to say' and *repetir* 'to repeat', which can take interrogative as well as *que*-complements:

(146) a. Repitieron que no querían ir.
repeated:3p that not wanted:3p to go
'They repeated that they didn't want to go.'

b. Repitieron que a cuántos habíamos invitado.
repeated that how many had:1p invited
'They asked repeatedly, how many we had invited.'

c. Repitieron cuándo llegarían.
repeated:3p when would arrive:3p
'They repeated when they would arrive.'

This class of predicates are basically ambiguous between a variant of class four predicates and a variant of class three predicates. While the interrogative complements of these predicates may or may not be preceded by *que*, as (146b) and (146c) show, there is a crucial meaning difference between the two. When the embedded interrogative is preceded by *que* these predicates behave like class three predicates, i.e., the complement is interpreted as that of a *wonder*-class predicate. Without the *que*, however, these predicates behave like class four predicates. So if they would arrive at 4:00PM, then (146c)

is true if and only if they repeated that they would arrive at 4:00PM. This corresponds to the interpretation of *know*-class predicates of English.

### 2.7.3 Suñer (1989)

From the observations above, Suñer (1989) proposes a feature system about the distribution of interrogative complements in Spanish. She assumes the existence of two features: +/-wh and +/-prop. The first feature is syntactic in that it corresponds to a moved *wh* in Spec CP (S-Structure or LF). The second feature is semantic in that it differentiates the type of questions from the type of propositions, propositional complements being +prop, and questions, -prop. The idea is that the five verb classes mentioned in the last section are associated with the following combinations of features:

(147)
| | |
|---|---|
| Class I : | [-wh, +prop] |
| Class II : | [+wh, -prop] |
| Class III : | [+wh, -prop], [-wh, +prop] |
| Class IV : | [+wh, +prop], [-wh, +prop] |
| Class V : | [+wh, +prop], [-wh, +prop], [+wh, -prop] |

These feature combinations indicate that Class I predicates (like *creer*, 'to believe') take propositional complements that do not contain a wh-phrase in their Spec, CP. Class II predicates (like *preguntar*, 'to ask') take question complements that contain a wh-phrase in their Spec, CP (presumably at S-Structure for Spanish). Class III predicates (like *gemir*, 'to groan') take complements that are possible complements for Class I and Class II predicates. Class IV predicates (like *saber*, 'to know') take propositional complements that may or may not have a wh-phrase in their Spec, CP. Class V predicates (like *decir* 'to say, tell') take complements that are possible complements for Class III

and class IV predicates. It is assumed that the two features, while independent, nevertheless show marked combinations. It is assumed that the unmarked feature combinations are [+wh, -prop] and [-wh, +prop], i.e., there is a markedness relation of the following kind:

(148) Unmarked clausal complements: $\alpha$ prop $\rightsquigarrow$ -$\alpha$ wh

[+wh, +prop] is a marked combination. Note that Suñer does not have any explanation for why [+wh, +prop] is much more common than [-wh, -prop], the latter probably nonexistent in the world's languages[18]. Suñer assumes, following G&S (1989), that the smallest type for wh-clauses is that of propositions, i.e., sets of possible worlds, but can be type-lifted in the right environment to partitions. Note that according to G&S, the denotation of the lowest type for *Who walks?* (in Spanish, *¿Quién camina?*) is as follows:

(149) $\lambda i[\lambda x[\mathbf{walk}(a)(x)]=\lambda x[\mathbf{walk}(i)(x)]]$

This is the denotation of the complement of predicates like English *know* and Spanish *saber*. According to Suñer, the function of *que* in Spanish is to convert the denotation of the kind in (149) to a question denotation of the following kind:

(150) $\lambda a\lambda i[\lambda x[\mathbf{walk}(a)(x)]=\lambda x[\mathbf{walk}(i)(x)]]$

This is the denotation of complements with the feature combination [+wh, -prop]. This means that on this view, the *que*+embedded interrogative combination is always interpreted as a question rather than a proposition. There is a slight problem that Suñer

[18]This would be instantiated by a clause that is interpreted as a question but contains no wh-phrases, even though the latter exist in the language and appear in canonical questions.

notes, viz., the fact that predicates of Class II (*preguntar*. 'to ask') can optionally appear without a *que* before an embedded interrogative, which means that there has to be some independent mechanism for getting the denotation in (150) from the denotation in (149).

There are some problems with this view, some of which overlap with my criticism of G&S (1989). As mentioned in the previous sections, this proposal postulates the existence of a +wh syntactic feature which is independent of the semantic type of the clause that its bearer c-commands. This forces subcategorisation for a syntactic feature, and that is undesirable. Furthermore, it is difficult to make sense of a binary +/-prop feature on semantic grounds. If a clause is +prop, that means it denotes a proposition. A -prop clause should be able to denote anything else a clause is capable of denoting, but in Suñer's use, it can only denote a question. This is of course not a major problem, one would just replace selection of a -prop feature with selection for questions. (148) will be modified accordingly, and will be two statements instead of one[19].

The more serious problem with this view involves the empirical generalizations claimed by Suñer. Recall that on the perspective we have adopted, there should be

[19](148) is important for reasons not explicitly noted by Suñer. If the two features were entirely independent, then given that there are four possible combinations of features, i.e., [+wh, -prop], [-wh, +prop], [+wh, -prop], [-wh, -prop], and that a predicate can subcategorize for any number of these features, one would expect $2^4 = 16$ predicate classes instead of five classes. Even if one considers the fact that one does not find the combination [-wh, -prop], one would expect 8 instead of 5 predicate classes. (148) tells why, e.g., there cannot be a predicate that subcategorizes only for [+wh, +prop]. In fact, if one takes the absence of [-wh, -prop] as given, and assumes that feature values of +/-wh are filled in from the values of +/-prop, then one would expect exactly 5 predicate classes. This is because if a predicate selects only -prop, it must be +wh (class II). If a predicate selects only +prop, it can take either only -wh (unmarked, class I) or both + and - wh (marked, class IV). If a predicate selects both + and - prop, then the unmarked combination is [+wh, -prop], [-wh, +prop] (class III); the only possible marked combination being [+wh, +prop], [-wh, +prop], [+wh, -prop] (class V).

no appeal to an independent syntactic feature +wh. Moreover, as mentioned in the last section, I have assumed that predicates like *wonder* and *know* both select questions, and moreover, questions are realized syntactically in a given language in a uniform way that should not distinguish the two classes. Spanish as described by Suñer is an apparent counterexample, because it seems that the complements of the two classes of predicates have different syntactic realizations: one appearing with a (sometimes optional) *que*, the other appearing without a *que*. In the next section I will argue that this generalization is actually false, and Plann's original idea more accurately describes the distribution of the *que*+embedded interrogative anyway. I will argue that the classes of predicates that take *que*+embedded interrogative and those that take simply embedded interrogatives are not *wonder*-class predicates as opposed to *know*-class predicates. The relevant distinction between the two classes of predicates is something else.

### 2.7.4 *Que* as a Quotative marker

Recall that Plann's generalization, in essentials following Rivero, was that the *que* + embedded interrogative was the complement of speech-act verbs and predicates and appeared in exactly those contexts where it was possible to independently have direct discourse complements. This is a very different generalisation from Suñer's, although the predictions of the two coincide most of the time, because of the fact that what I called *wonder*-type predicates are largely speech-act verbs, the latter broadly construed to include physical as well as mental speech acts. The obvious thing to look for when comparing the two generalizations is to try to find predicates belonging to the *wonder*-

class in their semantics, but which are not speech-act verbs. While such predicates are are not easy to find, I could find one such predicate, viz., *investigar* 'to investigate'. This predicate takes question-complements but not propositional or direct discourse complements, as the following examples show:

(151) a. Investigaron si se puede curar el SIDA.
investigated:3s whether refl. can:3s cure the AIDS
'They investigated whether or not AIDS can be cured.'

b. * Investigaron que el SIDA se puede curar.
investigated:3s that the AIDS refl. can:3s cure
'* They investigated that AIDS can be cured.'

c. * Investigaron, "¿Se puede curar el SIDA?"
'* They investigated, "Can AIDS be cured?" '

The above examples show that *investigar* is a *wonder*-class verb that cannot take discourse complements (as is obvious from the meaning of the verb anyway). It turns out that it cannot take the *que+* embedded interrogative complement either:

(152) a. Investigaron qué sucedió
investigated:3p what happened
'They investigated into what happened.'

b. * Investigaron que qué sucedió
investigated:3p that what happened
'They investigated into what happened.'

c. Investigaron (* que) cómo se puede curar el SIDA.
investigated:3p (* that) how refl. can:3s cure the AIDS
'They investigated into how to cure AIDS.'

d. Investigarán (* que) si se puede curar el SIDA.
will investigate:3p (* that) whether refl. can:3s cure the AIDS
'They will investigate whether or not AIDS can be cured.'

This fact is compatible with Plann's generalization, but not with Suñer's generalization. Given this fact, it is reasonable to assume that the complementizer-like *que* that appears

before the embedded interrogative is really an indicator of the fact that what follows is the object of a speech-act instead of indicating that what follows is to be interpreted as a question rather than a proposition (answer).

Further confirmation for this view comes from the fact that the *que* also appears before embedded *wh*-exclamatives, but exactly when the matrix predicate is a speech-act predicate. The following examples show the contrast between *decir* 'to say', and *ser increíble* 'be surprising' with respect to the exclamatives they can take as complements:

(153) a. Dije que qué bonito estaba el cielo.
said:1s that what nice was the sky
'I said how nice the sky was.'

b. * Es increíble qué cosas quién dice.
is incredible what things who says:3s
'It's incredible who says what.'

c. Es increíble qué cosas dice Maria.
is incredible what things says:3s Mary
'It's incredible what Mary says.'

d. * Es increíble que qué cosas dice Maria.
is incredible that what things says:3s Mary
'It's incredible what Mary says.'

Just as with questions, *wh*-exclamative complements also appear with a *que* when embedded under verbs of saying, but not other predicates[20]. Certainly, it does not seem to be the case that in these examples the *que* serves to convert something like (149) to an expression like the one in (150), as Suñer would claim.

Furthermore, it is noted in Plann(1982) that embedded interrogatives that are adjuncts to intransitive predicates rather than their complements, cannot be preceded by

[20]I am ignoring the exact semantics of exclamatives: it is arguable that they are propositions, or maybe interrogatives in guise.

a *que* even though the predicates in question are speech-act predicates, as shown in the following examples:

(154) a. Jaime habló/platicó sobre (*que) cómo pensaba que había
James talked/chatted:3s about (*that) how thought:3s that had
que hacer la revolución.
that to make the revolution
'James spoke/chatted about how he thought it was necessary to have a revolution.'

b. Martín charlaba acerca de (*que) cuándo habían llegado sus
Martin chatted:3s about (*that) when had:3p arrived his
abuelos a este país.
grandparents to this country
'Martin talked about when his grandparents had arrived in this country.'

On anyone's acount, the adjunct interrogatives are to be interpreted in these examples as questions rather than propositions. It is expected, then, that *que* should be able to appear at least optionally before the embedded interrogatives in these examples, if one accepts Suñer's contention that *que* is a marker of "true" questions as opposed to her "semi-questions". Plann's generalization, however, predicts correctly that *que* should be disallowed in these cases because the corresponding sentences with direct discourse interrogatives are bad:

(155) a. * Jaime habló/platicó sobre, "¿Cómo pienso que hay que hacer la revolución?"

b. * Martín charlaba acerca de, "¿Cuándo han llegado mis abuelos a este país?"

Again, Plann's generalization makes the right distinction as opposed to Suñer's.

Let us assume, pending further clarification, that speech-act verbs and predicates select a semantic category of what one might call *reports*. *Reports* can be realized

syntactically as direct discourse constituents that include all syntactic categories, as well as non-linguistic expressions like 'whoosh', epit[illegible] of all kinds, etc., as well as indirect discourse complements that in Spanish must be p[illegible]ed by *que*. At this point, I don't have enough information about Spanish syntax to determine whether *que* is a complementizer or not, but let me assume tentatively that interrog[illegible]ves preceded by *que* are CPs with two complementizers, the outermost CP taking the inner CP as a syntactic argument, i.e., the embedded interrogative *que quién llega*, 'that who arrives' as the following structure:

(156) $[_{CP_1}[_{C'_1}[$ que $[_{CP_2}[_{C'_2}[$ quién llega $]]]]]]$.

On this view, English would differ from Spanish in that question-reports in English can be realized syntactically only as direct discourse complements, whereas in Spanish they can be realized also as indirect discourse complements of the type shown in example (156), i.e., embedded interrogatives headed by *que*. One can tentatively assume that the five predicate-classes of Suñer's have the following s-selectional frames[21]:

(157) Class I (*creer* 'to believe') : ⟨ propositions ⟩
Class II (*preguntar* 'to ask') : ⟨ questions, reports ⟩
Class III (*gemir* 'to groan') : ⟨ reports ⟩
Class IV (*saber* 'to know') : ⟨ propositions, questions ⟩
Class V (*repetir* 'to repeat') : ⟨ propositions, questions, reports ⟩

Furthermore, Class IV and Class V are characterized by the fact that their meanings are restricted by the following meaning postulate:

[21]It is possible that predicates of Class IV are genuinely ambiguous, with one of two selecting propositions and questions, and the other selecting reports. I don't have evidence to choose between the two hypotheses.

