RECONSTRUCTION AND THE INTERPRETATION OF WHICH-PHRASES

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Although standard English word order places the interrogative word or phrase (or the main one, if there are more than one) first, with inversion of the verb, there is no real need for an order different from that appropriate to indicatives. (Hamblin (1973), p. 48)

1. INTRODUCTION

It is often assumed - both by semanticists and syntacticians - that wh-phrases are inherently quantificational. According to Karttunen (1977), for instance, wh-phrases have the semantics of existential quantifiers. The meaning of a question like (1) is obtained by quantifying-in an existential quantifier with the same meaning as "a man" into a so-called protoquestion:

(1) Which man snored?

Similarly, in most syntactic treatments of wh-questions in the GB-tradition it is assumed that wh-phrases are like quantifiers in that they need to take scope, and more in particular, that at the level of LF all wh-phrases must be either in the Spec of CP or adjoined to CP. This is often thought to provide some sort of semantic motivation for (overt or covert) wh-movement.

In this paper we want to question the parallelism between wh-phrases and quantifiers. We do this by considering the semantics of which-questions, in particular the semantic role of the N' sister of which. We start out by arguing (following a criticism of Groenendijk and Stokhof (1982, 1984) against Karttunen's theory) that the content expressed by the N' must be part of the propositions making up the question denotation rather than constituting an external restriction on which propositions go into the question denotation, or in Groenendijk and Stokhof's terminology, in the basic interpretation of a question the N' is understood de dicto rather than de re (section 2). After considering an alternative proposal by Heim (1994) in section 3, we argue that to account for the de dicto reading it is necessary to assume that overtly moved wh-phrases are

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reconstructed at LF and that in situ wh-phrases do not undergo LF wh-movement (section 4). A naive version of this reconstruction approach faces certain important semantic problems (section 4.3), which can be solved by assuming that which-phrases are presuppositional (section 5). The semantic contribution of the N sister of which to the propositions making up the question denotation has the force of a presupposition rather than an assertion. In this respect, which-phrases are like definite NPs. The presuppositional treatment of which-phrases not only solves the problems for the reconstruction approach, but also provides strong evidence for it based on certain presupposition projection facts. Since moved wh-phrases must be reconstructed for purposes of semantic interpretation and in situ wh-phrases remain in situ at LF, we conclude that there is in fact no semantic motivation for wh-movement. The widespread idea that wh-movement to Spec CP takes place for reasons of scope (analogous to QR) is therefore misguided. In section 6 we explore the more radical thesis that in fact wh-phrases are not quantificational at all by going back to Hamblin's (1973) treatment of wh-questions. In his system, question meanings do not come about by quantification. Instead, wh-phrases introduce alternatives into semantic computation, in much the same way that focused phrases do (Rooth 1985).

In many ways this paper is programmatic in nature, raising at least as many questions as it answers. For one thing, we do not address any questions about the exact nature of reconstruction (syntactic or semantic), nor do we consider the arguments pro and contra reconstruction based on binding phenomena - issues which are central to many of the other papers presented at the Tübingen workshop. However we do present some strong novel semantic arguments in favor of reconstruction. While in this paper we cannot explore all consequences of our alternative view of the role of wh-phrases, we will give enough arguments for a Hamblia-style analysis to make it look like a plausible alternative to the widely accepted quantificational view.

2. WHICH-PHRASES: DE RE VS. DE DICTO READINGS

2.1 Karttunen's semantics. Karttunen (1977) proposes that a question denotes the set of all true answers to the question. In a situation in which Meg, Ian and Susan called and nobody else did, the question in (2) would thus denote the set of propositions given informally in (3).

(2)  Who called?

(3)  {Meg called, Ian called, Susan called}

Now suppose that Meg, Sam and Ian are students, Susan is not a student, and otherwise the situation remains unchanged. Then intuitively, the set of true answers to (4) is (5):\(^1\)

(4)  Which students called?

(5)  {Meg called, Ian called}

Hence, Karttunen suggests that the question (4) denotes (K):

(K)  \(\lambda p \exists x[\text{student}(x)(w) \& p(w) \& p=\lambda w'[\text{called}(x)(w')]]\)

This is the set of all true propositions "x called", where x is in fact a student. (K) is the extension of the question in (4). The Karttunen intension is the function in (6), which yields for each world the set of true answers in that world.

(6)  \(\lambda w \lambda p \exists x[\text{student}(x)(w) \& p(w) \& p=\lambda w'[\text{called}(x)(w')]]\)

At this point it is useful to introduce a piece of terminology. Following von Stechow (1996) we will refer to the subformula following "\(p=w\)" in formulas like (K) as the question nucleus. Note that in Karttunen's theory the predicate corresponding to the N' restricts the set of propositions that make up the question denotation, but does not enter into the content of the propositions themselves, i.e. the N' is not part of the nucleus. It functions as a restrictor on the existential quantification much like the N' in a quantificational NP like every student, some student etc.

2.2 The de dicto reading. Groenendijk and Stokhof (1982, 1984) (henceforth: G&S) have the following criticism of this treatment of which-questions. Suppose that John knows who called. Intuitively, this implies that for everybody who did in fact call, John knows that that person called. Now if John knows of everybody who called that they called, he also knows of every student who in fact called that person called. Thus Karttunen predicts the following inference to be valid:

(7)  John knows who called.

Therefore:  John knows which students called.

This is because the set of propositions that are true answers to the question which students called? is a subset of the propositions that are the true answers to

\(^1\)We will ignore the distinction between singular and plural which-phrases throughout the paper.
the question *who called*?. So if John knows all propositions in (2), he must also
know all propositions in (4).

Now is this inference valid intuitively? G&S claim that Karttunen's analysis
reflects our intuitions about one possible reading of (4), which they call the *de re*
reading. However, there is according to G&S a second reading of (4) which is
not represented by Karttunen. In this reading, knowing which students called
implies awareness of the student-status of the callers. Thus knowing the true
answers to (4) implies that of every individual occurring in the propositional
answers, knowing that that individual is a student. Hence in a sense, the property
of being a student, in this reading, is part of the answers to the question that John
has to know in order for John to know which students called. In this *de dicto*
reading the information that someone is a student thus is part of the propositions
in the question set.

2.3 G&S. G&S argue for the following semantics for the *de dicto* reading of (4)
((G&S) is the question extension on G&S's analysis; the intension can be gained
by abstracting over the world variable w):

\[
\lambda w[\lambda x[\text{student}(x)(w') \& \text{called}(x)(w')] = \\
\lambda x[\text{student}(x)(w) \& \text{called}(x)(w)]]
\]

This is the proposition that the set of individuals who are students and called is
whatever it actually is. In the scenario sketched before, this would be the
proposition that the students who called are Meg and Ian and no-one else. There
are several differences between Karttunen and G&S. One difference is how
exhaustive knowledge of the answers to a question has to be. The G&S question
interpretation is strongly exhaustive, which means that since knowing which
students called is knowing the proposition in (G&S), the following two
inferences are predicted to be valid (in order to exclude considerations of *de re*
vs. *de dicto*, the second difference between (G&S) and (K), let us for the
moment ignore all non-students; we will come back to *de re/de dicto* presently):

(8)  John knows which students called.
     Sue called.
     Therefore:  John knows that Sue called.

(9)  John knows which students called.
     Sue did not call.
     Therefore:  John knows that Sue did not call.

The Karttunen denotation (K) is per se not strongly exhaustive; if *John knows
which students called* means that John knows every proposition in (K), then (8)
is predicted to be valid, but (9) is not. The Karttunen semantics of questions is
thus said to be weakly exhaustive, but not strongly exhaustive. See Heim (1994)
and Beck and Rullmann (1996) (henceforth: B&R) for a discussion of
exhaustivity and the relation between Karttunen and G&S.

