

# Presupposition Projection and the Interpretation of *which*-Questions

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## 1. Introduction

In this paper we challenge a number of assumptions that are commonly made in the analysis of *which*-questions, in particular the idea that *which*-phrases are semantically like indefinites. We argue instead that *which*-phrases are definites and therefore presuppositional. Key evidence for this proposal comes from presupposition projection facts: the presuppositions that we claim are associated with *which*-phrases turn out to project up from the base position of the *which*-phrase in exactly the same way that the presuppositions associated with a non-wh definite in the same position would. Because these presuppositions are projected from the *which*-phrase's base position, the same facts also provide support for a second claim defended in this paper: *which*-phrases must (or at least can) be interpreted in their base position. Thus, for purposes of interpretation *which*-phrases that are in the Specifier of CP position at the surface have to be reconstructed (by either syntactic or semantic means), and in situ *which*-phrases can simply stay where they are. In fact, we argue that there is no semantic reason why *which*-phrases would have to move either covertly or overtly. We also show that our analysis solves certain problems for in situ analyses of *which*-phrases without resorting to choice functions (cf. Reinhart 1997).

As our starting point we take Karttunen's (1977) theory of questions. According to Karttunen, a question denotes a set of propositions. The denotation of (1) for instance is the set of all true propositions "x called", where x is a student. Thus, if Meg and Ian are the students who called, then (1) will denote the set given in (2).

- (1) Which students called?  
(2) {Meg called, Ian called}

More generally, the translation of (1) is (3). (Note that, in contrast to Karttunen, we are using a logical translation language with variables  $w, w', w'', \dots$ , ranging over possible worlds.)

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

A crucial aspect of Karttunen's theory is the semantic role of the N' sister of *which* (e.g., *student* in (1)). The property denoted by the N' is not part of the content of the propositions in the set denoted by the question, but only plays a role in determining which propositions go into that set. In (2), for instance, the information that Ian and Meg are students is not part of the propositions in the question set, or more precisely, the propositions in the question set do not entail (or presuppose) that Ian and Meg are students. In the translation (3) the subformula 'student(w)(x)' is outside what von Stechow (1996) has called the question nucleus', viz., the subformula immediately following 'p=' in the translation of the question. As we will see in the next section, this is an important weakness of Karttunen's theory.

Karttunen (1977) derives the meaning of a question by assigning the wh-phrase the same interpretation as an existentially quantified NP and quantifying it into what he calls a proto-question. Transposing Karttunen's Montague Grammar analysis into a GB-style syntactic framework, the analysis of (1) would be as indicated in (4).

(4) [CP [NP *which student*]<sub>i</sub> [C' [C Q] [IP *t<sub>i</sub> called*]]]

Translation:

IP:  $\lambda w'[\text{called}(w')(x_i)]$

C:  $\lambda q\lambda w\lambda p[p(w) \ \& \ p=q]$

C':  $\lambda w\lambda p[p(w) \ \& \ p=\lambda w'[\text{called}(w')(x_i)]]$

NP:  $\lambda P\lambda w\exists x[\text{student}(w)(x) \ \& \ P(w)(x)]$

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

The trace of the wh-phrase is translated as an individual variable, and the IP gets translated as the proposition ' $\lambda w'[\text{called}(w')(x)]$ '. Identifying C' with Karttunen's proto-question, we can regard the interrogative complementizer C as an operator which turns the proposition denoted by the IP into the intension of the set of propositions ' $\lambda p[p(w) \ \& \ p = \lambda w'[\text{called}(w')(x)]]$ '. The wh-phrase *which student* receives the same translation as the corresponding indefinite NP *a student*. This is then combined with the C' meaning to derive the question interpretation by means of the special interpretation rule given in (5), the analogue of Karttunen's Wh-Quantification Rule (his (33)). Note that (5) is similar to, but not identical with, the standard quantifying-in rule.