(158) $V(x, Q) \rightarrow \exists p[V(x, p) \wedge p \text{ answers } Q]$.

(158) accounts for the fact that *que*-less interrogative complements of Class IV and Class V predicates are interpreted as assertions rather than questions. (157) accounts for the fact that *que* is optional in the interrogative compements of Class II predicates since they are questions or reports depending on the the absence vs. presence of *que*. Since Class III predicates select for reports only, *que* is obligatory. Since Class IV predicates do not select reports at all, *que* must be absent before their interrogative complements. The interrogative complements of Class V predicates are reports or questions depending on the presence vs. absence of *que*. An immediate problem arises, however, from this approach. Note that Class II predicates select reports but cannot take indicative reports, as the following examples show:

(159) a. * Juan preguntó que el SIDA se puede curar.
John asked:3s that the AIDS refl. can:3s cured
'* John asked that AIDS can be cured.'

b. * Juan preguntó, "El SIDA se puede curar."
'* John asked, "AIDS can be cured." '

What is obviously going on is that the meaning of a speech-act verb constrains the range of report complements the verb can allow. It seems to be the case that if a speech-act verb selects for a semantic type (or sort, depending on one's underlying theory), then its report complements must be reports of entities belonging to that semantic type. The following principle states this:

(160) **Principle R**: If a predicate V selects categories $X_1$,..., $X_n$, as well as reports, and nothing else, then the report complements of V must be reports of categories restricted to $X_1$, ..., $X_n$. No such restriction applies to predicates that select reports only.

(160) ensures the fact that Class II predicates can report questions only, Class IV predicates can report questions as well as propositions, whereas Class III predicates can report anything. The perspective adopted here does not require an independent syntactic *+wh* feature which predicates subcategorize for. The generalization that selection is semantic is also maintained.

There is further evidence for the perspective adopted here as opposed to that of Suñer's. Recall that on my account the *que+* interrogative is not really a question semantically, but a question-*report*. There are respects in which the two can be distinguished. Thus questions can appear as concealed questions, as discussed before in this chapter, viz., NPs that are interpreted as questions. On the other hand, there are NPs that can name or describe speech-reports but none that can be interpreted as reports (except as direct quotes). It follows that with predicates that select reports, the report reading must be unavailable with NPs that can otherwise be interpreted as concealed questions in the right environment. This indeed seems to to be the case in Spanish[22]. Note that Class II, III, and V select reports, on my view. Since Class II predicates also select questions, they should be expected to allow concealed questions, *ceteris paribus*. This is the case, as in the following example:

(161) Le preguntó la hora/su dirección/el precio.
him asked:3s the time/his address/the price
'She asked him the time/his address/the price (i.e., what the time was, etc.).'

[22]Suñer notes this problem, and provides no satisfactory solution.

Class III and Class V verbs behave interestingly. Consider the following example with Class V verbs:

(162) Maria dijo/repitió la hora/su número de teléfono/el precio.
Mary asked/repeated the time/her telephone no./the price
'Mary said/repeated the time/her telephone number/the price.'

On Suñer's account, (162) is expected to have *two* readings:

(163) a. Mary said/repeated the time/her phone no./the price.
b. Mary asked/asked repeatedly the time/her phone no./the price.

This is because both [+wh, +prop] and [+wh, -prop] are capable of being realized as concealed questions (in her terminology, question and semi-question). But the second reading is missing, contrary to expectation. On the account argued for here, however, this is no mystery, since there is only one concealed question reading to be expected. Similar remarks hold for Class III predicates. Thus, (164a) and (164b) are at best marginal if not ill-formed:

(164) a. ?? El niño gimió/sollozó su nombre .
the boy groaned/whimpered his name
'The boy groaned/whimperedd his name.'
b. * El niño gimió/sollozó la hora/el precio .
the boy groaned/whimpered the time/the price
'The boy groaned/whimpered the time/the price.'

On Suñer's account, Class III predicates subcategorize for [+wh, -prop] and [-wh, +prop], and so (164a) and (164b) are expected to have exactly one reading, corresponding to [+wh, -prop], which is the following:

(165) The asked by groaning/whimpering what his name/the time/the price was.

This certainly does not correspond to (164a), (164b). On my account, Class III predicates do not select questions, only reports. So they are not expected to allow concealed questions at all. (164a) and (164b) show that this is indeed the case. These observations, then support the general framework I have adopted to Suñer's[23].

In the discussion above, I assumed without argument that in Spanish, speech-act verbs and predicates select *reports*, a special kind of semantic object that is different from the corresponding argument of other propositional attitude verbs and predicates. Since lexical items that "mean" the same thing in different languages are expected to have the same selectional properties, at least with respect to semantic selection, it is expected that speech-act verbs and predicates in other languages, e.g., English should also select *reports* instead of, or on top of, propositions even though the syntactic realization of the two types might be different in different languages. Moreover, one must clarify the nature of *reports*, and the ways in which they differ from propositions (or whatever the second argument of verbs like *believe* are taken to be). It is well-known since Frege that complements of propositional attitude verbs like *believe* are referen-

[28] A word of caution needs to be added here. Suñer includes the verbs *tartamudear* 'to stutter', *susurrar* 'to whisper', *balbucear* 'to babble' in Class III. The following sentences are, however, good:
(i) El niño tartamudeó/susurró/ balbuceó su nombre/la hora/el precio.
This is entirely unexpected on Suñer's as well as on my account. Whereas I expect them to be bad. Suñer's theory predicts that (i) should be interpreted as in (165). It turns out, however, that these verbs are not Class III verbs, but rather Class V verbs, and correspondingly have one expected reading. That these verbs are Class V verbs is shown by the fact that the following are grammatical sentences:
(ii) El niño tartamudeó/susurró/ balbuceó qué era su nombre/el precio.
(iii) El niño tartamudeó/susurró/ balbuceó qué hora era.
(i.e., the boy stuttered/whispered/babbled what his name/the price/the time was, interpreted exactly as the concealed question counterparts.) Thanks to Esther Torrego for this observation.

tially opaque, and so one early proposal about the nature of *that*-clauses was that they denote objects called propositions. Of course it is quite controversial what propositions are. One simple proposal deriving from Kripke and Montague, and defended by Stalnaker and Lewis, identifies propositions as sets of possible worlds. On this view, the denotation of the embedded *that*-clause in the following sentence:

(166) John believes that Bill is hungry.

is the proposition

(167) $\{w \in W \mid \text{Bill is hungry in } w\}$

The obvious problem with this view is that on this view, equivalent propositions are equal, and so if someone believes something, (s)he also believes everything logically equivalent to it. Furthermore, if one knows or believes one tautology, one knows all tautological statements, and so on a certain view about the nature of mathematics, one also knows everything about mathematics if one knows or believes some true mathematical statement. In other words, the notion of propositions as sets of possible worlds is too coarse-grained if objects of propositional attitudes are to denote propositions. There are various attempts to develop a more fine-grained notion of propositions, some purely semantic, e.g., Thomason (1980), Chierchia & Turner (1988), etc.; some mixed syntactic-semantic, e.g., Higginbotham (1991), Larson & Ludlow (1990)[24]. What is recognised by all and everyone, is that whatever the notion of proposition one is working with, the objects of verbs like *believe, know*, etc., are at least as fine-grained as

[24]The latter two are elaborations of some early work of Davidson's, more on this below.

sets of possible worlds. Since most people assume that embedded indicative clauses are to receive a uniform semantic treatment, the indicative sentential direct objects of speech-act verbs are also assumed to denote propositions, whatever they are taken to be.

There are reasons to believe that objects of speech-act verbs differ subtly from other propositional attitude verbs. This is certainly the case with verbs that can take direct quotes as complements, for, direct quotes don't have to be sentential or propositional or even linguistic, and furthermore can be in a different language, as the following examples show:

(168) a. The demonstrators at Gramajo's commencement shouted, "Assassin !"
b. The demonstrators at Gramajo's commencement shouted, "¡ Asesino!"
c. John mumbled, "Whoosh !"
d. John said, "What a pity!"

It is certainly not the case that the direct quote is always interpreted as a phonological string, devoid of syntactic or semantic structure. As pointed out in Partee(1973), material inside quotes can be antecedents for anaphora, VP-deletion, etc.:

(169) a. This sign says, "George Washington slept here", but I don't believe *he* really did.
b. "I talk better English than both of youse!" shouted Charles, thereby convincing me that he didn't.
c. What he actually said was, "It's clear that you've given this problem a great deal of thought," but he meant quite *the opposite*.

The direct quotes in the above examples have to be interpreted as propositions, and have the usual syntactic structure. On the other hand, even sentential direct quotes don't *have* to be interpreted as propositions. Notice that the following sentence

(170) John said/mumbled/shrieked "Flying planes can be dangerous!"

can be true even in a situation in which the speaker doesn't know what John means by that sentence and in fact, John doesn't mean anything in particular, either because he is mad or just wants to tease others. In other words, direct quotes can be interpreted as propositions but don't have to be, they can be interpreted as utterances, or what I call reports. Now it is not entirely clear to what extent these remarks carry over to *that*-complements of speech-act verbs. In the scenario mentioned above for (170), if we replace the direct quotes with *that*-clauses, the result seems to be bad for *say* but good for manner-of-speaking verbs like *mumble, mutter, shout*:

(171) a. ?? John keeps saying that flying planes can be dangerous.
b. John keeps mumbling that flying planes can be dangerous.
c. John was muttering that flying planes could be dangerous.
d. John kept shouting that flying planes could be dangerous.

In short, even *that*-clause objects of manner-of-speaking verbs can be interpreted as utterances that may not express any proposition whatsoever. For these cases, an analysis along the lines of Davidson (1968) is almost forced upon us. On this view, sentence like (172a) is interpreted as (172b) (example from Lepore & Loewer (1989)):

(172) a. Barbarella said that she is hungry.
b. $\exists u$[said(Barbarella, $u$)$\wedge SS(u, that)$]. [She is hungry].

In (172b), the variable $u$ ranges over *utterances*, the demonstrative $that$ refers to the English utterance *She is hungry*, and $SS$ is the samesaying relation that relates two utterances as saying the same thing, and can relate utterances of different languages,

and probably even nonsensical utterances. Davidson's analysis of *say that* has been extended to other propositional attitude verbs, e.g., in Higginbotham(1986, 1990), Larson & Ludlow(1990), but crucially the variable $u$ in (172b) ranges not over utterances but over other objects that they take to approximate propositions (Logical forms in the former case, Interpreted logical forms in the latter case). The discussion above shows that speech-act verbs are indeed ambiguous according to whether their arguments are utterances (or *reports*) and propositions, and that for the former case Davidson's analysis holds more or less unmodified.

To sum up, the distinction that Spanish shows between speech-act verbs and other verbs and predicates of propositional attitudes follows from a distinction in the semantics of the two classes of predicates.

### 2.7.5 Conclusions

The Spanish facts show that contrary to Suñer, the complementizer *que* is a marker of a speech-act rather than an indicator of a distinction between questions and answers (what she calls semi-questions). The English as well as the Spanish facts show that the question/answer distinction in the interpretation of embedded interrogatives is not marked in the syntax, and that the distinction is not a case of selection of different semantic types, but a matter of the lexical semantics of the predicates in question.

# Chapter 3

# Quantificational Variability in Embedded Interrogatives

## 3.1 Introduction

In the last chapter, I argued that all predicates that allow *wh*-clause complements other than free relatives s-select Questions. This means that predicates like *know* as well as predicates like *wonder* s-select Questions, but the former also s-select propositions. One must then explain what distinguishes predicates that show QVE from those that don't. In this chapter I suggest that predicates that show QVE are predicates that are true of an agent and a Question if and only if their propositional correlate is true of the agent and some answer to the question. Since answers to questions are propositions, predicates that show QVE with embedded interrogatives are predicates that independently s-select propositions as well. Furthermore, predicates that show QVE must satisfy further conditions, e.g, structures that contain them with embedded interrogative complements must be able to presuppose some sentence containing a weaker propositional attitude predicate. Predicates that are like *know* in the relevant respect but lack such presuppositions

do not show QVE, e.g., *to conjecture (about)*. I will argue that QVE involves quantifying over amounts of answers, at least for adverbials that I dubb adverbials of *quantity*. I introduce the notion of *Questions* and *Answers* first, and then outline the basics of amount quantification. I will then discuss QVE in greater detail, going through various predicate-classes taking embedded interrogatives that do or do not show QVE.

## 3.2 Questions and Answers

### 3.2.1 Hamblin and Karttunen on Questions

One of the earliest and most well-known approaches to the semantics of interrogatives appears in Hamblin (1971), later modified in Karttunen (1977). On this view, a question denotes the set of propositions that constitute the possible answers to it. So a yes/no question, or its embedded variant, the *whether* question, like (173a) and (173b) denotes the set of propositions in (173c):

(173) a. Did John leave?
b. whether John left.
c. { that John left, that John did not leave }.