Let us now focus on the interpretation of *which student*, and in particular on
where the information that an individual is a student is represented. Notice that
knowing (G&S) in our scenario is knowing that the students who called are Meg
and Ian - hence if knowing a proposition implies knowing everything implied by
that proposition, this implies knowing that Meg and Ian are students. The
information that people are students is treated on a par with the information that
they are callers. This contrasts with Karttunen's analysis, where the two bits of
information were not treated alike. The student-property ended up outside the
nucleus, the caller-property inside.

(G&S) represents the *de dicto* reading of (4). G&S also have a way of deriving
the *de re* reading, and can thus account for both.

In this paper, we want to pursue an analysis of the *de re/de dicto* ambiguity in a
Karttunen-style theory, in the sense that the basic denotation of a question is
taken to be a set of propositions (the true answers to the question, which jointly
make up the weakly exhaustive true answer), rather than a single proposition
(the strongly exhaustive true answer to the question). We have given arguments
for taking the Karttunen interpretation as the basic question meaning in B&R,
which concerned the issue of exhaustivity, and which we will not repeat here.
While we wish to acknowledge our intellectual debt to G&S concerning their
insights into the *de re/de dicto* interpretations, we will try to account for them in
our favourite Karttunen framework without further comment on their analysis.

In this, we have a predecessor. Heim (1994) gives an account of *de dicto*
readings on the basis of Karttunen's semantics for *which*-questions. We will
discuss her proposal in the next section.

3. Heim (1994)

3.1 De dicto via exhaustivity. Heim (1994) extends Karttunen's basic proposal
for the semantics of questions to account for the behaviour of question-
embedding verbs like *know*. The effects she accounts for are strong vs. weak
exhaustivity as discussed above. To capture these, she adds two concepts of
what it means to be an answer to a question to Karttunen's basic question
meanings. The formal definitions are given in (10) and (11). QK is the Karttunen
intension.

(10) Definition of *answer1*:
     \[*\text{answer1}(w)(\text{QK}) = \neg(\text{QK}(w))\]

(11) Definition of *answer2*:
     \[*\text{answer2}(w)(\text{QK}) = (\text{QK}(w))\]
(11) Definition of answer2:

\[
\text{answer2}(w)(\text{QK}) = \lambda w \text{[answer1}(w)(\text{QK}) = \text{answer1}(w)(\text{QK})]
\]

Answer2 is used to account for strong exhaustivity, and yields a proposition that for most question meanings it is applied to is equivalent to the meaning G&S would assign to that question. What is of interest to us here is that, at least for most run-of-the-mill predicates, it is in fact equivalent to the G&S de dicto meaning of the question, although the basic Karttunen denotation we started out with was as described in section 2.1., where the information about the student-status of the caller was not part of the individual propositions. Nonetheless, knowing the answer2 to the question (4) implies knowledge of the student-status of the individuals in the individual propositions. This miracle can only be believed given a formal proof. Heim (1994) gives such a proof, but also notes that the equivalence of answer2 to the G&S denotation breaks down for (admittedly somewhat contrived) predicates like being identical to oneself and living with one's actual spouse. She proposes a solution to this problem in terms of structured meanings, which we will not review here.

For the subsequent discussion, there is one point of importance in this explanation of the de dicto interpretation:
The equivalence to G&S and the de dicto interpretation comes about via the application of answer2. Answer2 enforces strong exhaustivity. Hence exhaustivity and the de dicto interpretation are predicted to be related: no exhaustivity - no de dicto reading. We believe that this is wrong.

3.2 De dicto not linked to exhaustivity. Heim argues that the noun answer, as in know the answer to the question Q, does not require a strongly exhaustive interpretation of Q. We agree with her, and in fact argue in B&R that there is a not even weakly exhaustive interpretation in cases like (12):

(12) John knows only one answer to the question which Dutch Olympic athletes won a medal.

At the same time, we believe that interpreting the which-phrase de dicto is as easily possible here as it is in examples like (4). However, the de dicto interpretation cannot possibly come about via exhaustivity in (12).
The intuitions about de re/de dicto distinctions are generally not very strong. So perhaps (12) by itself would not suffice to convince anybody that Heim’s explanation is not sufficient. There is a case that we believe to be much clearer that involves the question embedding predicate agree on. Agree on is discussed at length in Lahiri (1991). We will not go too deeply into his discussion, which centers around quantifiability variability effects, and those tend to complicate matters considerably. Here, we will ignore the complication, although it is of course clear that those cases have to be looked at in principle.

We will focus on a property that agree on has as a question embedding predicate which is very rare: it does not require the answer-propositions to the question it embeds to be true. Hence in (13),

(13) John and Bill agree on who was elected.

the propositions that John and Bill agree on do not have to be true, i.e. they have to be possible answers to the question rather than true answers. Notice that this alone suffices to make the standard notions of exhaustivity inapplicable. For John and Bill to agree on Q, no relation is required to the set of true answers to Q. They could be completely mistaken, or fail to have any beliefs about actual true answers to Q, and still agree on Q. Hence agree on does not make use of either answer1 or answer2. Actually, we need to modify even Karttunen’s basic semantics a little, since we need to talk about possible answers rather than true answers to the question embedded under agree. The operation Hamb defined below does that.

(14) Hamb(\text{QK})(w) = \{ p \text{ there is a w such that QK}(w)(p) \}

Given a Karttunen intension, Hamb will yield for any given world w the set of all possible answers, i.e. the set of all propositions that are true in some possible world. We have called this operation Hamb since the resulting set of propositions is similar to the question semantics suggested by Hamblin (1973). We will discuss the relation between Hamblin and Karttunen in more detail in section 4.1.

Equipped with this, we suggest the following semantics for agree on (which would probably have to be modified to account for quantifiability variability data, but should suffice for our purposes):

(15) agree (X) (QK) (w) iff for all x in X, all p in Hamb(QK)(w):

• if x believes p in w, then for all y in X: y believes p in w

• if x believes non p in w, then for all y in X: y believes non p in w

Now what about agree on and which-questions? A de dicto reading of a which-phrase such as which physicists would imply that the individuals denoted by the subject of agree have to also agree on the physicist-status. Hence for (16) to be true people would have to be physicists in John and Bills belief-worlds rather than the actual world. On such a reading, (16) would be true and appropriate in the scenario described in (17).

(16) John and Bill agree on which physicists are Nobel prize winners (this year).
(17) Scenario: Agatha and Dorothy are physicists and Nobel prize winners.
Waldemar is a Nobel prize winner, but not a physicist. Pumuckl is neither.
John and Bill believe that Agatha, Waldemar and Pumuckl are physicists
and Nobel prize winners. They have no beliefs about the others.

An example that illustrates the existence of such a reading quite clearly is one in
which the subjects of agree are likely to be mistaken about the restriction.
Consider (18):

(18) Jonas and Ida agree on which European countries have a king.

Jonas and Ida are small children. (18) can be true intuitively if Jonas and Ida
believe of the same entities that they are European countries and kingdoms, even
though the entities are not European countries at all. This is very clearly a de
dicto reading.

As we said above, agree on does not seem to be amenable to an analysis in
terms of exhaustivity at all. Hence we have shown that there are non-exhaustive
de dicto readings.

We conclude that de dicto readings should be dissociated from the issue of
exhaustivity. This leaves us without an analysis of de dicto readings in a
Karttunen framework.