(5) Subtree [CP NP[+wh]<sub>i</sub>  $\alpha$  ]

translates as  $\lambda w\lambda p[\text{NP}'(\lambda w'\lambda x_i[\alpha'(w')(p)]) (w)]$

While we have used question intensions here to get the semantic composition right, in our examples we will generally use extensions.

Other recent analyses of questions in GB-based theories have implemented Karttunen's theory in slightly different ways (compare e.g. Dayal (1996), Heim (1995), von Stechow (1996)). What all these approaches have in common is the central role played by the interrogative complementizer in deriving the proto-question (or something close to it), the analysis of *which*-phrases as existentially quantified NPs, and the use of a process akin to quantifying-in for combining the two. An important advantage of this type of analysis is that it allows for the interpretation of multiple wh-questions without any additional semantic rules, because the quantifying-in of the wh-phrase is iterable. Consider an example like (6a). Assuming that the in-situ wh-phrase *which student* is moved at LF and adjoined to CP, applying rule (5) at both CP-nodes in the LF (6b) will yield the translation (6c). To see what this means in practice, let's again consider a concrete situation. Suppose that Meg and Ian are students and that Jones and Smith are professors. Now if Meg met Jones and Ian met Smith, and no other meetings between a student and a professor took place, then the question (6a) will denote the set of propositions given in (7).

- (6) a. Which student met which professor?  
 b. [CP which professor<sub>j</sub> [CP which student<sub>i</sub> [C' C [IP t<sub>j</sub> met t<sub>i</sub> ]]]]  
 c.  $\lambda p \exists x \exists y [\text{student}(w)(x) \ \& \ \text{professor}(w)(y) \ \& \ p(w) \ \& \ p = \lambda w' [\text{met}(w')(x, y)]]$
- (7) {Meg met Jones, Ian met Smith}

Note that neither the information that Meg and Ian are students nor that Jones and Smith are professors is part of the propositions in (7). Karttunen's semantics for questions can therefore be thought to provide some sort of semantic motivation for the existence of LF wh-movement. In order for the proper question meaning to be derived, the N' must function as a restriction on the propositions of the question meaning, but must not itself be part of those propositions, and in order to achieve that all *which*-phrases need to have scope over the proto-question at LF. Therefore, *which*-phrases that are in situ at S-structure have to move to Spec of CP at LF.

In this paper we argue against some key ingredients of Karttunen's analysis of *which*-questions, although we maintain the basics of his approach in that we too analyze questions as sets of propositions. We start out by discussing (in section 2) a criticism raised by Groenendijk and Stokhof (1982), who argue that Karttunen's analysis does not capture what they call the *de dicto* reading of *which*-questions. We agree with them and show how the *de dicto* reading can be handled in a Karttunen style semantics by interpreting *which*-phrases in their base position, reconstructing *which*-phrases that were moved overtly and leaving unmoved *which*-phrases in situ. The resulting analysis - which actually is very close to Hamblin's (1973) proposal - runs into a number of important problems, which is why we refer to it as the naive approach (section 3). We then propose to solve these problems by treating *which*-phrases as definites. As an important clue to this we regard the parallelism in presupposition projection behavior between ordinary definites on the one hand, and *which*-phrases on the other hand (section 4). In section 5, we further spell out this proposal by analyzing *which*-phrases as definites containing a free variable that gets bound by the question operator in Comp (e.g. *which man* = the man *x*). We mention certain philosophical problems for this approach and in section 6 consider an alternative analysis in which the free variable in a *which*-phrase ranges over properties rather than individuals (e.g. *which man* = the man who has property P).

## 2. Groenendijk and Stokhof's criticism

### 2.1. *De dicto vs. de re interpretations of which-questions*

Groenendijk and Stokhof (1982, 1984) criticize Karttunen's semantics of questions because of the kinds of inferences it licenses or fails to license. Concerning *which*-phrases, there is a sense in which they consider his semantics too strong, in that it licenses too many inferences. Consider (8):

- (8)            John knows who called.  
 =>          John knows which students called.

The question 'Who called?' in the antecedent has the interpretation given in (8').