On the other hand, a constituent question like (174a) denotes the set of propositions in (174b):

(174) a. Which house(s) is(/are) new?
b. { that $a_1$ is new, ..., that $a_n$ is new }.

if $a_1$, ..., $a_n$ are the houses. Similarly, a multiple question, e.g.,

(175) Who saw who?

denotes the set of propositions

(176) { that $a_1$ saw $a_1$, that $a_1$ saw $a_2$, ..., that $a_m$ saw $a_1$, ..., that $a_m$ saw $a_m$ }.

if $a_1$, ..., $a_m$ are the persons in the universe of discourse. Karttunen (1977) is a variant of this model, with the difference that the propositions that constitute the denotation of a question are the true ones. E.g., the denotation of the question in (173a) and (173b), on this view, is not the set in (173c), but the set consisting of the proposition *that John left* or *that John did not leave*, whichever is the true one. Similarly, the propositions contained in the denotation of a constituent question like (174a) are also just the true ones, i.e., the denotation of (174a) is

(177) $\lambda p \exists x[\check{p} \wedge house(x) \wedge p = \hat{} new(x)]$.

Karttunen treats *wh*-NPs as quantifiers. Cf. Karttunen (1977) for the details of deriving the denotations.

One can also imagine slightly different variations on the same theme as Hamblin and Karttunen. One of the characteristics of Karttunen's system is that it treats singular and plural *wh*-NPs alike, and so *which house* and *which houses* have the same denotation. But since plurals denote collections, or whatever, depending on one's theory of plurals (cf., e.g., *Which women love each other?*), one can incorporate the difference between singular and plural *wh*-NPs, and this gives denotations that differ slightly from the Hamblin-Karttunen denotations (Heim, Class Lectures, 1989). If ones takes the

lattice-theoretic approach, following Link (1984), the denotation of a plural predicate can be obtained by closing the denotation of the corresponding singular predicate under sum formation. For example, one say that

(178) $x \in [houses]$ iff $x$ is a sum of $y$'s such that $y \in [house]$.

The plural determiner can then be treated just like its singular counterpart, and the Hamblin denotation of the plural form of the sentence in (174a) turns out to be (179):

(179) [*which houses are new*]= $\lambda p \exists x[houses(x) \wedge p = \hat{} new(x)]$.

On the further assumption that a sum of things is new just in case all its parts are, the set above can be described as follows:

(180) $\lambda p \exists X[\exists z[z \in X \wedge \forall y[y \in X \rightarrow house(y)]] \wedge p = \hat{} \forall y[y \in X \rightarrow new(y)]]$.

In a world with just three houses $a_1$, $a_2$, $a_3$, this is

(181) { that $a_1$ is new, that $a_2$ is new, that $a_3$ is new,
that $a_1$ and $a_2$ are new, that $a_2$ and $a_3$ are new, that $a_1$ and $a_3$ are new,
that $a_1$ and $a_2$ and $a_3$ are new. }.

The denotation in (181) is slightly different from that in (174b), and can be related in a certain way to the partition semantics to be discussed in the next section.

### 3.2.2 Partition Semantics

This view of the semantics of questions appears in a developed form in Higginbotham& May (1981), Higginbotham (1991), Groenendijk& Stokhof (1981, 1984), although the basic idea can be found in much earlier work, e.g., Harrah (1956), Hamblin (1958), Levi

(1967). According to this view, a question represents a state of maximal ignorance with respect to something, an answer being a *relief from ignorance* (Levi). Moreover, *the possible answers to a question are an exhaustive set of mutually exclusive possibilities* (Hamblin (1958)). So a question of the form *whether p* can be characterized by a partition of the states of nature into those compatible with $p$ and those incompatible with $p$. The difference between this view and that of Hamblin (1971) becomes evident when we look at constituent questions. The denotation of the question *What houses are new?*, on this view, is neither (174b) nor (181), but the following set of propositions[1]:

(182) If $a_1$, ..., $a_n$ are the houses in the world, then
[*which houses are new*] = { that $a_1$, ..., $a_n$ are new
that $a_1$ is new and $a_2$ is not new, ..., $a_n$ is not new
that $a_2$ is new and $a_1$, $a_3$, ..., $a_n$ are not new,
...
that $a_1$ and $a_2$ are new, and $a_3$, ..., $a_n$ are not new,
...
that $a_1$, ..., $a_n$ are not new }.

Each proposition in the denotation of the question in (182) is a complete specification of what houses can possibly be new, given the houses in the world. Note that every element of the set in (182) is incompatible with every other member of the set, and so if propositions are identified with the possible worlds in which they are true, the denotation of a question defines a partition on the set of possible worlds. Note that:

(183) $X$ is a *partition* on a set $S$ iff $X$ is a set of sets such that (i) $\cup X = S$, and (ii) for any $Y, Z \in X$, if $Y \neq Z$, then $Y \cap Z = \phi$.

[1]This is a slightly modified version of the Groenendijk& Stokhof formulation, discussed briefly in Chapter 2. The Higginbotham (1991) formulation is slightly different, and a modified version of it will be adopted later, in connection with QVE.

One of the major motivations for this theory is that viewing questions as partitions of possible worlds enables one to define the notions of a *partial answer* and a *complete answer*, as well as the relation of *presupposition* between between questions and propositions rather simply. Since questions on this view are states of maximal ignorance with respect to a certain predicate, a *partial answer* is any proposition that relieves some of the ignorance by ruling out some of the alternatives. More precisely, in terms of partition semantics[2]:

(184) A proposition $p$ is a *partial answer* to a question $Q$ iff $p$ is incompatible with at least one $q \in Q$, i.e., iff there is at least $q \in Q$ such that $q \cap p = \phi$.

A proposition $p$ is a *complete answer* to a question $Q$ if it relieves ignorance entirely by specifying completely the predicate being questioned, i.e.,

(185) A proposition $p$ is a *complete answer* to a question $Q$ iff $p$ is compatible with exactly one $q \in Q$, i.e., iff there is exactly one $q \in Q$ such that $q \cap p \neq \phi$.

Similarly, a question $Q$ presupposes a proposition $p$ iff every proposition in $Q$ entails $p$,[3] i.e.,

(186) A question $Q$ *presupposes* a proposition $p$ iff $\cup Q \subseteq p$.

It may be noted that on the partition semantics view, each member of the denotation of a simple question is a *complete answer*, exactly one of them being true in any given

[2]This is one formulation. Slightly different formulations will be adopted later, where answers will be identified with sets of propositions rather than propositions. This makes the formulation of QVE easier, as we will later see.

[3]Note that this dilutes somewhat Hamblin's (1958) requirement that possible answers be jointly exhaustive. The above-quoted statement would have to be modified accordingly, i.e., possible answers should be jointly exhaustive with respect to worlds that satisfy the presuppositions of a question

world. This makes it possible to define the notion of a *partial answer* rather easily on this approach.

As with Higginbotham& May (henceforth, H& M) point out, it is not at all clear how the notion of a *partial answer* is to be defined in Karttunen's system. They point out that if one takes a question $Q$, say *Which houses are new?*, then a partial answer will be any statement that implies the falsehood of some proposition in $Q$. Thus, (187)

(187) At least two houses are new.

is a partial answer to the question, being inconsistent with those elements of $Q$ which entail that fewer than two houses are new. Now, in Karttunen's theory one might define a *partial true answer* to be a proposition which holds in every possible world in which the complete true answer holds. Then, assuming that the complete true answer to the above question contains more than one proposition, (187) will be a partial true answer. On the other hand, (188)

(188) At least two houses are not new.

will in general not be a partial answer on this definition. But (188) obviously gives relevant information, if true.[4] In H&M's words (slightly modified so as to keep to the original example), "...Perhaps this circumstance reflects an ambiguity in the notion of a *complete* answer; if one is given a list of all and only those [houses which are new], the question is still not answered completely unless one knows that the list is, in fact,

[4]Strictly speaking, neither (187) nor (188) are partial answers in themselves as defined in the above sections. However, they both become partial answers in conjunction with the propositions *that* $a_1$ *is a house, ..., that* $a_n$ *is a house*, if $a_1, ..., a_n$ are houses in the universe of discourse.

exhaustive. A natural speculation is that Karttunen's theory might be adjusted so that the set of propositions corresponding to the question is the set whose members are all propositions [*x is new* for *x* a new house, and *x is not new* for *x* a non-new house]. In this case, (188) could be a true partial answer. While this adjustment could go some way toward accomodating the notion of partial true answers, just what effect it would have on the remainder of Karttunen's system is unclear."

I think H& M are right to point out that it is unclear how the notion of a *partial answer* can be defined on the Hamblin-Karttunen view. If one modifies the Hamblin denotations somewhat, to include in the denotation constituent questions like *Which houses are new*, the proposition {that no house is new} (this might be needed for independent reasons), and introduces pluralities, one can show that as long as we have models rich enough to distinguish all logically independent sentences, there is a one-to-one mapping between the Hamblin denotations and the Partitional denotations, and this enables us to define the notion of a *partial answer* as well as a *complete answer* in terms of Hamblin denotations. Let me remark that these definitions are not at all transparent, and are just translations of the intuitively clear partitional definitions, which one might prefer on counts of elegance alone. For the formal details, see the appendix below.

### 3.2.3 Quantifying into Questions

In the previous sections, I discussed some of the theories of simple interrogatives, i.e., simple single or multiple *wh*-questions, as well as yes-no questions. In this section, I will discuss another variety of interrogatives that have been argued to require a com-

plication of the semantics of interrogatives, as well as the semantics of quantifiers. The relevance for this will become clearer later, when I discuss the presence vs. lack of QVE when interrogatives of this kind are embedded under *know*-class predicates. The relevant examples involve cases like the question in (189a) where the expected answer is something like (189b):

(189) a. Who did everyone see?
b. John saw Bill, Mary saw Peter, Jill saw Cindy, ..., Cindy saw Bill. (where John, Mary, Peter, ..., Cindy are all the persons.)

(189b) is what is often called the pair-list reading. On one view, argued for by Belnap&Bennett (1977), Higginbotham (1991), May (1985, 1990), the answer in (189b) is an answer to the question whose logical form has *everyone* with wide-scope over *who*, i.e., the following:

(190) $\forall x$[**person**($x$)] which $y$[**person**($y$)][**saw**($x$, $y$)].

Since the nuclear scope of the universal is a question rather than a formula, and quantification is normally defined when the nuclear scope is a formula (or in some formulations, a predicate), some new mechanism must be invented to quantify into questions. Belnap&Bennett (1977), and Higginbotham (1991) do just that. Engdahl (1986), and Chierchia (1991), on the other hand, argue that *wh*-phrases always have wide-scope with respect to the regular quantifiers like *all*, etc., and so quantifying into questions is unnecessary. On this view, (189b) is just one variant of what they call functional readings, which is independently needed anyway. I will discuss the two proposals one after the other.

**Higginbotham (1991)**

Recall that according to the proposal in Higginbotham (1991), simple interrogatives denote partitions of states of nature. Furthermore, each member of a partition is viewed as a set of propositions rather than propositions. Thus, one member of the partition denoted by (191a) is the set in (191b):[5]

(191) a. Who did John see ?

b. { John saw $a_1$, John saw $a_2$, ¬John saw $a_3$, ..., ¬John saw $a_n$ } ($a_1$,...,$a_n$ are all the persons in the the context.).

(In G&S's version, instead of (191b), one would have the proposition John saw $a_1 \wedge$John saw $a_2 \wedge ... \wedge \neg$ John saw $a_n$.) Now the idea behind quantifying into questions is to create *blocs* that are sets of partitions. To answer a question of this kind is to answer each question in some *bloc*. E.g., consider the interrogative in (192a) and the corresponding logical form in (192b):

(192) a. Where are two screwdrivers?

b. [two $x$: screwdriver($x$)][What $\alpha$: place($\alpha$)]$x$ at $\alpha$.

The question expressed by (192b) is the class of all classes of partitions each of which, for at least two screwdrivers $a$ and $b$ as values of $x$ (and for no other objects than screwdrivers as values for $x$) contains the partition for the interrogatives

(193) a. [What $\alpha$: place($\alpha$)]$a$ at $\alpha$

[5]This is a slight simplication: In Higginbotham (1991) (191b) will also contain the propositions $a_1$ is a person, ..., $a_n$ is a person. This roughly corresponds to Groenendijk&Stokhof's *de dicto* readings for questions. I will suppress these propositions for ease of exposition, as the rules for quantifying into questions get much simpler when these are omitted.

b. [What $\alpha$: place($\alpha$)]$b$ at $\alpha$

The classes of partitions are called *blocs*, and classes of them *questions of order 1*. To answer a question of order 1 is to answer every question in one of its blocs. It follows that to answer (192a) is to answer both the question where $a$ is and the question where $b$ is, for at least two screwdrivers $a$ and $b$.