4. THE NAIVE DE DICTO APPROACH

4.1 Beck and Rullmann (1996). On the basis of the arguments given in the
preceding section, we conclude that the de dicto reading of questions should not
be derived in the way Heim proposes by means of answer2, but should be built
directly into the basic question denotation. Given a Karttunen-style semantics
can be done straightforwardly by assigning to the question "which students
called?" the following interpretation, as we proposed in B&R:

\[(B&R) \quad \lambda p \exists x[p(w) \& p=\lambda w'[student(x)(w') \& called(x)(w')]]\]

Again, (B&R) represents the B&R extension, and the corresponding intension
can be gained by abstraction over w. The difference with the original Karttunen
denotation (K) is that the information that the relevant individuals are students is
now part of the propositions that make up the question set (i.e. part of the
nucleus). In the situation introduced in section 2.1 (Meg, Sam and Ian are
students, and Meg, Ian and Susan called), the question will denote the following
set of propositions:

(19) \{Meg is a student who called, Susan is a student who called\}

Apart from exhaustivity (B&R) contains the same information as G&S's
denotation of the question on the same scenario (i.e. the proposition that Meg
and Susan (and no one else) are the students who called). In fact, in B&R we
show that we can derive the G&S denotation from the B&R intension QB&R by
applying answer2; i.e.:

(20) \text{answer2(w)(QB&R) = (G&S)}

This time what we have is full equivalence in all cases, without any restriction
on the type of question predicate involved and without any need for using
structured meanings to get around that problem, as was the case for Heim. We
believe that having available as potential question denotations both our non-
exhaustive de dicto interpretation (B&R) and G&S's (strongly) exhaustive de
dicto interpretation (G&S) is necessary to account for the full range of meanings
that questions can be observed to have. For extensive arguments we refer the
reader to B&R.

The idea that a which-question denotes a set of de dicto propositions which
include the information contained in the N' sister to which is by no means
original. In fact it was already proposed in Hamblin's analysis of questions
which predate Karttunen's. The only other difference between his analysis and
Karttunen's is that in Hamblin's analysis the propositions in the question set are
not required to be true. Hamblin's denotation for the question which students
called can be represented as follows:

\[(H) \quad \lambda p \exists x[p=\lambda w'[student(x)(w') \& called(x)(w')]]\]

We will refer to (H) as the Hamblin extension. A Hamblin intension will be a
constant function, namely the function that assigns to every world the set of
possible answers to the question (which does not depend on the facts in
the actual world). In the scenario described above Hamblin's question extension
will consist of the following set of propositions:

(21) \{Meg is a student who called, Sam is a student who called,
Ian is a student who called, Susan is a student who called\}

\[3\text{In giving this translation we are ignoring the fact that Hamblin worked in the framework of English as a Formal Language, rather than that of PTQ assumed by Karttunen, Groenendijk and Stokhof, and ourselves. In PTQ terms, our formula (H) represents the extension of the question. In EFL the denotation of a sentence is a proposition (a set of possible worlds) i.e. what is called its intension in PTQ terminology. For Hamblin the denotation of a question is simply a set of propositions.}\]
This difference between Hamblin's analysis and ours is a non-essential one, we believe. On the one hand the propositions that are false in the actual world can easily be eliminated when necessary, by applying an operation we call "Kartt" to a question intension Q:

\[ \text{Kartt}(Q(w)) = \{ p(Q(w)(p) & p(w)) \} \]

On the other hand we can derive Hamblin's denotation (H) from the B&R question intension QB&R by applying the "flattening" operation Humb defined in section 3.2. We thus have the following equivalences (QH is the Hamblin intension as introduced above):

\[ \begin{align*}
\text{Kartt}(QH)(w) &= (B&R) \\
\text{Hamb}(QB&R)(w) &= (H)
\end{align*} \]

Because of this, we will for the moment stick to (B&R) rather than (H) as the basic question denotation. We will have reason to come back to Hamblin's analysis, however, when we discuss issues related to the syntax semantics interface in more detail in section 6.

To derive (B&R) as the interpretation for "Which students called?" we have to make sure that the translation of the N' students somehow ends up in the question nucleus, rather than outside it as in Karttunen's theory. The simplest way to achieve this is to reconstruct the wh-phrase (or at least its N' part) to the position of the trace. We will call this the "naive" reconstruction approach, because it has some rather obvious failings, which we will discuss in section 4.3.

In this paper we don't have anything substantive to say about the particular method by which reconstruction of the N' is achieved. Rather than literal lowering of the N' we could adopt the recent "copy and delete" approach to movement and reconstruction as developed in the minimalist program by Chomsky (1993). On the other hand, reconstruction of the N' could be achieved by entirely semantic means (i.e. lambda-conversion) using techniques proposed to handle scope reconstruction effects by von Stechow (1991), Cresti (1995) and Rullmann (1995). For discussion of the pros and cons of syntactic vs. semantic reconstruction, in particular with respect to binding phenomena, we refer to some of the other papers presented at the Tübingen workshop (e.g. papers by Fox, Lechner, Romero, Sharvit, von Stechow, Sternefeld). Either approach is compatible with the main point we wish to make in this paper, namely that the N' needs to be reconstructed into the question nucleus in some way or another.

When we turn to wh-in-situ the approach we are pursuing has an obvious advantage. On the naive approach a multiple wh-question like (24) will have the denotation in (25):

\[ \begin{align*}
(24) & \quad \text{Which man saw which woman?} \\
(25) & \quad \lambda p \exists x \exists y (p(w) & \land \lambda w' \{ \text{man}(x)(w') \land \text{woman}(y)(w') \land \text{saw}(x,y)(w') \})
\end{align*} \]

Since the N' woman needs to be interpreted in the question nucleus, we may simply assume that it stays put. No LF-raising to the Spec of CP or adjunction to CP is necessary or even desirable. In recent work by Reinhart (1995) and Dayal (1996) the problems for theories that assume obligatory LF wh-movement have become abundantly clear. For one thing, as Reinhart points out, we would have to assume that LF wh-movement does not obey the usual island constraints, which would make it unlike both overt wh-movement and QR:

\[ \begin{align*}
(26) & \quad \text{Who will be offended if we invite which philosopher?}
\end{align*} \]

An approach to the semantics of wh-questions which does away with the need for in situ wh-phrases to undergo LF movement clearly has some syntactic advantages then. However, the particular approach we introduced in this section also faces some serious semantics problems as we will see in section 4.3.

4.2 Deriving de re readings. (B&R) only represents the de dicto reading of which students called. It should not be forgotten though that the N' in a which-phrase can also be understood de re, i.e. the original Karttunen denotation (K) does represent an existing reading. Groenendijk and Stokhof (1982, 1984), whose basic question denotation is de dicto, derive de re readings by quantifying-in the CN (analogous to QRing the N' in the syntactic framework we adopt). We feel that though this approach gives the right results, it is somewhat misleading in that it uses a technique that was originally intended to account for the scope of generalized quantifiers. This suggests that the two phenomena have something in common, in particular that they should be sensitive to the same syntactic constraints. This does not appear to be the case however.\(^3\)

We will adopt a different method to achieve the same result as Groenendijk and Stokhof. Rather than QRing the N', we assume that the world-variable of the N' can be chosen freely. For instance, whereas in the de dicto reading (27b) the

\[^3\text{It should be pointed out though that Groenendijk and Stokhof do not actually claim that de re readings and quantifier scoping are restricted by the same syntactic constraints. The difference between their approach and ours probably does not reflect any difference of opinion about the facts, but just a different feeling about the empirical import of using a syntactic rule like quantifying-in to account for a certain semantic phenomenon. The theoretical framework they were working in (Montague grammar) was less concerned with capturing grammatical restrictions on possible derivations than the "principles and parameters" approach we adopt.}\]
What such examples show is that the world variable of an N' is independent of the scope of the NP of which this N' is a part. These cases cannot be explained by QRing the whole NP since that would destroy the NP scoping required on the intended readings. They are evidence then in support of the idea that the choice of the world variable on the N' is free and independent of the scope of the NP.

Enç's and Heim's arguments can be carried over to questions. Questions with how many are potentially ambiguous in scope (Frampton 1990, Cresti 1995, Rullmann 1995). (30a), for instance, can be interpreted either as (30b) or as (30c):

(30) a. How many alligators does Mary want to catch?
   b. For which n: there are n alligators x such that Mary wants to catch x
   c. For which n: Mary wants it to be the case that there are n alligators x such that Mary catches x

Now notice that on both readings alligators can be understood either de dicto or de re. In particular, there exists a reading in which the how many phrase has narrow scope with respect to want (as in (30c)), but where alligators is de re. A possible scenario in which this reading would be true is the following: Mary shows John a picture of an alligator and says that she wants to catch two of those animals to keep as pets in her backyard pond. John however happens not to be very knowledgeable about reptiles, and believes that the animal in the picture is a crocodile. In this situation John knows the following proposition:

(31) λw[wants(Mary,λw∃x(alligator(x)(w) & catch(Mary,x)(w")))]

That is, John knows that Mary wants to catch two entities which in the actual world are alligators. Since it is impossible to represent this reading by means of quantifier scoping only, it must be possible to evaluate the predicate alligator with respect to a "higher" possible world.