- (8')     $\lambda p \exists x [\text{person}(w)(x) \ \& \ p(w) \ \& \ p = \lambda w' [\text{called}(w')(x)]]$

Suppose knowing a question complement implies knowing each element of the question set. Then Karttunen predicts this inference to be valid: If you know all proposition in (8'), you must know all propositions in (3), since the latter is a subset of the former. Groenendijk and Stokhof claim that there is a reading of the consequent (the *de dicto* reading) in which (8) is not a valid inference. This is a reading in which for John to know which students called, he must be aware of the student status of the callers, that is, the information that people are students ought to be a part of the propositions that John knows - hence in the simple story we are telling now about what knowledge of a question complement means, a part of the question nucleus.

Groenendijk and Stokhof acknowledge that there is also a reading of the consequent (the *de re* reading) in which (8) is a valid inference, and in which John can know which students called without being aware of people's student status. It is the failure to account for the *de dicto* reading they regard as a problem for Karttunen.

Groenendijk and Stokhof take the *de dicto* reading to be the basic meaning of the question, and we will follow them in this respect. They derive the *de re* reading by means of a special mechanism involving quantifying the N' into the question. We will not discuss the *de re* reading any further in this paper, nor the way in which it can be derived (see Beck and Rullmann (to appear) for a suggestion of an alternative mechanism).

## 2.2. Exhaustivity

Groenendijk and Stokhof criticize the inferences Karttunen's semantics licenses in another respect too, this time arguing that his theory is too weak in that it fails to predict certain valid inferences to be licensed. Consider (9):

- (9)            John knows who called.  
                  Sue called.  
      =>        John knows that Sue called.

Karttunen predicts this inference to be valid, under the assumptions introduced above. (9) exemplifies weak exhaustivity: completeness of knowledge in terms of knowing all propositions that are true answers. However, there is a stronger form of exhaustivity (strong exhaustivity) that Karttunen fails to account for. Groenendijk and Stokhof argue that (10) also is a valid inference.

- (10)           John knows who called.  
                  Sue did not call.  
      =>        John knows that Sue did not call.

Karttunen's theory, as it stands, does not predict this inference to be valid. Knowledge of all true answers to a question does not imply any knowledge about false answers.

We agree with Groenendijk and Stokhof that *which*-questions have a *de dicto* interpretation, and we agree that questions can have a strongly exhaustive interpretation. However, we do not think that strong exhaustivity is a property of the semantics of the question itself, as questions are not uniformly interpreted strongly exhaustively. We discuss this issue at length in Beck & Rullmann (to appear), and propose to resolve the apparent non-uniformity in interpretation by employing Heim's (1994) notions of what it means to be an answer to a question.

The discussion there also motivates why we do not follow Heim's ingenious way of deriving de dicto readings via exhaustivity. We refer the reader to Beck & Rullmann for a proper discussion, and conclude here that we still need a way to incorporate de dicto interpretations of *which*-phrases into the basic Karttunen question denotation. This is the topic that we pursue in this paper.

### 3. Putting *which*-phrases inside the question nucleus

#### 3.1 A naive approach

Following Groenendijk and Stokhof, we concluded that the information represented by the N' sister of *which* needs to be part of the propositions in the question set. Unlike Groenendijk and Stokhof, we will try to implement this idea directly in a Karttunen-style semantics for questions, in which the basic meaning of a question is a set of propositions. The most straightforward way of doing this is by putting the predicate translating the N' in the question nucleus, thus translating (11a) as (11b). The information that *x* is a student is then treated on a par with the information that *x* called.

- (11) a. Which student called?  
 b.  $\lambda p \exists x [p(w) \ \& \ p = \lambda w' [\text{student}(w')(x) \ \& \ \text{called}(w')(x)]]$   
 c. {Meg is a student who called, Ian is a student who called}

In a situation in which Meg and Ian are the students who called, the question will denote the set of propositions (11c). Knowing the propositions in (11c) implies knowing that Meg and Ian are students, so this captures the de dicto reading. For illustration, we also provide a multiple *which*-question and its translation in (12a) and (12b). If Meg and Ian are students who met professors Jones and Smith, respectively, and no other student-professor meetings took place, this question will denote the set of propositions in (12c).