A slightly simplified version of Higginbotham (1991) procedure for quantifying into questions is as follows. Consider the interrogative in (194):

(194) $[Zx\text{: }\Phi(x)][\text{WH}\alpha\text{: }\Phi'(x,\alpha)]\ ?\theta(x,\alpha).$

Here, $Z$ is a generalized quantifier, WH is the interrogative *wh*-quantifier, and $\Phi$ and $\Phi$ are restrictions on the generalised quantifier and the interrogative quantifier respectively. Let $[\text{WH}\alpha\text{: }\Phi'(x,\alpha)]\ ?\theta(x,\alpha) = \Sigma$. Let $Q(\Sigma, f(a/x))$ be the semantic value of $\Sigma$ when $x$ is assigned the value $a$ (other variables are assigned the values that $f$ assigns to those variables). If the denotation of $Z$ is $\mathbf{Z}$, the domain of the model is $A$, and $K = \{a : \Phi(a)\}$, then define $\hat{Q}(\Sigma, f(a/x), \Phi) = Q(\Sigma, f(a/x))$ if $\Phi(x)$ is true on $f(a/x)$, undefined otherwise. Then the semantic value of (194) on the assignment $f$ is given by $Q(((194)), f)$ in (195):

(195) $Q(((194)), \text{f}) = \{X : (\exists S)[S \subseteq A \wedge \mathbf{Z}(K,S) = 1 \wedge [X = \{Q^{+}(\Sigma, f(a/x), \Phi) : a \in S\} \vee (K \cap S = \phi \wedge X = \{\{\phi\}\})]]\}.$

Since natural language determiners are conservative in the sense of Keenan&Stavi (1986), i.e., $\mathbf{Z}(K, S) = \mathbf{Z}(K, K \cap S)$ for all $K$, $S$, the above can be rewritten as (196):

(196) $Q(((194)), f) = \{X : (\exists S)[S \subseteq A \wedge \mathbb{Z}(K, S) = 1 \wedge X = \{Q^{+}(\Sigma, f(a/x), \Phi) : a \in K \cap S\}]\}$.

since $Q^{+}(..., f(a/x), ...)$ is defined only when $f(a/x)$ satisfies $\Phi(x)$, i.e., when $a \in K$.

To see how this works, consider the interrogative (197a) with the scope in (197b):

(197) a. Which screwdriver(s) did everyone use ?

b. $\forall x$: person($x$)[WH$\alpha$: screwdriver($x$)]$x$ use $\alpha$.

Suppose there are two persons $a$ and $b$ and one screwdriver $\chi$ in the universe of discourse. Then the semantic value of the nuclear scope of the universal quantifier is the partition

(198) $\{ x \text{ use } \chi, \neg x \text{ use } \chi \}$.

For this example, $K = \{a, b\}$. If there is any $S$ such that All($K$, $S$)=1, $K \subseteq S$, i.e., $K \cap S = K$. (196) then reduces for this case to (199):

(199) $Q(((197b)), f) = \{X : X = \{Q^{+}(\Sigma, f(a/x), \Phi) : a \in K\}\}$.

which is simply (200):

(200) $\{ \{ \{ \{a \text{ use } \chi\}, \{\neg a \text{ use } \chi\}\}, \{ \{b \text{ use } \chi\}, \{ \neg b \text{ use } \chi\}\}\}\}$.

This question of order 1 has exactly one bloc which contains two questions. An answer to (197b) must answer both questions. The set of propositions $\{a \text{ use } \chi, b \text{ use } \chi\}$ then is an answer to the original question, since it answers both questions in the bloc.

**Engdahl (1986), Chierchia (1991)**

Engdahl (1986), and following her, Chierchia (1991) have proposed a slightly different different approach to handle examples like

(201) Who did everyone see?

The proposal derives from the fact that answers to questions can often be functions rather than lists of propositions. Thus, a possible answer to a question like (202a) can be (202b):

(202) a. Who does every Englishman love?
b. *His mother* (i.e., Every Englishman loves his mother).

Of course, (202a) can also be answered by a list of pairs like (203):

(203) Peter loves Mary; John, Sally; Sam Sandra; etc.

Answers like (202b) have been called functional answers, and answers like (203) can be called pair-list answers. The fact that questions like (202a) are a distinct type from the types of questions we have discussed earlier so far is that questions like (204a) allow functional answers but not pair-list answers:

(204) a. Who does no Italian married man like?
b. *His mother-in-law.*
c. * Giovanni, Maria; Paolo, Francesca, etc.

The basic idea behind this approach is to interpret these interrogatives as requests for specification of certain functions. To put it informally, (202a) can be paraphrased as follows:

(205) a. which function $f$ is such that every Englishman loves $f(x)$ ?

b. which function $f$ makes the following true: $\forall x$[englishman($x$)][$x$ loves $f(x)$]

Given that the functional reading cannot be reduced to the pair-list cases (since the former is possible in cases where the latter is not), Engdahl and Chierchia argue that quantifying into questions can be avoided by reducing the pair-list answers to the functional answers. Given that a pair-list is just a specification of a function, like a graph, the two are indeed identifiable. On Chierchia's formalization of this notion in terms of Karttunen's theory, a question like (202a) denotes the set in (206):

(206) $\{p: {}^{\vee}p \wedge (\exists f)p = {}^{\wedge}\forall x$[englishman($x$)][$x$ loves $f(x)$]$\}$.

Of course, it remains to be explained why certain interrogatives of this type, like (204a) do not admit of pair-list answers. For this case, a ready answer is available, viz., that in order for some question to be answered by a pair-list answer, the first member of the pair must be from the domain that restricts the quantifier. This is not possible if the restriction is a quantifier like *no*. In fact, on Chierchia and Groenendijk&Stokhof's view the "quantifying into questions" and thereby allowing pair-list answers is possible only if the quantifier is universal (*every, each, the both*, etc., since only in these cases can the function be specified in that way.

## Discussion

Both of the views mentioned above accept the fact that functional answers exist. Where they disagree is on the question of whether quantifying into questions should be needed

or not, and whether the pair-list answers should be reduced to functional answers or not. In criticism of these theories, the following points can be made.

On the view that allows quantifying into questions, it is predicted that quantifying into yes-no questions should be possible, because the recursive definition applies to all questions, irrespective of whether they are *wh*-questions or yes-no questions. Thus, (207) is predicted to be ambiguous:

(207) a. Did everyone go to the party?
b. Did two men go to the party?

The quantified-in reading is a request to tell whether (s)he went to the party or not, for each person. But this reading does not seem to be available. [6] There is no semantic reason for this to be impossible. It is hard to imagine any syntactic reason for this to be disallowed either. So this remains a problem. Note that on Engdahl's theory this may not be a problem, because presumably only *which, who*, etc. can be interpreted as *which function*, not *whether*, and only one reading is predicted.

A second problem has to do with the range of quantifiers that can be "quantified-in". G&S's and Chierchia's claim that only universal quantifiers can be quantified into questions is clearly false, since it is definitely possible to quantify-in *two, at least two, most, many (?)*. While judgements on these are rather slippery, the only quantifiers that strongly disallow quantifying into questions are monotone decreasing quantifiers like *no, few, at most n*, etc. Note the contrast between (208a) and (208b):

[6] Belnap&Bennett (1977) and Belnap (1982) claim that this is possible. They claim that *whether anyone came* can be interpreted as a universal quantifier quantified into a yes-no question. Belnap cites *whether the present king of France is bald.* Neither of the examples is convincing.

(208) a. (Tell me) what at least a few people did.

b. * (Tell me) what few people did. (on the reading where *few* has wide scope.)

It is unclear whether either of the theories has any explanation for this fact, if it is indeed one. One could attempt to construct an explanation if one accepts the point of view that accepts quantifying into questions. If one goes through the definition of the denotations for quantifying in, one can see that quantifying in *no* into a question yields as value $\{\{\{\phi\}\}\}$. Moreover, given any monotone quantifier Z, there is always an $S$ (as in (195)) such that Z($K$, $S$)=true, and $K \cap S = \phi$, viz., $S = \phi$. Consequently, the semantic value of a question derived by quantifying in a monotone decreasing quantifier always contains the bloc $\{\{\phi\}\}$. Put in other words, a question that has been derived by quantifying in a monotone decreasing quantifier is a pointless question in the sense that it can be answered by saying nothing. Strictly speaking, then, such interrogative forms are not strictly ungrammatical but just express pointless questions.

The third point has to do with examples with interrogatives embedded under predicates that show QVE. This point will be discussed in greater detail later, but I will just introduce the facts. Consider the following example:

(209) John mostly knows who everyone saw.

The most obvious and unproblematic readings that (209) has are the following:

(210) a. $\forall x$[person($x$)]most($y$)[person($y$)$\wedge$ $x$ saw $y$][John knows that $x$ saw $y$].

b. most($y$)[person($y$)$\wedge\forall x$[$x$ saw $y$]][John knows that [$\forall x$[$x$ saw $y$]]].

However, this sentence has another reading, which is hard to put down in simple formulas like (210a) and (210b), but can be roughly described as follows. If I write out the pair-list answer in full, then (209) is true on this reading if and only if John knows most propositions in the list. So if the pair-list answer is *Bill saw Bob, Bob saw Phil, Phil saw Bill*, then (209) is true if John knows that Bill saw Bob and Bob saw Phil, even though he may not know that Phil saw Bill. This reading cannot be obtained in a straightforward fashion in the Engdahl-Chierchia theory. I will argue later that if one takes the pair-list answer on its own right, and adopt the view that QVE involves quantifying amounts of answers, then this can be explained on the quantifying-into-questions view, but not otherwise, at least not in a straightforward way.

### 3.2.4 Summary

In this section, I discussed a few well-known theories about the semantics of questions which define the notion of answers directly as some function of the denotation of the corresponding question, rather than in an indirect fashion, as is the case with BH. In the latter system, the notion of an *answer* to a question does not have any significance in case of interrogatives embedded under predicates like *know*, since, on this view, interrogative complements of predicates like *know* are just open sentences that are interpreted after the process of presupposition-accomodation. In the theories discussed above, predicates of the *know*-type are characterised by the fact that these (e.g., $know_{IV/Q}$) are true of an individual and a question if and only if their proposition-taking counterpart (i.e., $know_{IV/t}$ for $know_{IV/Q}$) is true of the individual and some (or the(?)) answer to the question. I

will adopt the perspective of partition semantics in later discussion, although it may not be so crucial in some of the discussion that is about to follow. My reformulation of QVE can be translated into a Karttunen-Hamblin type theory if one so desires. I adopt the former because of the ease with which complete and partial answers are definable in the latter system, although it does complicate the treatment of embedded interrogatives somewhat.

## 3.3 Quantificational Variability

### 3.3.1 Introduction

The reformulation of QVE that I am about to propose is based on the idea that QVE involves quantification over *parts* of answers. I observe first that there are two kinds of adverbs of quantification that are relevant to the phenomenon of QVE. The original proposal of Lewis (1975) about unselective quantifiers, as well as their use in Heim (1982a) in analyzing indefinites as as free variables, stems from a large variety of adverbs of quantification, viz., e.g., *usually, rarely, seldom, commonly, mostly, often, in general, frequently*, and so on, an overwhelmingly large number of which can be called adverbs of *frequency*. A perusal of the adverbs used to illustrate QVE in Berman (1990) shows that the adverbs are drawn from two classes: adverbs of *frequency* and what one might call adverbs of *quantity*, examples of the latter being, e.g., *mostly, for the most part, in part, to a large extent*, etc.[7]. It was noted in Berman (1990) that judgements

[7] *Mostly, for the most part*, and probably the other adverbs of quantity as well, are ambiguous between being adverbs of frequency and adverbs of quantity.

about QVE are less secure with adverbs of frequency. I will, for this reason concentrate on adverbs of quantity as I take it that these illustrate the core of QVE. As I have mentioned earlier, predicates that show QVE are the *know*-class predicates, viz., predicates that are true of an individual and a question if and only if their proposition-taking counterparts are true of the individual and some answer to the question. So John knows (completely) who came to the party if and only if he knows the complete answer to the question *Who came to the party?* (Since *know* is factive, the answer has to be true as well.). Predicates of the *wonder*-class, on the other hand, have the property that they relate individuals and questions irreducibly, following G&S (1981, 1984). Predicates of the former class include *remember, indicate, realize, list, record, guess, decide, be certain*, etc. Predicates of the later class include *inquire, ask, interrogate, investigate*, etc. There are some exceptions to the generalisation: thus the predicate *conjecture (about)*, though from the *know*-class, does not show QVE, neither does *be relevant*. I will eventually provide reasons for why these predicates do not show QVE.

Given that adverbs of quantity can be associated with anything capable of having parts, one can say things like (211):

(211) a. Mary knows, in part, Beethoven's fifth symphony.
b. Mary mostly knows Beethoven's fifth symphony. (stress on *knows*)
c. Mary mostly knows the boys that live around the corner. (stress on *knows*)
d. Mary partly knows the boys that live around the corner. (stress on *knows*)
e. The boys that live around the corner are, for the most part, idiots.

The intended readings being that Mary knows most or part of Beethoven's fifth sym-

phony, most of the boys that live around the corner are idiots, and so on. The part-whole structure might derive from the way things are, as in (211a)-(211b) (*Beethoven's fifth symphony*), or derive from the abstract objects linguistic expressions denote, as in (211c)-(211e) (*the boys that live around the corner*). Since answers to questions have a natural part-structure given by the semantics of partitions (or in other theories as well), we would expect to find QVE in predicates of the *know*-class. There is no corresponding notion of a "part" of a question, and so QVE is not expected with predicates of the *wonder*-class. The problem, will be to characterise the notion *quantity* of an answer. The general development of the rest of this work will assume that a sentence of the form

(212) *a* mostly/partly/largely *Vs wh-Q*.

where $V$ is a predicate of the class that shows QVE, and $Q$ is a *wh*-question, means something like the following:

(213) most/some/a large "relevant" part of an answer to $Q$, *a* $V$*s* that part of that answer to $Q$.