4.3 Problems for the naive approach. In this section we have argued that the N' sister of a which phrase is always part of the question nucleus, which implies that at LF moved which phrases must be reconstructed and in situ which phrases are not raised. Although there are some good arguments for this analysis, as it stands it also yields results that are bluntly wrong, which is why we have called it the naive approach. To see where the problem arises consider the following pairs of questions (on their de dicto interpretation):

(32) a. Which unicorn does Bill want to catch?
   b. How many unicorns does Bill want to catch?
(33) a. Which lady wants to catch which unicorn?
b. Which lady wants to catch how many unicorns?

The naive approach predicts that (32a) and (33a) can be paraphrased as in (34a) and (35a), respectively (the formulas in (b) give the official interpretations):

(34) a. For which $y$: Bill wants that $y$ is a unicorn and Bill catches $y$
b. $\lambda p\exists y[p(w) \land p(w) \! \![\text{want}(\text{bill}, \lambda w[\text{unicorn}(y)(w)) \land \text{catch}(\text{bill}, y)(w))]](w')$

(35) a. For which $x$, $y$: $x$ is a lady and $x$ wants that $y$ is a unicorn and $x$
catches $y$
b. $\lambda p\exists x\exists y[p(w) \land p(\lambda w[\text{lady}(x)(w) \land \text{want}(x, \lambda w[\text{unicorn}(y)(w)) \land \text{catch}(x, y)(w)])](w')]$

It is clear that these are not possible interpretations of the question. The problem is that the predicate unicorn should not be part of the content of what Bill wants. Contrast this with the corresponding how many question in (32b) and (33b), which according to what we've said so far are interpreted as follows:

(36) a. For which $n$: Bill wants there to be $n$ unicorns $y$ such that he catches $y$
b. $\lambda p\exists n[p(w) \land p(\lambda w[\exists n\exists y[\text{unicorn}(y)(w)) \land \text{catch}(\text{bill}, y)(w)])](w')$

(37) a. For which $x$, $n$: $x$ is a lady and $x$ wants there to be $n$ unicorns $y$ such that he catches $y$
b. $\lambda p\exists x\exists n[p(w) \land p(\lambda w[\text{lady}(x)(w) \land \text{want}(x, \lambda w[\exists n\exists y[\text{unicorn}(y)(w)) \land \text{catch}(\text{bill}, y)(w)])](w') ]$

In this case we do get the appropriate readings, since now it should be part of what Bill wants that the objects he catches are unicorns.

There is another problem for the naive approach which was pointed out by Reinhart (1995):

(38) Which linguist read every book by which philosopher?

Interpreting which philosopher in situ certainly has the advantage of obviating
the violation of island conditions that would be caused by extracting it out of
the relative clause at LF. However, a naive in situ approach will yield the
interpretation in (39), which is blatantly wrong:

(39) a. For which $x$, $y$: $x$ is a linguist who read every $z$ such that $y$ is a
philosopher and $z$ is a book by $y$.
b. $\lambda p\exists x\exists y[p(w) \land p(\lambda w[\text{languist}(x)(w) \land \forall z[\text{philosopher}(y)(w) \land \text{book}(z)(w) \land \text{by}(z, y)(w)]] \rightarrow \text{read}(x, z)(w')]]$

The problem is here that the condition philosopher$(y)(w')$ ends up in the
antecedent of the conditional, so that for any choice of $y$ which is not a
philosopher, the conditional as a whole will be true. Thus if Joseph is a linguist
who read every book by Howard Stern (who is not a philosopher in any possible
world), the proposition "Joseph read every book by Howard Stern" would be a
true answer to the question. The key to both problems for the naive
reconstruction approach is that the predicate translating the N' sister of which
is treated as an assertion on a par with the rest of the question nucleus. Although
there is good reason to assume that the content of the N' is part of the question
nucleus, as we saw in section 3, the problematic cases just discussed show that it
must be given a special status. In the next section we will show that both
problems can be solved if we treat the contribution of the N' to the content of
the question nucleus not as an assertion, but as a presupposition. We will give
empirical evidence on the basis of presupposition projection facts demonstrating
that the content of the N' sister of which is presupposed in the same sense that
the N' sister of the definite determiner the is.

5. A PRESUPPOSITIONAL ACCOUNT OF WHICH-PHRASES

5.1 Why are which-phrases different from how many-phrases? Before we
present our empirical arguments, let us spell out what is involved in a
presuppositional account of which.. Our basic proposal is that a which-phrase
is like a definite in that the content expressed by the restrictor (the N') is
presupposed rather than asserted. This idea has actually been suggested to us by
Irene Heim and Maribel Romero - we would like to use this opportunity to thank
both of them once more; it has also independently been argued for by Diana
Cresti (this volume). To make the idea more concrete, consider the following
example:

(40) Which man did Meg see?

Recall that in the naive approach the denotation of this question is a set of
propositions 'of the form' "Meg saw $x$ and $x$ is a man", for instance:

(41) $\{\text{Meg saw Sam and Sam is a man, Meg saw Ian and Ian is a man,}
\text{Meg saw Carl and Carl is a man}\}$
In the presuppositional account the fact that \( x \) is a man is not asserted but presupposed. Since the semantic contribution of the definite determiner the is to introduce just such a presupposition, we can describe the question denotation on the presuppositional account of which as a set of propositions of the form "Meg saw the man \( x \)"

- "Meg saw the man Sam"
- "Meg saw the man Ian"
- "Meg saw the man Carl"

We are assuming a standard Fregean treatment of the here, where the man is defined iff there is exactly one man, and if defined, denotes that man. Since proper names like Sam have unique referents anyway, the man Sam will denote Sam if Sam is a man, and will be undefined otherwise. (For simplicity we assume that man Sam forms an N' with an intersubjective interpretation \( \{x \text{ man}(x) \& x=\text{Sam}\} \); for further details, see below.)

In this paper we will model presuppositions by means of partiality (although we recognize that for a fuller treatment in particular of presupposition projection it may be necessary to move to a dynamic semantics as in Heim (1992a) and Beaver (1992, 1994)). A sentence containing a presupposition bearing expression will thus denote a (possibly) partial proposition which has no truth value in certain worlds. The denotation of a which-question will also consist of (potentially) partial propositions. The proposition "Meg saw the man Sam" contained in the denotation of (40) for instance is the partial proposition \( p \) such that:

- \( p \) is true in \( w \) iff Sam is a man in \( w \) and Meg saw Sam in \( w \)
- \( p \) is false in \( w \) iff Sam is a man in \( w \) and Meg did not see Sam in \( w \)
- \( p \) is undefined otherwise

Returning now to the example that was problematic for the naive approach, the denotation of (42) will contain propositions of the form "Bill wants to catch the unicorn \( x \)"; such as:

- Bill wants to catch the unicorn Xavier
- Bill wants to catch the unicorn Isabella

(42) Which unicorn does Bill want to catch?

The question then is of course what sort of thing the proposition "Bill wants to catch the unicorn Xavier" is. It will be some (possibly) partial proposition, i.e. a proposition that may be undefined in certain worlds. But since in "Bill wants to catch the unicorn Xavier" the presupposition-inducing definite description is in the scope of an propositional attitude verb (want), we first have to decide how partiality gets transmitted from the complement of this verb to the main clause. In other words, we have to address the problem of presupposition projection.

5.2 Presupposition projection. Karttunen (1974) and Heim (1992a) have observed that verbs like want act as filters for presupposition projection. The presuppositions of the complement of want get projected as presuppositions about the beliefs of the subject. That is, if \( p \) presupposes \( q \), then "\( x \) wants that \( p \)" presupposes "\( x \) believes that \( q \)." This can be demonstrated with examples like the following (cf. Heim (1992a)):

(43) Patrick believes that it rains and he wants it to stop raining.
(44) Patrick is under the misconception that he owns a cello, and he wants to sell his cello.
(45) John believes he saw a unicorn and an elephant. He wants to catch the unicorn.

In each example the second conjunct carries a presupposition which is satisfied by the context created by the first conjunct. Take (43). The aspectual verb stop presupposes the truth of its complement, i.e. if it stops raining at \( t \), it must have been raining up until \( t \). Karttunen and Heim's observation about the filter behavior of want therefore implies that "Patrick wants it to stop raining" presupposes "Patrick believes that it is raining". This is confirmed by the fact that in (43) the conjunction as a whole does not presuppose anything. Similarly in (44) and (45). "Patrick wants to sell his cello" presupposes that Patrick believes he owns a (unique) cello, and "Patrick wants to catch the unicorn" presupposes that Patrick believes he saw a (unique) unicorn.

Since want projects the presuppositions of its complement as presuppositions about the beliefs of its subject, the proposition "Bill wants to catch the unicorn Xavier" will carry the presupposition that Bill believes that Xavier is a unicorn. Thus, the proposition "Bill wants to catch the unicorn Xavier" can now be identified as the proposition \( p \) such that:

- \( p \) is true in \( w \) iff in \( w \) Bill believes that Xavier is a unicorn and in \( w \) Bill wants to catch Xavier;
- \( p \) is false in \( w \) iff in \( w \) Bill believes that Xavier is a unicorn and in \( w \) Bill does not want to catch Xavier;
- \( p \) is undefined otherwise.
The observations about the presupposition projection behavior of "want" not only allow us to identify the partial propositions that are in the set denoted by *which*-questions. More importantly, they make it possible to devise an empirical test for the presuppositional treatment of *which*. Consider again the question "which unicorn does Bill want to catch?" The presuppositional account of *which* predicts that this question will presuppose not that there are unicorns, but merely that Bill believes so. That this is indeed the case can be shown by considering the following two-sentence discourse:

(46) Bill thinks he saw two unicorns. a green one and a blue one.

Which unicorn does Bill want to catch?

Since as a whole this discourse does not presuppose anything about the existence of unicorns, the presuppositions of the second sentence (the question) must be satisfied in the context created by the first. That is, "which unicorn does Bill want to catch?" presupposes no more (and no less) than that Bill believes there are unicorns.

It is important to note here that examples like (46) show not only that a presuppositional account of *which* is possible, but that it is necessary. No other phenomenon than presupposition has exactly the right property, namely that a *which* phrase originating in the scope of a verb like want has certain effects on the beliefs of the subject. Moreover, this example shows that the N of the *which* phrase semantically must be interpreted in the scope of want because otherwise we won’t predict the right presuppositional effect. In particular, a de re reading can’t account for the felicity of a discourse like (46), since it does presuppose the existence of unicorns.

Another point that needs to be addressed is the fact that when uttered out of context the question "which unicorn does Bill want to catch?" does seem to presuppose the existence of actual unicorns. *which*-questions are not unique in this respect. The same phenomenon can be observed with ordinary definites. In isolation (47) seems to presuppose that there is a (unique) unicorn in the actual world, but in a context like (48) it becomes clear that the only thing it presupposes is that Bill believes there is a (unique) unicorn:

(47) Bill wants to catch the unicorn.

(48) Bill thinks he saw an elephant and a unicorn. He wants to catch the unicorn.

To be more precise, when a hearer hears (42) or (47) in isolation, she will tend to accommodate a stronger proposition than is strictly necessary to satisfy the presupposition. She will accommodate not just that Bill believes that there is a unicorn, but also that (the speaker believes that) there actually is one. Following suggestions by Karttunen and Heim we believe that this effect is due to a general property of accommodation, namely the fact that a proposition that is to be accommodated needs to be uncontroversial and unsurprising. This is inherent to the Gricean nature of accommodation. If the speaker wants to communicate a controversial or otherwise surprising proposition she should do so by means of an explicit utterance rather than rely on accommodation. We may assume that certain default assumptions guide the hearer in deciding what to accommodate. One plausible default assumption of this sort is that the hearer will assume that Bill’s beliefs are not in conflict with what is actually the case, unless the speaker explicitly indicates that they are. Therefore if the speaker needs to accommodate in order to satisfy the presupposition that Bill believes there is a unicorn, she will prefer accommodating the existence of a unicorn in both the real world and Bill’s belief-worlds to accommodating it just for Bill’s belief-worlds, unless there is any indication to the contrary. Although this explanation is admittedly vague, it seems plausible enough to account for the tendency (and it certainly is no more than that) to read (42) and (47) when presented out of context as presupposing the existence of unicorns.

The presuppositional account extends to other propositional attitude verbs than just want. As observed by Karttunen and Heim, factive verbs like know act as holes for presupposition projection. For instance, (49) presupposes that there is a unique unicorn:

(49) Bill knows he caught the unicorn.

On the other hand, verbs like believe and think are filters which project the presuppositions of their complement as presuppositions on the beliefs of their subjects. Just like (47), (50) presupposes that Bill believes there is a unique unicorn (although out of context we may again be inclined to accommodate the stronger assumption that there actually is one):

(50) Bill thought he had caught the unicorn.

The facts we find in *which*-questions are completely parallel. (51) presupposes that there are unicorns and (52) that Bill believes there are unicorns:

(51) Which unicorn does Bill know he caught?
(52) Which unicorn does Bill think he caught?
Again, the presupposition projection facts show unequivocally that semantically the predicate unicorn needs to be in the scope of the attitude verb.

The presuppositional account of which-phrases also solves the problem for the naive approach noted by Reinhart (1995) in connection with (38), repeated here as (53):

(53) Which linguist read every book by which philosopher?

Since the presupposition that the author must be a philosopher appears in the restriction to the universal quantifier, it will project as a presupposition of the main clause. Therefore, (53) will denote a set of partial propositions p of the form "x read every book by y" such that

- p is true in w iff x is a linguist in w and y is a philosopher in w and in w x read every book by y;
- p is false in w iff x is a linguist in w and y is a philosopher in w and in w x did not read every book by y;
- p is undefined otherwise.

Picking a non-philosopher will no longer result in a proposition that counts as a true answer to the question, so Reinhart's problem is avoided.

We have seen not only that the presuppositional account of which can save the reconstruction approach from certain problems, but also that the facts of presupposition projection demonstrate that reconstruction of which-phrases is necessary. Our analysis allows us to account for the seemingly contradictory behaviour of which-phrases with respect to intensional operators: it seemed that while which-phrases could be interpreted de dicto relative to the intensional context created by the question, they could not be interpreted de dicto relative to any other intensional operators. We have argued that the latter observation is not really true, and that their presuppositional nature obscures the fact that which-phrases can indeed be interpreted de dicto relative to intensional verbs.

In the remainder of this paper we will explore the implications of the reconstruction approach for our view of the syntax semantics interface.

6. INTERPRETATION IN SITU: HAMBLIN + PRESUPPOSITION

We have arrived at the conclusion that at least part of a which-phrase has to be interpreted in the nucleus of the question. This has the following two consequences for how compositional interpretation should proceed:

(i) an overtly moved which-phrase is (partly or wholly) reconstructed

(ii) an unmoved which-phrase is (partly or wholly) interpreted in situ

There are still various alternatives for what the syntax semantics interface could look like, though, some of which we will now briefly consider. The first two alternatives rely on a Karttunen-style mechanics for deriving question interpretations - that is: the variation in the answers in the question set comes about by existential binding of an interrogative variable that is associated with the wh-phrase.