Everywhere, I will draw parallels between quantifying over parts of objects denoted by ordinary NPs (usually plural definite descriptions) of the type mentioned in (211). The notion of a "relevant" part is partly pragmatic, and will be discussed later in section 3.3.4. I will assume that the "relevant" answer in the restriction of the quantifier in (213) is derived by presupposition-accomodation, along the lines of Berman (1990) but extended to non-factives [8].

[8]See Chapter 1 for a detailed development, considering a range of factive and nonfactive predicates.

### 3.3.2 Adverbials of Quantity and Frequency

There are two classes of adverbials that are often conflated in discussions about QVE (cf. Berman (1990) and subsequent work dealing with the phenomenon in other languages like Japanese), but the two should really be kept separate. These are the so-called adverbs of *frequency* and what I will call adverbs of *quantity*. I identify the cases of QVE with the latter as the "core" cases of QVE, whereas QVE as exemplified in examples involving the former are probably the result of something more basic. In the discussion so far and in the rest of this work, I have mainly considered the adverbs of quantity and will not have much to say about adverbs of frequency, but it is important to see in what respects they are different and why they should be considered separately.

Adverbs of frequency were the original motivation for the proposals about unselective binding as well as for analysing indefinites as free variables. These adverbs include adverbs like *usually, rarely, seldom, commonly, mostly, often, in general, frequently*, and so on. Adverbs of quantity, on the other hand, include adverbs like *mostly, for the most part, in part, to a great extent*, etc. For some speakers, adverbs of quantity can also be used as adverbs of frequency, but not vice-versa. A short list of examples of adverbs of these two classes is given below:

(214) Adverbials of *frequency*: *seldom, usually, always, often, generally, commonly, in general, frequently, mostly, rarely, now and then, in many cases, sometimes*, etc.

Adverbials of *quantity*: *mostly, for the most part, partly, in part, largely, to a great extent, with few exceptions, completely*, etc.

It was observed in Berman (1989) that judgements about QVE seem to be less secure

with adverbs of frequency. Typically, expressions containing adverbs of frequency express some kind of generalisation and so are ill-formed when they modify sentences containing episodic embedded interrogatives. Thus, it does not make sense to say (215a)as contrasted with (215b):

(215) a. * John usually knows what Bill did yesterday at 3:00 AM.
b. John usually knows what Bill does on Sundays.

Moreover, consider a sentence like (216):

(216) John usually knows who does well on the exam.

A simple-minded application of BH yields the following reading reading for the above sentence:[9]

(217) most($x$)[$x$ does well on the exam][John knows that $x$ does well on the exam].

The sentence (216), however, doesn't really mean (217), it seems. Imagine the following scenario. On one exam, there are 200 people who do well on the exam (this exceptionally good performance was achieved by some drastic improvement in the conditions in the inner-city neighborhood school system) and John knows of all of them that they do well on the exam. This was preceded by 10 exams, in which only 2 people do well, and John knows nothing about them. According to (217), (216) is true in this situation. But the intuition in this case is that (216) is false. This scenario illustrates that (218) cannot be a reading for (216) either:

[9]This problem is recognized in Berman (1990) and left unsolved.

(218) most($\langle x, y \rangle$)[$x$ is a person $\wedge y$ is an exam$\wedge x$ does well on $y$][John knows that $x$ does well on $y$].

since of the $11 \times 202 = 2222$ pairs, John is ignorant about 20 pairs only, and so (218) is true. On the other hand, (216) doesn't have to mean (219):

(219) most($y$)[exam($y$)]$\forall x$[$x$ does well on $y$][John knows that $x$ does well on $y$].

In order for (216) to be true, it does not have to be the case that for most exams John completely knows who does well on the exam. Thus in a situation in which there are 20 exams, and 10 people do well on each exam, and for 16 of those exams, John knows of exactly 9 people each that have done well in these exams, that they did well on the exam. The intuition in this case is not crystal clear, but most people seem to find (216) true in this case. In fact, it is hard to pin-point what the truth-conditions of this sentence really are. Similar examples can be multiplied. Thus, consider the following example, slightly different from (216):

(220) John usually finds out who takes the exam.

In a situation in which there had been 10 exams and 5 people each took the exam, and John found out that they took the exam, but in yesterday's exam, there were too many exam-takers and no one would divulge their names, so John couldn't find out who took the exam. It is probably true to say (220) in this situation, in fact, (221) is not a contradiction at all in this situation:

(221) John usually finds out who takes the exam, but he did not manage to do so yesterday as noone would tell him.

A rough paraphrase of examples like (216) or (220) would be something like:

(222) For most exams, John knows more-or-less who did well on the exam.

(222) is too vague, but is probably about the best approximation to the meaning of (216) available.

Adverbs of frequency are rather different in this regard. They typically modify sentences with episodic embedded interrogatives. Thus, the following sentences are perfectly acceptable:

(223) a. Mary partly knows who Bill saw yesterday at 3:00 PM.
b. Mary mostly knows who Bill saw yesterday at 3:00 PM.
c. For the most part, Mary knows what Sally did yesterday at 3:00 PM.
d. To some extent, Mary knows what Sally did yesterday at 3:00 PM.

Related to the episodic vs. habitual distinction is the fact that whereas adverbs of frequency can bind variables deriving from indefinites[10], adverbs of frequency cannot do so. The contrast between (224a) and (224b) on the one hand, and (224c) and (224d) on the other, is instructive:

(224) a. John usually knows whether a man is right for the job (or not).
b. John often knows whether a man is right for the job (or not).
c. * John knows, in part, whether a man is right for the job (or not).
d. * John knows, for the most part, whether a man is right for the job (or not).

The relevant reading for (224a)-(224b) we are interested in is the following:

[10] Assuming the Kamp-Heim analysis of indefinites.

(225) MOST/MANY($x$)[$x$ is a man][John knows whether $x$ is right for the job].

(224a) and (224b) have (225) as one of their readings, but (224c) and (224d) are marginal. *Mostly*, being ambiguous, allows a reading like (225), although it might be marginal for some people:

(226) ? John mostly knows whether a man is right for the job or not.

In fact, a perusal of other simple examples will show that adverbs of frequency can typically bind variables deriving from indefinites[11], but adverbs of quantity do not:

(227) a. A man usually has many enemies.
b. A man often has many enemies.
c. * A man, for the most part, has many enemies.[12]
d. * A man, in part, has many enemies.
e. ? A man mostly has many enemies.

The relevant reading on which the contrast in (227) exists is the following, of course:

(228) MOST/MANY($x$)[$x$ is a man][$x$ has many enemies].

Adverbs of quantity can, however, take bare plural and definite NPs in their scope:

(229) a. Men, for the most part, are bad judges of character.
b. Media experts in the US, for the most part tend to be too indoctrinated.
c. The men in the garden, for the most part, were an unruly lot.
d. The children, for the most part, were playing in the garden.
e. The people in this group are, for the most part, some of the brightest young men and women in the country.

[11] This is discussed at some length in Chapter 1.

[12] This is OK on an irrelevant interpretation, viz, that a man has many enemies most of the time.

Given that bare plurals can be interpreted as kind-denoting terms (Carlson (1977)), and plural definite descriptions can be analysed as denoting the supremum of individuals satisfying a predicate (thus, $\|\textbf{the men}\| = \sigma(x)[\textbf{men}(x)]$, as in Link (1984)), and thus being different from the "normal" indefinites, (229) is not surprising.[13] Further evidence for this claim comes from the fact that sentences like (229a) get worse when the matrix predicate is a stage-level predicate rather than a kind-level predicate (a generic, for example):

(230) ? Men, for the most part, are playing in the garden right now.

Recall that adverbials of quantity, as opposed to adverbials of frequency can appear with episodic predicates. As (229d) shows, there is no such contrast if the subject is a plural definite description rather than a bare plural.[14] The general point is that whereas adverbials of frequency can be taken to bind variables arising from indefinites, adverbials of quantity are plausibly viewed as relating more abstract objects like kinds or plural individuals to predicates. What exactly these adverbials of quantity do will be explained in section 3.3.3, for the case where the subject is analysed as a plural individual.

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[13]Some analyses of bare plurals analyse them as indefinites. If one accepts the Lewis-Kamp-Heim theory of indefinites, then bare plurals must also be analysable as indefinites since they are perfectly acceptable in sentences with adverbs of frequency on the relevant readings.

[14]One can construct examples like the following: (i) Experts, for the most part, are blaming government policies for the recession.
Normally only stage-level predicates take the present progressive, and the matrix predicate in the above example would appear to be a stage-level predicate. Notice however, that without the adverbial of quantity, this sentence has the "universal" rather than the existential interpretation. Thus, (ii) is closer to (iii) in its interpretation than (iv):
(ii) Experts are blaming government policies for the recession.
(iii) All (or almost all) experts are blaming government policies for the recession.
(iv) Some experts are blaming government policies for the recession.
Thus it would appear that the matrix predicate in (i) is a kind-level predicate after all.

Before closing the discussion in this section, let me make a brief point. The discussion of examples like (216), repeated as (231):

(231) John usually knows who does well on the exam.

is strongly reminiscent of the so-called proportion problem as it arises with the Lewis-Kamp-Heim analysis of indefinites. The problem here as well as there is that it is unclear what these adverbials quantify over, e.g., in the above example, whether they quantify over exams, over people who take the exam, or some combination of the two. The discussion in the first part of the chapter showed that it is probably the latter, but of course it is unclear what combination of the two is the right one. Now one promising solution to this problem is outlined in Berman (1987), where it is suggested that adverbials of quantification (he considers only adverbials of frequency) quantify over minimal situations, e.g., for (232), exam-situations or $x$-doing-well-on-the exam-situations. The reason why these sentences have such imprecise truth conditions, on this view, arises from the fact that situations can be individuated in various different ways in natural language, not just one. Keeping to (231), exam-situations could be minimal situations in some contexts, $x$-doing-well-in-a-particular-exam-situation could be a minimal situation in others, and so on. One can extend the Berman (1987) theory to sentences involving embedded interrogatives and adverbials of frequency, but I will not attempt to do that here in any detail. Now can one say the say the same thing about adverbials of quantity? The answer seems to be in the negative.

Adverbials of quantity, as noted throughout, can appear in generic/habitual or episodic

sentences. Since the proportion problem arises in habitual/generic contexts, the question to ask is whether adverbials of quantity can cause the proportion problem in habitual/generic contexts. Note that episodic sentences are irrelevant to the issue, even though the proportion problem does not arise in episodic sentences. In a sentence like the following:

(232) John mostly knows who did well on yesterday's exam.

Since there is only one exam-situation at hand in (232), the only thing to quantify over are subsituations of this exam, like $x$-did-well-on-the-exam-situation, and so the extension of Berman (1987) suggested is consistent with the fact that the proportion problem does not arise in episodic sentences. On the other hand, adverbials of quantity are sometimes ambiguous between frequency and quantity readings. Thus, *mostly* can also mean *on most occasions* or *most of the time*, *for the most part* can mean *most of the time*, and so these adverbials probably do give rise to the proportion problem, as in the following examples :

(233) a. John mostly knows who does well on the exam.
b. John knows who does well on the exams, for the most part.

However, there are adverbials of quantity that are unambiguous, e.g., *partly*, which has the interpretation of an existential, and so cannot quite give rise to the proportion problem, but illustrates something similar. Consider the following examples:

(234) a. John partly knows who knows who did well on the exam yesterday.
b. John partly knows who does well on the exam.

These examples are both unambiguous. Thus, (234b) only has the interpretation in (235):

(235) $Gn_x$[John partly knows who does well on $x$].

The point is that *partly* does not quantify over exam-situations, and so (234b) is false if most of the time John knows nothing about who did well on the exam, but partly knows sometimes, who does well on the exam. In this respect it is crucially different from the corresponding adverbial of frequency, viz., *sometimes*:

(236) John sometimes knows who does well on the exam.

(236) does not require, in order to be true, that John generally know in exams, something about who did well on it.

To sum up, QVE as illustrated with the two classes of adverbials is really two different phenomena. QVE with adverbials of frequency is probably some kind of quantifying over situations. QVE with adverbials of quantity, on the other hand, in comparing "quantities" of two answers, and this straightforwardly leads us to amount quantification.

### 3.3.3 Amount Quantification

In this section, I will outline the basics of what might be called "amount quantification"[15], based on the theory proposed for mass quantification in Higginbotham (1991) (briefly

[15]This is distinct from "measures of amount".

hinted at in Chapter 1). The idea is to formalize the notions "part-of", "most-of", "all-of", etc. I outline the basic idea for mass-terms[16] first, and extend the same to plural count quantification, and explain the relevance of the latter to our purpose at hand.

There exist various proposals about analyzing plurals and mass-terms as complete Boolean Algebras, e.g., Link (1984), Lønning (1987), Roberts (1986), etc. Restricting ourselves to mass-terms, the proposal in Lønning (1987), e.g., is that mass-terms like *water, coffee*, etc. denote elements of a boolean algebra (they can also function as predicates.). Furthermore, individuals in the denotations of predicates are elements of a Boolean Algebra, too. A major problem in analysing expressions with mass-terms has been the problem of analysing quantificational mass NPs as in the following expressions:

(237) a. Most water is wet.
b. Much coffee grows in the continent of America.
c. Some water is brackish.
d. Show him some kindness.