- alternative 1: a part of the which phrase does the existential binding - this implies LF movement at least of which.
- alternative 2: default existential binding of the interrogative variable - no LF movement necessary.

The third alternative goes back to Hamblin (1973):

- alternative 3: wh-phrases introduce alternatives directly, no existential binding is involved in the compositional derivation of question meanings - interpretation completely in situ, no LF movement.

Below, we will sketch what alternatives 1 and 2 could look like, but then we will focus on the third and most radical perspective, in which wh-phrases are not quantificational at all.4

6.1 Alternatives 1 and 2. Alternative 1 and 2 are jointly if sloppily represented by the LF in (54):

(54) Which student called

\[ \lambda w. (\lambda p \exists x (p(w) & p=\lambda w [\text{the student}(w) x_1 \text{called in } w])] \]

\[ \text{wh}_j \]

\[ \lambda \varphi \lambda w. (\lambda x \lambda p (p(w) & p=\lambda w [\text{the student}(w) x_1 \text{called in } w]) \]

\[ \{ \varphi (\lambda x (w')(p) \}

\]

\[ \lambda (\lambda w. (\lambda p (p(w') & p=\lambda w [\text{the student}(w) x_1 \text{called in } w] \}

\]

\[ \text{the student } x_1 \text{ called} \]

---

4Ramchand (1997) also explores a similar approach, arguing for it and against quantificational analyses on the basis of Bengali data. Unfortunately, her paper has come to our attention too late for us to be able to discuss it here.
Following Heim (1992b) and von Stechow (1993), there is an interrogative operator associated with the C position which yields question-type meanings. The operator corresponds to Proto-question formation in Karttunen's original analysis.

The first alternative is to assume that the determiner which still represents an existential quantifier in the Spec of CP, although its N' must be part of the question nucleus. At LF the which phrase therefore has to be split up. For in situ wh-phrases this would involve LF raising of which to Spec of CP, while for overtly moved wh-phrases this would mean LF reconstruction of only the N′ into the nucleus.

The second alternative differs from the first rather minimally in that the existential binding is done by a default operator rather than by which, which on this alternative would be semantically empty (or at most be translated as a free variable). No splitting up of the which-phrase would have to take place, and reconstruction would involve the which-phrase as a whole. LF wh-movement becomes unnecessary.

Alternatives 1 and 2 boil down to the idea that which student is decomposed into a non-interrogative part "the student x" and an interrogative part, which might be just the interrogative variable (default-bound existentially - alternative 2) or the interrogative variable plus its existential binder (alternative 1). No matter how, we end up with just a bare existential quantifier upstairs of the interrogative operator, because the rest of the which-phrase is analysed as non-interrogative and, in case it has moved overtly, reconstructed into the nucleus. The details of these analyses could be worked out in various ways, which we are not going to do here. See e.g. Cresti (1995), von Stechow (1996) and B&R for suggestions.

The first alternative involves LF wh-movement of which, and thus runs into the problems mentioned in section 4.1. Apart from that, we have no evidence against either of these two alternatives. However, we think that at this point it is instructive to consider the third alternative, Hamblin's (1973), which does not involve any existential quantification at all. We will pursue this alternative to implement our proposal rather than the other two, for the following reason:

It seems to us that on Karttunen's analysis, where wh-phrases are associated with quantificational force, the main argument for doing so is based on his treatment of which-phrases. On his analysis, those do indeed look like standard restrictive quantification. Given our analysis, this is no longer true. Which-questions would involve at most a bare existential quantifier, while the predicate translating the N′ is part of the question nucleus rather than forming a restriction on the existential quantifier. There is no wh-phrase that can be argued to do anything else with any real force. So, should wh-phrases be associated with bare existential quantifiers then?

Look at the mechanics of Karttunen's proposal. The result we want to end up with is a set of propositions. The existential quantifiers does nothing but ensure that there is variation in the proper place inside these propositions. In a sense, it is just an artifact of how Karttunen derives question-type meanings. Hamblin has a different way of achieving the same result. Given the (now) absence of any argument in favour of quantificational nature of wh-phrases, we believe it is worthwhile to consider this third alternative. Moreover, Hamblin's original proposal ran into the problems mentioned in section 4.3. Given our presuppositional analysis, this is no longer the case, so that it makes sense now to resurrect his analysis.

6.2 Alternative 3: Hamblin. The basic idea in Hamblin's proposal is that wh-phrases themselves introduce alternatives into semantic computation - that is, wh-phrases denote sets. It then becomes necessary to combine semantic values in a more flexible way, in particular, to do functional application pointwise between members of sets (compare Hamblin 1973, Rooth 1985; we actually depart somewhat from Hamblin technically: he assumed all meanings to be sets homogeneously. We don't think this has any consequences.)

(55) Definition of flexible functional application:

\[
\begin{align*}
f((a)) &= \\
(i) & f(a) \\
(ii) & \{ m: \exists x \in a: m=f(x) \} \\
(iii) & \{ m: \exists g \in f: m=g(a) \} \\
(iv) & \{ m: \exists x \in a: \exists g \in f: m=g(x) \}
\end{align*}
\]

whichever is defined.

Consider now the question in (56), and assume that it has the structure indicated in (57).

(56) Who saw what?

(57) \([\_who [\_psaw what]]\)

As we said above, the idea is that wh-phrases denote sets. The denotations of who and what are given in (58) and (59) respectively.\(^3\)

(58) \([\_who] = \{ x: \text{person}(x)(w) & C(x) \} \]

(59) \([\_what] = \{ y: \text{non-person}(y)(w) & C(y) \} \]

\(^3\text{For expository purposes, we treat the restriction of who to persons as "being a person in the real world". This is not intended to be a real part of our analysis. Let's ignore how the restrictions on who and what come in.}\)
Here C is a free predicate variable that denotes the set of "relevant" objects, whose value is contextually determined. Let's assume for concreteness that the set of contextually relevant persons and non-persons are actually as indicated in (60) and (61).

(60) \{ x: \text{person}(x)(w) & C(x) \} := \{ \text{Miriam, Mona, Helmut} \}

(61) \{ y: \text{non-person}(y)(w) & C(y) \} := \{ \text{the Eiffel tower, the Golden Gate bridge} \}

To interpret the VP in (57), we then need flexible functional application to combine the relation see (type $<$e,$<$e,$<$s,$<$t$>$,$>$>) with the denotation of what (a set of individuals rather than an individual).

(62) $[[ \text{vp saw what} ]] = [[\text{saw}]] ([[\text{what}]])) = (\text{via (55 (ii)))}$

\[
\lambda \lambda \lambda w[x \text{ saw the Eiffel tower in } w], \\
\lambda \lambda \lambda w[x \text{ saw the Golden Gate bridge in } w]
\]

The VP then denotes a set of properties, the property of having seen the Eiffel tower and the property of having seen the Golden Gate bridge. This set of properties can be combined with the denotation of who as indicated in (63):

(63) $[[ \text{who saw what} ]] = [[\text{saw what}]] ([[\text{who}]])) = (\text{via (55 (iv)))}$

\[
\lambda w[\text{Miriam saw the Eiffel tower in } w], \\
\lambda w[\text{Mona saw the Eiffel tower in } w], \\
\lambda w[\text{Helmut saw the Eiffel tower in } w], \\
\lambda w[\text{Miriam saw the Golden Gate bridge in } w], \\
\lambda w[\text{Mona saw the Golden Gate bridge in } w], \\
\lambda w[\text{Helmut saw the Golden Gate bridge in } w]
\]

Notice that the resulting set of propositions is the same as the set denoted by (64), assuming the same contextual restrictions on persons and non-persons:

(64) $\lambda p \exists x \exists y[\text{person}(x)(w) & \text{non-person}(y)(w) & p = \lambda w[\text{x saw y in } w]]$

(64) is the translation that Karttunen would assign to the question (56), apart from the trivial difference that he requires the propositions in the question set to be true. Remember that this requirement can always be added, as in (65).