Quantification with count nouns is well-understood since Mostowski (1957), Barwise&Cooper (1981), Higginbotham&May (1981), Keenan&Stavi (1986), etc. In this tradition, quantifiers are defined as functions from n-tuples to truth-values. Thus if $D$ is a non-empty domain of a model, a restricted quantifier $Q$ can be over $D$ can be viewed as a function $f_Q$ from ordered pairs of subsets of $D$ into truth-values. Quantifiers care only about how many about how many things fall under the predicates which they are in construction

[16]Ignoring issues that are not relevant here, e.g., the relevance of homogeneity and cumulativity of predicates, etc.

with, and so they satisfy Mostowski's condition, viz., that they respect permutations over the domains over which they are defined. Formally, the condition is that if $\mathcal{A}$ is any permutation or automorphism of $D$ (a one-to-one map of $D$ onto itself), then for any subsets $A$ and $B$ of $D$, the following is true:[17]

(238) $f_Q(A, B) = f_Q(\mathcal{A}(A), \mathcal{A}(B))$.

(Note that $\mathcal{A}(A) = \{\mathcal{A}(a) : a \in A\}$.) If $A$ and $B$ are subsets of $D$, we can associate with them what Higginbotham&May call their cardinal diagram, the quadruple (239):

(239) $(\|A \cap B\|, \|A \cap \overline{B}\|, \|\overline{A} \cap B\|, \|\overline{A} \cap \overline{B}\|)$.

As a simple generalization of a result of Mostowski's, it is shown in H&M that $f_Q$ satisfies Mostowski's condition if and only if it is completely determined by the cardinal diagram for $A$ and $B$, for all ordered pairs $\langle A, B\rangle$ of subsets of $D$. Thus all quantifiers can be viewed as conditions on (239) ( All($A$,$B$)=1 iff $\|A \cap \overline{B}\| = 0$, Most($A$, $B$)=1 iff $\|A \cap B\| > \|A \cap \overline{B}\|$, and so on.).

Now the problem with mass-quantifiers is that (239) is of no use, since the notion of cardinality does not make sense in case of mass-terms. The suggestion in Higginbotham (1991) is to define mass quantifiers as functions from ordered pairs of elements of a Boolean Algebra with a *measure* $\mu$ (the measure $\mu$ is intended be a formalisation of the notion of size, or relative amount, for entities that mass-terms denote. Recall that a *measure* $\mu$ is defined to be a function from the elements of a Boolean algebra to the non-negative real numbers with the property that if $a \otimes b = \mathbf{0}$, then $\mu(a \oplus b) = \mu(a) + \mu(b)$.)

[17]Keenan&Stavi (1986) and others analyse possessive NP's as quantifiers. If that is the case, then Mostowski's condition does not hold for these quantifiers.

to truth values, and furthermore, they are required to preserve $\mu$-automorphisms, that is, an automorphism that preserves measure. So if $R$ is the domain of a Boolean structure, then $g$ is a $\mu$-automorphism provided that it is an automorphism of $R$, and in addition satisfies the condition (240):

(240) $\mu(g(M)) = \mu(M)$

for all $M$ in $R$. The analogue of the cardinal diagram in this case is the measure diagram, viz., the quadruple (241):

(241) $(\mu(A \otimes B), \mu(A \otimes \overline{B}), \mu(\overline{A} \otimes B), \mu(\overline{A} \otimes \overline{B}))$.

Just like count quantifiers, one can define mass quantifiers like *all, some, most, much,* etc. on the basis of (241). Thus, all($A$,$B$)=1 iff $\mu(A \otimes \overline{B}) = 0$, some($A$,$B$)=1 iff $\mu(A \otimes B) \neq 0$, most($A$,$B$)=1 iff $\mu(A \otimes B) > \mu(A \otimes \overline{B})$, and so on. There are a few caveats that one must mention. Mostowski's result does not hold in general in this case. While it is true that every function of the quadruple in (241) preserves $\mu$-automorphisms, and is thus a quantifier, the converse does not hold. That is, there could exist measures such that there is no unique function of (241) corresponding to a quantifier. Higginbotham (1991) shows that for a certain class of simple measures, Mostowski's result does hold, and these measures, viz., those that respect ratios, are all we need. The second point to note is that these quantifiers are measure-dependent in the sense that, e.g., most($a$,$b$) could have different truth values with respect to different measures. This does seem to accord with intuition, at least with mass-terms. Thus a sentence like the following:

(242) Most carbon in this box is brittle.

may have different truth values depending on whether the measure is weight-ratio or volume-ratio.

The reason why this is important for our purposes is that this way of looking at quantification will enable us to formalise notions like *most* of the answer, *part* of the answer, etc. Furthermore, if one analyses plurals as in Link (1984), where it is proposed that the models for natural languages be enriched with plural individuals, i.e., sums of the more familiar individuals, such an extension of quantification theory is needed anyway even for count nouns. To see this, consider a simple example. Suppose there are three men in a model, $a$, $b$ and $c$, and $a$ and $b$ are fat, but $c$ is not. In this model, (243) is true:

(243) Most men are fat.

However, on Link's theory, there are seven individuals that the predicate *men* is true of, viz., $a$, $b$, $c$, $a \oplus b$, $b \oplus c$, $a \oplus c$, $a \oplus b \oplus c$, of which, the predicate *is fat* is true only of three, viz., $a$, $b$ and $a \oplus b$, and false of the rest. (243) is predicted to be false in this situation, giving us the wrong result. The point is that is one has plural individuals, quantifiers don't "count" individuals, but compare their extent, which for count nouns is the number of atomic subparts of the maximal individual that a certain predicate is true of. So if Higginbotham's theory is extended to Link's theory, a sentence like (243) is to be analysed as (244):

(244) $\mathrm{most}(\sigma x[\mathbf{men}(x)], \sigma x[\mathbf{fat}(x)])$.

where a restricted quantifier like *most* is analysed as a function from ordered pairs of individuals to truth values. Given the nature of the denotation of count nouns, viz., the fact that they are atomic, this is a much easier task than defining quantification for mass-terms. What one has to do is define a measure $\mu$ that "counts" the number of atoms in an individual. For an atomic Boolean algebra, this can be defined by first defining a function $\Psi$ that maps elements of the algebra to sets of atoms of the algebra. The measure can then be defined from the function $\Psi$ as follows[18]:

(245) a. $\Psi(a) = \{b : b \text{ is an atom } \wedge\, b \leq a\}$.
b. $\mu^*(a) = \|\Psi(a)\|$.

Thus for the individual $c = a \oplus b$, $\Psi(c) = \{a, b\}$, and $\mu^*(a) = 2$. Let's assume that the count subsystem of the model for a natural language is a complete atomic Boolean algebra, $\langle R, \oplus, \otimes, ^-, 0, 1\rangle$, where the terms have their usual meanings.[19] One can then show that $\mu^*$ is a well-defined measure, and that quantifiers based on this measure satisfy the Mostowski condition,[20] and so they are well-defined. This is a simple consequence of the fact that, for a complete Boolean algebra, the function $\Psi$ defined in (245) is an isomorphism onto the power set ($\mathcal{P}(A)$) of the set of atoms ($A$) of $R$.

With this redifining of quantification, it is possible to define the usual count quantifiers, *all, many, most, some, few*, etc. rather simply as follows:

[18]In (245a), the $\leq$-relation is the same as the *II-relation of Link (1984), viz., "is a part of".

[19]Since languages contain count as well as mass subsystems, the domain of a complete model will, in general, not be an atomic Boolean algebra. I will assume that the count subsystem is a complete atomic Boolean algebra. This might require, e.g., decomposing predicates that can be true of mass as well as count terms into a count predicate and a mass predicate, and so on.

[20]The proof, modeled on Higginbotham&May (1981), is given in the appendix, and references for unproved statements are also provided there.

(246) a. $\text{all}(a,b) = 1$ iff $\|\Psi(a \otimes \bar{b})\| = 0$.

b. $\text{some}(a,b) = 1$ iff $\|\Psi(a \otimes b)\| \neq 0$.

c. $\text{most}(a,b) = 1$ iff $\|\Psi(a \otimes b)\| > \|\Psi(a \otimes \bar{b})\|$.

d. $\text{many}(a,b) = 1$ iff $\|\Psi(a \otimes b)\| \geq n$, for some contextually specified large $n$.

e. $\text{few}(a,b) = 1$ iff $\|\Psi(a \otimes b)\| \leq n$, for some contextually specified small $n$.

and so on. Given that these quantifiers are in a sense isomorphic to the count quantifiers as they are usually defined, the properties of the latter carry over to the former. Thus, these new quantifiers are conservative if and only if their old counterpart is, and so on. Quantifier scope is not a problem either. Thus a sentence like (247a) with the usual LF in (247b) can be analysed as (247c):

(247) a. Every man loves some woman.

b. $\forall x[x \text{ is a man}]\exists y[y \text{ is a woman}][x \text{ loves } y]$.

c. $\text{all}(\sigma x[\text{ man}(x)], \sigma x[\text{some}(\sigma y[\text{ woman}(y), \sigma y[x \text{ love}(y)]])])$.

I must emphasize that one may or may not wish to reanalyse count quantification the way I have suggested. It must be recognised that there is no other way of defining mass-quantifiers. One may have strong reasons to adhere to the usual quantifiers. If so, the quantifiers I have defined in this section are still useful to formalise the notion of "amount-of" for things that happen to be made up of atomic parts. I argue later that answers are one such type of entity.

### 3.3.4 Questions and Answers in Embedded Contexts

The usual assumption made in the literature is that interrogatives in embedded contexts are interpreted the same way as in non-embedded contexts, BH being the exception.

The major motivation for most theories about the semantics of questions comes from a consideration of embedded interrogatives. I will make a few points here about questions and answers in embedded interrogatives, and tentatively choose a certain variety of partition semantics over other variants, giving reasons. This is not very crucial for my purposes. What I need, as I discussed in Chapter 1, is some theory of embedded interrogatives that uses a notion of answer as a *thing* that can be referred to in embedded contexts.

I have mentioned before that in English as well as in other languages, there are two kinds of predicates, broadly speaking, that embed interrogatives, viz., those that also take indicative clause complements or at least complements that are interpreted as propositions, e.g., *know, be aware, recall, remember, forget, learn, notice, find out, discover, tell, show, indicate, inform, disclose, decide, determine, specify, agree on, guess, predict, bet on, estimate, be certain (about), be convinced (about)*, etc., as those that do not, e.g., *ask, wonder, investigate, be interested in, depend on*, etc. The former are true of questions iff their proposition-taking counterpart is true of some answer to the question. On Karttunen's theory, this is guaranteed for factive predicates like *know* by means of the following meaning postulate:

(248) $\forall x \forall \mathcal{F} \Box [know'_{IV/Q}(x, \mathcal{F})$
$\leftrightarrow [\forall p[\mathcal{F}\{p\} \rightarrow know'_{IV/t}(x, p)] \wedge [\neg \exists q \mathcal{F}\{q\} \rightarrow know'_t(x, \neg \exists q \mathcal{F}\{q\})]]].$

What (248) says is that one question if and only one knows one knows exhaustively every proposition in the question's denotation, and if the denotation of the question in the world in question is empty, knows that the denotation is empty. (248) says nothing

about predicates like *be certain about, agree on* where the related answer does not have to be true, and so is not the denotation of the question in that world, but is the denotation in some other world.

While this formulation is good to a first approximation, it is deficient on two counts, viz., too weak in some ways and too strong in other ways. I consider each of these below.

### Strong Exhaustivity

Firstly, at least in certain cases, the exhaustivity requirement is much stronger than implied by (248). At first thought, it would appear that in order for John to know who came to the party in a situation in which Mary and Susan came to the party and noone else did, John must not only know that Mary and Susan came to the party, but also that they are the only ones who did. So if John falsely believes that Bill and Sue came to the party, it will not be true to say that John knows who came to the party. There is a response to this objection, presented in Berman (1990). Berman claims that in the situation described above, John does know who came to the party but does not know that he knows it, thus denying Hintikka's view that if one knows $p$, one knows that (s)he knows $p$. On the other hand, if John has false beliefs about Bill and Sue, it is, strictly speaking, true to say that John knows who came to the party, but one would not say so because it is simply misleading.

Berman's explanation for ignoring the negative part[21] found in partitional denotation

[21]Like $\neg P(a)$ as part of an answer to the question $\mathrm{Wh}(x)[P(x)]$.

is plausible for a wide range of cases, but is not unproblematic. One problem has to do with *which*-questions dealing with very precise things, like facts about mathematics. Consider the following example, due to Higginbotham:

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

there is a strong intuition that in order for (249) to be true, not only must it be true that John knows that 11, 13, 17 and 19 are prime, but must also know that none of the others are. If the latter does not obtain, it is just false to say (249) rather than simply misleading. Intuitions about other cases also indicate that the negative part of the answer cannot be altogether ignored. Thus, as pointed out to me by Barbara Partee (p.c.), the following sentence from Berman (1990):

(250) The Maitre d' at Maxim's usually knows which customer tips well.

is better approximated by (251b) than by (251a):

(251) a. $\forall x$[$x$ is a customer and $x$ tips well][The Maitre d' at Maxim's knows that $x$ is a customer and $x$ tips well].

b. $\forall x$[$x$ is a customer][The Maitre d' at Maxim's knows whether $x$ tips well].

A theory like that of Karttunen or BH cannot be made to derive (251b) as the right reading for (250), but a partition-based theory can.

Furthermore, the case when the answer to a question of the form $\text{Wh}(x)[P(x)]$ is $\neg\exists x[P(x)]$ is not exactly a trivial case. Note that according to BH a sentence like (252):

(252) Bill knows what they serve for breakfast at Tiffany's.

is interpreted as (253):

(253) $\forall x$[they serve $x$ for breakfast at Tiffany's $\rightarrow$
Bill knows that they serve $x$ for breakfast at Tiffany's].

Now if ill-luck befalls Tiffany's and they stop serving breakfast. Then (253) is true even if Bill knows nothing about Tiffany's. Clearly, (253) is false in such a situation. Now this may not appear to be a strong objection at first, given that people have no intuitions about the truth value of a universal sentence when its restriction is empty.[22] But unlike the latter cases, the judgements in this case seem to be rather clear. Thus it seems that for the following sentence to be true:

(254) John always knows who does well on the exam.

John must know that noone has done well on the exam when that situation arises.

Now the case mentioned above cannot in principle be handled by BH. Karttunen's meaning-postulate does capture this case, but by force. (248) has a separate clause for this case, but this does not follow from anything. On the partitional view, the denotation of the true answer in the situation when nothing satisfies the questioned predicate is precisely the proposition that nothing satisfies the questioned predicate?[23] This does seem to be an advantage of the partitional view over Karttunen.

[22]Thus the following two sentences are both true since there are no unicorns:
(i) Every unicorn is blue.
(ii) Every unicorn is non-blue.
But people have varying judgements about the truth values of these two cases.

[23]To be more precise, a conjunction of propositions that jointly say so.

**Lack of Exhaustivity in certain contexts**

The second point, briefly touched upon in Chapter 1, is that sometimes exhaustivity even upto the strength implied by (248) is not essential. There are the well-known cases due to Hintikka, which show that at least in interrogative infinitives, much weaker answers will do, as in the following examples:

(255) a. John knows where to buy gas for the car.
b. John knows who to look for to collect his passport.
c. Mary remembers where to go in order to get her license.

In order for (255) to be true, John doesn't have to know, of all places that sell gas, that they sell gas: just one place will do. I.e., sentences like (255) are interpreted as (256a) rather than (256b):

(256) a. $\exists x$[one can buy gas at $x$][John knows that one buy gas at $x$].
b. $\forall x$[one can buy gas at $x$][John knows that one buy gas at $x$].

The readings in (255) exhibit what Hintikka calls the *existential desideratum* of questions, as opposed to the universal desideratum that alone is claimed to exist by Karttunen. Sometimes, one can produce examples with intermediate desiderata in context, although these are harder to come by. Thus one can respond to the command in (257a) by saying (257b):

(257) a. What are the possible structures for the following sentence? (Give at least three).
b. I can tell you what the possible structures for the following sentence are.

(257b) does not have to mean that I can give all the possible structures, just that I can give you enough to satisfy you.

### Conclusions

In this section I gave some reasons for choosing the partitional view of the question-answer relationship, arguing from facts about embedded interrogatives. Then I discussed the range of possible interpretations of interrogatives embedded under predicates of the *know*-class. The latter issue is relevant to what the default interpretation of embedded interrogatives are, i.e., in absence of adverbials of quantity.

## 3.3.5 *Natural* Answers and *Natural* parts

### General Introduction

In the last I gave certain reasons for preferring the partition-semantics view. Earlier I mentioned two versions of this general approach. On one version, viz., that of Groenendijk&Stokhof, an interrogative as in (258):

(258) Who left?

denotes a set of propositions[24], each of which looks like the following :

(259) that $a_1$ left and that $a_2$ left and that $a_3$ did not leave and...and that $a_n$ did not leave.

where $a_1, ..., a_n$ are the persons in the universe of discourse. The second version, due to Higginbotham&May (1981)[25], analyses interrogatives as denoting sets of sets of propo-

[24]This is a slight simplification.

[25]Karttunen (1977) notes that in deriving the readings for interrogatives in a crucial order in his system yields the denotations that are in effect the same as what Higginbotham&May (1981) were to later propose. He rejects this approach, however

sitions. So instead of (260), they have the following as a member of the denotation of (258):

(260) { that $a_1$ left, that $a_2$ left, that $a_3$ did not leave, ..., that $a_n$ did not leave }.

The advantage for our purposes in using (260) instead of (258) should be obvious: if an answer is a thing with atomic parts, the atomic parts are easily recoverable from the denotation (260): they are just the members. On the other hand, there doesn't seem to be any obvious way of recovering information about the atomic parts if one accepts (259) as the denotation. Given that the algebra of propositions is atomless, it is conceivable that one can formulate some measure that will enable us to formalise notions like *mostly, partly,* etc. But there doesn't seem to be any obvious way of making this work at this time. I will then assume that answers of the kind relevant for analysing QVE do have atomic parts, and thus prefer (260). Assuming that answers are sets also makes the Boolean structure of answers more apparent than on the other view.

Let me call answers like (260) *natural* complete answers. Subsets of complete natural answers are *natural* partial answers. It was mentioned earlier that the definitions of complete and partial answers in partition-semantics is more general. There certainly are many more partial answers than the natural partial answers. If $Q$ is the question denoted by an interrogative, the set of propositions $S$ is a natural complete answer if and only if $S \in Q$. A set of propositions $P$ is a natural partial answer, iff $P \subseteq S$ for some $S \in Q$. Furthermore, given any natural partial answer $P$, its power set $\mathcal{P}(P)$ is a Boolean algebra in conjunction with the operations of set union, set intersection,

complementation with respect to $P$, and the zero element $\phi$ and the maximal element $P$. Let $N_p(x, Q)$ translate "$x$ is a natural partial answer to $Q$". Also, for any set of propositions $S$ $\check{S} = \forall p \in S[\check{p}]$.

There is one consequence of analysing answers to questions as sets of propositions rather than propositions that I must mention. Given that, e.g., to *know* a question is to *know* the answer (or maybe, an answer) to the question, we need predicates that take sets of propositions as arguments. So in addition to $know_{<e,<<<s,t>,t>,t>>}$, and $know_<e,< s,t >>$, we need predicates like $know_<e,<< s,t >,t >>$. Predicates like the latter are related to the former in specific ways. Let me call the three *know*s $know_q$, $know_p$ and $know_a$ respectively. The latter two are related by the following relation:

(261) $know_a(x, S) \leftrightarrow \forall p \in S[know_p(x, p)]$.

(261) expresses the fact that *know* is cumulative and distributive in the sense that one knows a set of propositions if and only if one knows every proposition in that set. A predicate like *be surprising*, which also has all the three variants mentioned above, is not distributive, only cumulative. Thus, while (261) would in general be false for (261), the following does hold:

(262) a. $surprising_a(P) \wedge surprising_a(Q) \rightarrow surprising_a(P \cup Q)$
b. $\forall p \in S[surprising_p(p)] \rightarrow surprising_a(S)$

Most predicates of the *know*-class, factive as well as non-factive, e.g., *tell, remember, be certain about, agree on*, etc. behave in this regard like *know*, i.e., they obey (261).

Predicates of surprise and relevance, on the other hand, do not obey (261), although some of them, like *be relevant* probably obey a weaker variant of (261).

### QVE as Comparison of natural partial answers

There are two major motivations for analysing QVE the way I propose to. The first motivation is that given the discussion of predicates of surprise and relevance in Chapter 1, one has to be able to refer to answers as wholes rather than open sentences. There I showed that one needed a sum-operation on what might be construed as the atomic parts of an answer and that this problem could not be solved by introducing plural individuals in the denotation of the questioned phrases. The definition of natural partial answers given in the last does just that.

The second motivation is in a sense more important, viz., to show that QVE is just a special case of quantifying by adverbials of quantity more generally. Thus, consider the following sentences:

(263) a. John mostly ate the cookies.
b. John partly ate the cookies.
c. John ate the cookies, for the most part.

The sentences in (263) have many readings where *mostly*, etc., can quantify over extents of time, but they can also be interpreted as follows:

(264) John ate most/part of the cookies.

If we analyse adverbials of quantity like the quantifiers defined in section 3.3.3, then (264) is to be interpreted as:

(265) most/some($\sigma x$[cookies($x$)], $\sigma x$[ate($j, x$)]).

Just as with embedded interrogatives, the first argument of the quantifier can be provided by presupposition-accomodation. Thus the following sentence:

(266) John mostly read the books by QUINE.

has, as one of its many interpretations, (267a), or, in our terms,(267b):

(267) a. Most of the books that John read were books by Quine.
b. most ($\sigma x$[book($x$) $\wedge$ read($j, x$)], $\sigma x$[book($x$) $\wedge$ read($j, x$) $\wedge$ by-Quine($x$)]).

Although the first argument of the quantifier is a thing, viz., the books that Quine read, it is obtained by presupposition-accomodation.

Since natural partial answers as I have defined them have the right Boolean structure, it makes sense to analyse QVE as well in these terms. The sentence (268a), then can be analysed as (268b):

(268) a. John mostly knows who did well on yesterday's exam.
b. most($\sigma x$[$N_p(x, Q) \wedge \check{x}$], $\sigma x$[$N_p(x, Q) \wedge$ know $(j, x)$]).

and similarly for the other predicates, factive as well as non-factive. A sentence with a non-factive predicate like *be certain about* (269a) will be analysed as (269b):

(269) a. John is mostly certain about who did well on yesterday's exam.
b. most($\sigma x$[$N_p(x, Q) \wedge$ believe($j, x$)], $\sigma x$[$N_p(x, Q) \wedge$ certain $(j, x)$]).

## 3.4 APPENDIX

### .1 The definability of Partitional denotations from modified Hamblin denotations (in some cases)

Let the Hamblin denotation of a simple interrogative be $S$, which is a set of sets of propositions. For each $S_i \in S$, define the following set

(270) $S^i = \{A$ : for some $S_j \in S$, such that $S_i \cap S_j \neq S_i$, $A = S_i \cap S_j\}$.

and define

(271) $S'_i = S_i - \bigcup S^i$.

Then the set

(272) $S' = \{A$ : for some $i, S'_i = A\}$.

is a partition in the sense that all its members are disjoint. So if one begins with a Hamblin denotation, this operation will give the corresponding questions-as-partitions denotations.

To see that the members of of $S'$ are disjoint, suppose, to the contrary, that there are two distinct sets, $S'_k, S'_l \in S'$ such that for some $a$,

(273) $a \in S'_k, a \in S'_l$.

This means that

(274) a. $a \in S_k, a \notin \bigcup S^k$.

b. $a \in S_l, a \notin \bigcup S^l$.

Now, from the definition of $S$, it follows from $a \in S_k$ and $a \in S_l$ and $a \notin \bigcup S^k$, that $S_k \cap S_l = S_k$, i.e., $S_k \subseteq S_l$. Moreover, from the definition of $S$, it follows from $a \in S_l$ and $a \notin \bigcup S^l$ and $a \in S_k$, that $S_l \cap S_k = S_l$, i.e., $S_l \subseteq S_k$. But if $S_k \subseteq S_l$ and $S_l \subseteq S_k$, $S_l = S_k$ and hence $S'_l = S'_k$, contra hypothesis. So $S'_l$ and $S'_k$ must be disjoint.

Now note that if we are dealing with the Hamblin denotation $S$ of a simple interrogative with singular NPs, the corresponding partitional denotation will not be a partition of $\bigcup S$. This is easily seen from the fact that, for example, the Hamblin denotation of a question like *"Which house is big?"* is { *that* $x_1$ *is big, that* $x_2$ *is big, ..., that* $x_n$ *is big* }, each of whose members may be compatible with the others. The partitional denotation, on the other hand, is { *that* $x_1$ *is big and nothing else is, ..., that* $x_n$ *is big and nothing else is* }. So if a world $i$ is compatible with, say, $x_1$ and $x_2$ being big, then $i \in \bigcup S$, but $i \notin \bigcup S'$.

Simple interrogatives with plural NPs are different, however, in that the operation defined above does have the property that $\bigcup S = \bigcup S'$. This can be proved as follows.

Note first that Hamblin denotations of plural questions have the property that if $S_i, S_j, S_l, \ldots \in S$, then $S_i \cap S_j \cap S_l \ldots \in S$. E.g., if a Hamblin denotation for *"which books are new"* has, as some of its members, *"that* $x_i$ *is new"*, *"that* $x_j$ *and* $x_l$ *are new"*, *"that* $x_m$ *and* $x_n$ *and* $x_p$ *are new"*, and so on, it will also have the proposition *"that* $x_i$ *and* $x_j$ *and* $x_l$ *and* $x_m$ *and* $x_n$ *and* $x_p$ *and ... are new"*.

To see that $\bigcup S = \bigcup S'$, note that for all $i$,

(275) $S'_i \subseteq S_i$

from the definition of $S'$. It follows, then, that $\bigcup S' \subseteq \bigcup S$, since $S' = \{A : A = S'_i\}$ and $S = \{A : A = S_i\}$. We must now show the converse, i.e., $\bigcup S \subseteq \bigcup S'$. Suppose this is not true, i.e., for some $a$,

(276) $a \in \bigcup S$ but $a \notin \bigcup S'$.