(65) Kartt(Q)(w) = (p\{Q(w)(p) & p(w)\})

Importantly, then, we are able to arrive at the same question denotation as Karttunen without associating wh-phrases with quantification in any sense.

Rather, they themselves introduce the alternatives that the question will ultimately denote. This treatment assimilates wh-phrases and their "scope" to focus rather than to quantity.

6.3 Which-phrases revisited. Now, let's look at our actual final suggestion for the treatment of which-phrases in this framework. Remember that our proposal is that the denotation of (66) can be paraphrased as in (67).

(66) Which woman snores?

(67) For which x: the woman x snores.

Hence, the denotation of the question is a set of partial propositions like (68):

(68) $[[ \lambda w[\text{the woman}_w \text{ Mona snores in } w] ]](w) =$

- 1 if woman(Mona)(w) & snores(Mona)(w)
- 0 if woman(Mona)(w) & $\neg$ snores(Mona)(w)
- undefined otherwise

In order to get this result, we assume the following denotation for the (compare Heim 1991); this is essentially a Fregean semantics for the definite determiner:

(69) $[[\text{the}]](N'c<e,<s,\ldots>)(P'c<e,<s,\ldots>)(w) =$

- 1 if for the unique a such that $N'(a)(w): P(a)(w)$
- 0 if for the unique a such that $N'(a)(w): \neg P(a)(w)$
- undefined otherwise

Moreover, we assume that woman Mona as in the woman Mona denotes the following property:

(70) $\lambda x \lambda w[\text{woman}(x)(w) & x=\text{Mona}]$

We can achieve this by taking Mona to (optionally) denote the property of being identical to Mona, and interpreting woman Mona as predicate modification.

(71) a. $[[\text{Mona}]] = \lambda x \lambda w[x=\text{Mona}]$

b. $[[\text{woman Mona}]] = \lambda x \lambda w[[\text{woman}]](x)(w) & [[\text{Mona}]](x)(w)$

Hence, the woman Mona will be defined (and refer to Mona) iff Mona is a woman.

Now, in the paraphrase (67) above, which woman occurred as "the woman x" with x bound from outside to ensure variation over individuals. Variation in Hamblin's framework comes about by some lexical item itself introducing
alternatives into semantics. Hence we have to assume that some meaning component of which woman does that, just like in the case of who and what above. Let's call this element wh. Which-phrases can then be decomposed as indicated in (72):

(72) \( \text{which } N' = \text{the } N' \text{ wh} \)

where \( \{ \text{wh} \} = \{ x : C(x) \} \)

Furthermore, lets suppose that the set of contextually given entities is as in (73).

(73) \( \{ x : C(x) \} := \{ \text{Miriam, Mona, Helmut} \} \)

The denotation of which woman is then the set of functions given in (74).

(74) \( \{ \text{which woman} \} = \)

\( \{ \text{the } \} \{ \{ \text{woman } \text{wh} \} \} = \)

\( \{ \text{the } \} \{ \{ \text{woman } \} \{ \{ \text{wh} \} \} = \)

\[ \{ \text{the } \} \{ \lambda x \lambda w [\text{woman}(x)(w) \land x = \text{Miriam}], \lambda x \lambda w [\text{woman}(x)(w) \land x = \text{Mona}], \lambda x \lambda w [\text{woman}(x)(w) \land x = \text{Helmut}] \} \} = \]

\( \{ \{ \text{the woman Miriam} \}, \{ \{ \text{the woman Mona} \}, \{ \{ \text{the woman Helmut} \} \} \} \}

This set of functions can then be applied to the property of snoring to yield (75) as the semantics of (66).

(75) \( \{ \text{which woman snores} \} = \)

\( \{ \lambda w [\text{the woman } w \text{ Miriam snores}_w], \lambda w [\text{the woman } w \text{ Mona snores}_w], \lambda w [\text{the woman } w \text{ Helmut snores}_w] \} \)

(75) corresponds to the set of partial propositions indicated by the paraphrase (67).

Notice that we have chosen here to give the NP which woman the same index as the main predicate (snores). This represents a genuine de dicto reading. Note that the partial proposition that the woman Helmut snores will still be in the set of possible answers to the question, even if Helmut is not a woman in the actual world. Suppose now that the question occurs embedded as in (66) under a predicate that only cares about true answers:

(76) John knows which woman snores.

The proposition that the woman Helmut snores can never be true in the actual world (it is undefined there, since Helmut is not a woman), hence will never count as a true answer to the question. Suppose on the other hand that the question (66) occurs embedded under agree as in (77).

(77) John and Bill agree on which woman snores.

This is basically just like our earlier examples from section 3.2. John and Bill just might be mistaken about Helmut's sex and both believe that the woman Helmut snores. In section 3.2 the European country example demonstrated the need for this genuine de dicto reading of the question. The corresponding de re reading would come about by choosing to evaluate woman with respect to the actual world rather than the same world that snore is evaluated with respect to.

Notice also that the type of an NP "the N x" is that of a quantified noun phrase. So it is not strictly speaking correct to say that we interpret all which-phrases in situ. We interpret them in the nucleus of the question, and there, we expect that they are interpreted wherever other NPs of the same semantic type can be interpreted. According to standard assumptions we would expect which-phrases to be able to QR, like any other NP.

However, our treatment is in situ in the sense that wh-movement has no semantic motivation. Wh-phrases are integrated directly into the alternative propositions in the question set, they are no longer external to the propositions, so to speak. Hence it is possible and necessary to assume that wh-movement is reconstructed and that wh-in-situ does not wh-move at LF. In other words, there is no semantic motivation for LF wh-movement, a result that is in accordance with much of the recent literature on wh-in-situ (in particular Reinhart 1995).

6.4 Answer equivalences. An important point that we would like to draw your attention to is that to a certain extent, the equivalences described in section 4.1 carry over to our new semantics of which-questions. Let us refer to the new presuppositional semantics of a which-question proposed in this section as Qp (a question intension). It turns out that despite the change we made to the basic question denotation, the following is true for a certain subset of interrogatives:

(78) \( w'' \in \text{answer}_1(w)(\lambda w'[\text{Kartt(Qp)(w')]} \) iff \( w'' \in \text{answer}_1(w)(\text{QB}&\text{R}) \)

That is, the proposition that is the complete true answer to a question is true in the same worlds in the question semantics suggested in B&R, and the new question semantics argued for in this paper.\(^6\)

\(^6\)We conjecture that the two notions of answer2 will actually be equivalent, but we have not
Now why (and when) does (78) hold? Let us concentrate on *which*-questions, since that is the only semantic change we made. We will refer to the set Kartt(QP)(w) as (R&B), and to the corresponding intension as QR&B. It is clear that the question denotations (B&R) and (R&B) will not be completely independent. In a simple *which*-question of the form *which* N' has property P?, the following relation holds between (B&R) and (R&B): whenever (B&R) contains a proposition "x is an N' and has property P", (R&B) contains a proposition "the N' x has property P". A bit more formally: Whenever (B&R) contains a proposition p, then (R&B) contains a proposition p' such that

- w ∈ p'  → w ∈ p
- w ∉ p'  → w ∉ p
- p'(w) undefined → w ∉ p

But that means that w ∈ p iff w ∈ p'. The reverse of the above is also true: whenever (R&B) contains a proposition p', then (B&R) contains a proposition p, with the relation between p and p' as described above.

Consider now the two propositions corresponding to answer1. Since answer1 is the conjunction (or intersection) of all propositions in the question set, we need to define conjunction of partial propositions in order to know what answer1(w)(QR&B) is. The revised definition is given in (79).