It follows that for some $S_i$,

(277) $a \in S_i$.

but

(278) for all $j$, $a \notin S'_j$

i.e.,

(279) for all $j$, $a \notin S_j$ or $a \in \bigcup S^j$

i.e.,

(280) for all $j$, if $a \in S_j$, then $a \in \bigcup S^j$.

Let

(281) $A = \{S_i : a \in S_i \wedge S_i \in S\}$

From the remark about Hamblin denotations for simple interrogatives with plural NPs, it follows that $\bigcap A \in S$, i.e., $\bigcap A = S_m$, for some $m$. Moreover, $a \in \bigcap A$, i.e., $a \in S_m$. Now, for all $S_i \in A$, $S_m \subseteq S_i$, from the definition of $S_m$, and so, $S_m \cap S_i = S_m$, and so

$S_m \cap S_i \notin S^m$ (from the definition of $S^*$, and so $a \notin \bigcup S^m$, since all sets $S_k$ that contain $a$ have $S_m$ as a subset. So $a \in S_m$ but $a \notin \bigcup S^m$, contradicting (280). It follows, then, that $\bigcup S \subseteq \bigcup S'$.

Since $\bigcup S' \subseteq \bigcup S$, and $\bigcup S \subseteq \bigcup S'$, it follows that $\bigcup S = \bigcup S'$.

The remarks in the previous section indicate that partitional denotations (the Groenendijk & Stokhof formulation) can be defined from the modified Hamblin denotations in case of simple interrogatives where the questioned NP is plural, but not when it is singular. In the next section, I will show that it is possible to give a general definition of partial and complete answers in these cases, based on the modified Hamblin denotations.

## .2 Partial and Complete Answers

In the last section, I defined an operation that gave the partitional denotations from the modified Hamblin denotations. The operation I defined yields a mapping from the Hamblin denotations to partitional denotations which is one-to-one and onto. The mapping is obviously onto, since all $S'_i$s are derived from $S_i$s. It is also one-to-one, because if $k \neq l$, $S'_k$ and $S'_l$ are disjoint, and so $S'_k \neq S'_l$ if and only if $S'_k = S'_l = \phi$. This is possible only if $S_k = \bigcup S^k$ and $S_l = \bigcup S^l$. However, such a situation can never arise if we are operating with a rich enough set of possible worlds[26], as I assume the models for interpreting questions always are; unless $S_k = \phi$ to begin with. So it is reasonable to assume that $\phi$ in the partitional denotation can only be the image og of $\phi$ in Hamblin

[26]For example, if possible worlds are construed as isomorphic to maximal consistent sets, as is customary in standard modal logic.

denotation.

In the light of the above remarks, it does seem possible to give definitions of partial and complete answers in terms of the Hamblin sets, as follows:

*Partial Answer.* A proposition $q$ is a partial answer iff for some $S'_i \in S'$, $q \cap S'_i = \phi$. Since $S'_i$ corresponds to a unique $S_i$, this is true iff for some $S_i$,

(282) $q \cap (S_i - \bigcup S^i) = \phi.$

i.e.,

(283) $q \cap S_i \cap (\overline{\bigcup S^i}) = \phi.$

i.e., iff

(284) $q \cap S_i \subseteq \bigcup S^i.$

In words, (284) states that for some $S_i$, the worlds common to $q$ and $S_i$ are all contained in some one or another $S_j \in S$ which is not a superset of $S_i$.

*Complete Answer.* A complete answer $q$ is consistent with exactly one proposition in a partitional denotation, i.e., there must be exactly one $S'_i \in S'$ such that $q \cap S'_i \neq \phi$. This means that there is at most one $S_i \in S$, such that

(285) $q \cap (S_i - \bigcup S^i) \neq \phi.$

i.e.,

(286) $q \cap S_i \not\subseteq \bigcup S^i.$

I leave it to the reader to put (286) in prose.

As is obvious, the definitions given given above are just complicated translations of the partitional definitions. Furthermore the definitions are not completely general, as they don't apply to simple interrogatives with singular wh-NPs. It is reasonable to conclude then, that the partitional definitions of *partial* and *complete* answers make intuitive sense in a way that the Hamblin denotations do not.

## .3 Quantification for Atomic Boolean Algebras

Let $\langle R, \oplus, \otimes, ^-, 0, 1\rangle$ be a complete atomic Boolean algebra, and let $A$ be the set of atoms. The functions $\Psi : R \rightarrow \mathcal{P}(A)$ and $\mu^* : R \rightarrow \mathcal{R}$ are defined as follows:

(287) a. $\Psi(a) = \{b : b \text{ is an atom } \wedge\, b \leq a\}$
b. $\mu^*(a) = \|\Psi(a)\|$.

$a \leq b$ means that $a \otimes b = a$, or alternatively $a \oplus b = b$.

**Lemma 1.** $\Psi$ is an isomorphism from $R$ into $\mathcal{P}(A)$.

*Proof*: See Mendelson (1970), pg.136.

**Theorem 1.** $\mu^*$ is a measure.

*Proof*: Consider any $a, b \in R$ such that $a \otimes b = \mathbf{0}$. Since $\Psi$ is an isomorphism, it follows that $\Psi(a \otimes b) = \Psi(a) \cap \Psi(b) = \phi$, and that $\Psi(a \oplus b) = \Psi(a) \cup \Psi(b)$. Since $\Psi(a) \cap \Psi(b) = \phi$, $\|\Psi(a) \cup \Psi(b)\| = \|\Psi(a)\| + \|\Psi(b)\|$, and so $\mu^*(a \oplus b) = \mu^*(a) + \mu^*(b)$.

Hence $\mu^*$ is a measure. □

Lemma 2. $\Psi$ is onto.

*Proof*: Let $C \in \mathcal{P}(\mathcal{A})$. Since $R$ is complete, sup$C$ exists. Then $\Psi(\text{sup}C) = C$. To see this, let $a \in C$. Then $a$ is an atom, and from the definition of sup, $a \leq$ sup$C$, and hence $a \in \Psi(\text{sup}C)$. Therefore $C \subseteq \Psi(\text{sup}C)$. Let $a \in \Psi(\text{sup}C)$. Then $a$ is an atom and $a \leq$ sup$C$, i.e., $a \otimes \text{sup}C = a$. Now if $a \notin C$, then since $a \otimes \text{sup}C = \text{sup}\{a \otimes b : b \in C\} = 0$ (see Mendelson (1970), pg. 151). Since every $b \in C$ is an atom and $a \otimes b = 0$, it would follow that $a = 0$, a contradiction. Therefore, $\Psi(\text{sup}C) \subseteq C$, and thus, $\Psi(\text{sup}C) = C$. Therefore, $\Psi$ is onto. □

Lemma 3. Let $m$ be an automorphism of $A$. Moreover, if $P \subseteq A$, call the set $\{m(a) : a \in P$ as $m(P)$. Define the function $M_m : R \rightarrow R$ as follows:

$M_m(a) = \text{sup}\{m(b) : b$ is an atom $\wedge\, b \leq a\}$, i.e., $M_m = \text{sup}(\Psi(a))$.

Then $M_m$ is a $\mu^*$-automorphism of $R$.

*Proof*: In the proof of Lemma 3, it is noted that if $C \subseteq A$, then sup$C = \Psi^{-1}(C)$. This means that $M_m(a) = \Psi^{-1}(m(\Psi(a)))$. Since $\Psi$ and $m$ are both one-one and onto, so is $M_m$. Moreover, $M_m$ preserves the algebra, since $M_m(a \otimes b) = \Psi^{-1}(m(\Psi(a \otimes b)$. Since $\Psi$ is an isomorhism, this equals $\Psi^{-1}(m(\Psi(a) \cap \Psi(b))) = \Psi^{-1}(m(\Psi(a)) \cap$

$m(\Psi(b)))$, since $m$ is one-one and onto. Moreover, since $\Psi^{-1}$ is an isomorphism, this equals $\Psi^{-1}(m(\Psi(a))) \otimes \Psi^{-1}(m(\Psi(b))) = M_m(a) \otimes M_m(b)$. Similarly, $M_m(\overline{a}) = \Psi^{-1}(m(\Psi(\overline{a}))) = \Psi^{-1}(m(\overline{\Psi(a)})) = \Psi^{-1}(\overline{m(\Psi(a))}) = \overline{\Psi^{-1}(m(\Psi(a)))} = \overline{M_m(a)}$. To show that it preserves $\mu^*$, simply note that $\mu^*(M_m(a)) = \|\Psi(M_m(a)\| = \|\Psi(\Psi^{-1}(m(\Psi(a))))\| = \|m(\Psi(a))\|$. But since $m$ is one-one and onto, $m(\Psi(a)) \sim \Psi(a)$, and so $\|m(\Psi(a))\| = \|\Psi(a)\| = \mu^*(a)$. This completes the proof. $\square$.

**Theorem 2.** Mostowski's Condition. Let $\lambda$ be a cardinal number. A 4-*partition* of $\lambda$ is a quadruple $(\alpha, \beta, \gamma, \delta)$ of cardinals with $\alpha + \beta + \gamma + \delta = \lambda$. Let $\pi(\lambda)$ de the class of 4-partitions of $\lambda$. A $\lambda$-quantifier is a function: $\xi : \pi(\lambda) \rightarrow \{1, 0\}$. Let $\Phi$ be the set of $\lambda$-quantifiers $\xi$. Let $F$ be the set of restricted $\not\exists$-quantifications $f$ on $R$. Define a function:

$\nu : F \rightarrow \Phi$

by:

$\nu(f)$= the $\lambda$-quantifier $\xi$ such that, for all $a, b \in R$:

$f(a, b) = \xi(\mu^*(a \otimes b), \mu^*(a \otimes \overline{b}), \mu^*(\overline{a} \otimes b), \mu^*(\overline{a} \otimes \overline{b}))$.

Then $\nu$ is well-defined, one-to-one, and onto $\Phi$.

*Proof*: (Higginbotham&May (1981).) Suppose $a, b, a', b' \in R$, and:

$\mu^*(a \otimes b) = \mu^*(a' \otimes b')$

$\mu^*(a \otimes \overline{b}) = \mu^*(a' \otimes \overline{b'})$

$\mu^*(\overline{a} \otimes b) = \mu^*(\overline{a'} \otimes b')$

$\mu^*(\overline{a} \otimes \overline{b}) = \mu^*(\overline{a'} \otimes \overline{b'})$

Then there are functions $m_1, m_2, m_3, m_4$, given the definition of $\tilde{\mu}$ as follows:

$m_1 : \Psi(a \otimes b) \rightarrow \Psi(a' \otimes b')$

$m_2 : \Psi(a \otimes \overline{b}) \rightarrow \Psi(a' \otimes \overline{b'})$

$m_3 : \Psi(\overline{a} \otimes b) \rightarrow \Psi(\overline{a'} \otimes b')$

$m_4 : \Psi(\overline{a} \otimes \overline{b}) \rightarrow \Psi(\overline{a'} \otimes \overline{b'})$

which are one-one and onto. Since $\Psi$ is an isomorphism, $\Psi(a \otimes b) = \Psi(a) \cap \Psi(b)$, $\Psi(a \otimes \overline{b}) = \Psi(a) \cap \overline{\Psi(b)}$, and so on. Hence the domain of $m = m_1 \cup m_2 \cup m_3 \cup m_4$ is $\Psi(1) = A$ and so is its range. Moreover, since the domains as well are the ranges of $m_1, m_2, m_3, m_4$ are respectively pairwise disjoint, it follows that $m$ is one-one, onto and hence an automorphism of $A$. Moreover:

$m(\Psi(a)) = m_1 \cup m_2(\Psi(a')) = \Psi(a')$

$m(\Psi(b)) = m_3 \cup m_4(\Psi(b')) = \Psi(b')$

From the definition of $M_m$ in Lemma 3, it follows then that

$M_m(a) = \Psi^{-1}(m(\Psi(a))) = \Psi^{-1}(m(\Psi(a'))) = M_m(a')$, and similarly,

$M_m(b) = \Psi^{-1}(m(\Psi(b))) = \Psi^{-1}(m(\Psi(b'))) = M_m(b')$.

Since $f$ respects $\mu^*$-automorphisms of $R$, it follows that

$f(a, b) = f(a', b')$. Thus, $f$ is well-defined. From the definition of $\nu$, $\nu$ is trivially one-to-one.

Furthermore, $\nu$ is onto, because if $\xi$ is a $\lambda$-quantifier, then one can define a function $f : R \times R \to \{0,1\}$ by the following:

$f(a,b) = \xi(\mu^*(a \otimes b), \mu^*(a \otimes \overline{b}), \mu^*(\overline{a} \otimes b), \mu^*(\overline{a} \otimes \overline{b}))$

Now if $M$ is a $\mu^*$-automorphism of $R$, it is the case that, for example:

$\mu^*(M(a) \otimes M(b)) = \mu^*((M(a \otimes b))) = \mu^*(a \otimes b)$,

and so on for the other arguments of $\xi$, since $M$ is an automorphism. It follows, then, from the definition of $f$, that:

$f(a,b) = f(M(a), M(b))$.

Hence $f$ is a quantifier, and so $\nu$ is onto. This completes the proof. $\square$.

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