(79) answer1(w)(Q) is that proposition p such that

\[
\begin{align*}
p(w') &= 1 & \text{iff for all q in Q(w): } w' \in q \\
p(w') &= 0 & \text{iff for all q in Q(w): } q(w') \text{ is defined and for some q' in Q(w): } w' \notin q \\
p(w') \text{ is undefined otherwise; i.e.:} & \\
& \text{iff for some q in Q(w): } q(w') \text{ is undefined}
\end{align*}
\]

This new definition does not make a difference for answer1(w)(QB&R) compared to the definition in section 3.1, since all propositions in QB&R(w) are total. In the case of answer1(w)(QR&B), we end up with a partial proposition if QR&B(w) contains partial propositions. So the two notions of answer1 will not be the same proposition. However, the difference will once more only be with respect to worlds w' which are not an element of the proposition expressed by answer1:

A world w' will be in answer1(w)(QB&R) iff it is an element of all propositions in the question extension. As we noted above, for each of these propositions there is a corresponding proposition p' in QR&B(w) such that w' ∈ p' iff w' ∈ p. So whenever a world w is in all the propositions in QB&R, it must also be in all the proposition in QR&B(w), and vice versa. But if a world is in all propositions in QR&B(w), it is also in answer1(w)(QR&B), by definition of answer1. The same reasoning can be applied in the other direction, hence (78) must be true.

For illustration, let's work this out for a concrete case:

(80) Which woman snores?

Let's say our model contains the following entities: Mona, Judith, Elke, Helmut and Oscar, and let's assume that in the actual world w the situation is as follows:

- Mona, Judith and Elke are women;
- Helmut and Oscar are men;
- Mona, Judith and Helmut snore;
- Elke and Oscar don't snore.

The basic denotation we assign to (80) in the actual world w will be the following set of partial propositions:

(81) \{ λw'[the woman w' Mona snores w'],
         λw'[the woman w' Judith snores w'],
         λw'[the woman w' Elke snores w'],
         λw'[the woman w' Helmut snores w'],
         λw'[the woman w' Oscar snores w'] \}

Its intension, QP, will be the constant function which maps every world onto (81). To get (R&B) we need to apply Kartt to QP:

(82) (R&B) =
    Kartt(QP)(w) =
    \{ p: QP(w)(p) & p(w) =
        \{ \text{p: p is element of (81) & p(w) =}
        \{ \lambda w'[the woman w' Mona snores w'],
        \lambda w'[the woman w' Judith snores w'] \}\} \}

The other propositions in (81) are filtered out either because they're undefined in w (Helmut and Oscar), or because they're false in w (Elke). Now we can compute answer1:

(83) answer1(w)(QR&B) is that proposition p such that
- p is true in w' iff Mona and Judith are women in w' and Mcna and Judith snore in w';
- p is false in w' iff Mona and Judith are women in w' and either
  Mona or Judith doesn't snore in w';
- p is undefined in w' iff either Mona or Judith is not a woman in w'.

We can formulate this independently of the actual situation we chose above. In
an arbitrary world w, answer1(w)(QR&B) will be the proposition p such that:

(84) - p is true in w' iff
  for all x such that x is a woman in w and x snores in w:
    x is a woman in w' and x snores in w';
- p is false in w' iff
  for all x such that x is a woman in w and x snores in w:
    x is a woman in w' and x snores in w;
  for some x such that x is a woman in w and x snores in w:
    x does not snore in w';
- p is undefined in w' iff
  for some x such that x is a woman in w and x snores in w:
    x is not a woman in w'.

This can also be stated as follows: Let w be an arbitrary world and let
WoSno(w) be the set \{x: x is a woman in w and x snores in w\}. Then
answer1(w)(QR&B) will be the proposition p such that:

(85) - p is true in w' iff for all x in WoSno(w): x is a woman in w' and x
  snores in w';
- p is false in w' iff for all x in WoSno(w): x is a woman in w' and
  for some x in WoSno(w): x does not snore in w';
- p is undefined in w' iff for some x in WoSno(w): x is not a woman
  in w'.

Now how does this compare to our original non-partial proposition
answer1(w)(QB&R)? That is the conjunction of all true (total) propositions of
the form "x is a woman who snores". That is:

(86) answer1(w)(QB&R) is the proposition p such that:

- p is true in w' iff for all x in WoSno(w): x is a woman in w' and x
  snores in w';
- p is false in w' iff for some x in WoSno(w): either x is not a
  woman in w' or x does not snore in w'.

So the two propositions are indeed true in the same possible worlds.
Answer1(w)(QR&B) is undefined in worlds where someone who in the actual
world is a snoring woman is not a woman - a situation in which
answer1(w)(QB&R) would be false. That is, answer1(w)(QR&B) has the
presupposition that all the actual women snores are women, or, put differently:
the property of being a woman is presupposed information in all true answer
instances. But our new and our old answer1 are true in the same possible worlds.

It should be stressed, however, that this relation holds for simple questions of the
form which N' has the property P?, and for these questions is the desired result.
The two approaches are not generally equivalent, of course, or we could have
saved ourselves the trouble of writing this paper. In particular, we won't get
equivalence in the problematic Reinhart examples since the relation between
propositions p and p' contained in the respective question denotations will not be
the same (it won't be the case that p and p' differ only in when they are not true:
p can be true and p' undefined; this is because the denotation of the N' is in the
scope of another operator.).

7. Conclusion

On Hamblin's and our treatment, wh-phrases are not associated with
quantification either directly or via default existential quantification. The
relevant analogy here is focus. Our presuppositional treatment of which-phrases
has re-opened this possibility, since we got rid of the naive approach's problem
with interpretation in situ. One important consequence is that wh-phrases are not
related in any obvious way to interrogative scope. This raises the question of
whether we can account for the pertinent "scope" facts with this treatment in a
straightforward way, and also whether the analogy with focus as opposed to
quantification leads to any new insights into the matter. In fact, just about
everything that has received an explanation in terms of wh-scope will have to be
rethought on our approach. One phenomenon that ought to be mentioned in
particular are the so-called Baker ambiguities, as illustrated by (87):

(87) Who knows where we bought which book?

In (87), the wh-phrase which book can "take scope" either in the matrix question
or in the embedded question. The two wh-phrases that have undergone
wh-movement, however, "take scope" in whichever clause they occur in at S-
structure. These facts ought to be related to the syntax of wh-movement, of
course.

In order to be able to account for this phenomenon, we will have to incorporate
two things into our analysis: (i) a mechanism that allows flexibility as to when
the alternatives introduced by a wh-phrase become relevant, and (ii) a systematic way of relating the actual "scope" possibilities to syntax. As for (i), we think that whatever will account for the parallel focus effects such as (88) (examples from Rooth 1997) can be made to work for wh-phrases as well.

(88) a. We only introduced Marilyn to John.
   b. We also only introduced Marilyn to Bobby.

In (88b), also is understood to be associated with Bobby, and only is understood to be associated with introduced. The focus on Bobby can skip one focus sensitive operator, and only be evaluated when encountering also. This is analogous to the matrix interpretation of which book in (87) above. See Rooth (1997) and Wold (1995) for suggestions on how to deal with these data. We will not decide upon a particular course here, since the decision will influence choices with respect to (ii). Notice, though, that the existence of data like (88) confirms the analogy to focus we suggest for wh-phrases.

Concerning (ii), we have to admit that our proposal opens up a whole new range of possibilities of what the syntax semantics interface in interrogatives could look like, and that we are not at this point able to make a well-motivated suggestion. But we intend to come back to this in further research.

REFERENCES


Frampton, John (1990). The Fine Structure of Wh-Movement and the Proper Formulation of the ECP. Manuscript, Northeastern University.


Stechow, Arnim von (1993). “Die Aufgaben der Syntax”. In Joachim Jacobs,
Arnim von Stechow, Wolfgang Sternewald and Theo Vennemann (eds.):
Syntax. Ein internationales Handbuch der zeugenössischen Forschung/An
International Handbook of Contemporary Research. 1. Halbband/Volume

Semantics 4:57-110.

Wold, Dag (1995). How to Interpret Multiple Foci Without Moving a Focused
Constituent. Handout at the Workshop on Focus, UMass, Amherst,
December 1995.