- (12) a. Which student met which professor?  
 b.  $\lambda p \exists x \exists y [p(w) \ \& \ p = \lambda w' [\text{student}(w')(x) \ \& \ \text{professor}(w')(y) \ \& \ \text{met}(w')(x,y)]]$   
 c. {Meg is a student and Jones is a professor and Meg met Jones, Ian is a student and Smith is a professor and Ian met Smith}

We can make sure that the N' ends up in the question nucleus by interpreting all *which*-phrases in their base position, i.e., by reconstructing *which*-phrases that are in the Spec of CP in overt syntax and leave in situ *which*-phrases where they are. In this paper we assume a literal syntactic reconstruction process. Note however that our overall approach is equally compatible with an analysis which achieve reconstruction effects by semantic means ('semantic reconstruction'; see Cresti (1995), Rullmann (1995)).

We will translate *which*-phrases as generalized quantifiers containing a free individual variable, which is to be bound by the question operator Q in the Complementizer position. For instance, *which student* is translated as indicated in (13):

- (13) which student<sub>i</sub>            =>     $\lambda P \lambda w [\text{student}(w)(x_i) \ \& \ P(w)(x_i)]$

The question operator  $Q$  is assumed to be coindexed with all *wh*-phrases in the sentence. It binds the free variables in the *which*-phrases and turns the denotation of its complement into a set of propositions. This proposal can be found for instance in Berman (1991). In (14) we give an interpreted structure for the LF of (12a):

(14) [CP [C' [C  $Q_{i,j}$ ] [IP which student<sub>i</sub> met which professor<sub>j</sub>]]]

Translation:

IP:  $\lambda w'[\text{student}(w')(x_i) \ \& \ \text{professor}(w')(x_j) \ \& \ \text{met}(w')(x_i, x_j)]$

$Q_{i,j}$ :  $\lambda q \lambda w \lambda p \exists x_i \exists x_j [p(w) \ \& \ p=q]$

CP:  $\lambda p \exists x_i \exists x_j [p(w) \ \& \ p = \lambda w'[\text{student}(w')(x_i) \ \& \ \text{professor}(w')(x_j) \ \& \ \text{met}(w')(x_i, x_j)]]]$

More generally,  $Q$  as a binder and question operator is assumed to have the semantics in (15):

(15)  $Q_{1, \dots, n} \quad ==> \quad \lambda q \lambda w \lambda p \exists x_1, \dots, x_n [p(w) \ \& \ p=q]$

While the semantics for *which*-questions sketched above accounts for the *de dicto* reading, as it stands it also yields some results that are blatantly wrong, which is why we have called it the naive approach. We first outline these problems and then show how they can be resolved by adding the assumption that *which*-phrases are presuppositional.

### 3.2. Problems for the naive approach

The first problem for the naive approach concerns *which*-phrases in intensional contexts. Consider (16).

- (16) a. Which unicorn does Bill want to catch?  
 b. For which  $y$ : Bill wants that  $y$  is a unicorn and Bill catches  $y$ .  
 c.  $\lambda p \exists y [p(w) \ \& \ p = \lambda w'[\text{want}(w')(bill, \lambda w''[\text{unicorn}(w'')(y) \ \& \ \text{catch}(w'')(bill, y)]]]]]$

Under the naive approach, (16a) would be interpreted as (16b), or more formally (16c). It is clear that this is not a possible interpretation of the question. The problem is that  $x$  being a unicorn should not be part of what Bill wants. In case you are skeptical about reconstruction of moved *which*-phrases, consider (17), which illustrates the same problem for an *in situ which*-phrase:

- (17) a. Which lady wants to catch which unicorn?  
 b. For which  $x, y$ :  $x$  is a lady and  $x$  wants that  $y$  is a unicorn and  $x$  catches  $y$ .  
 c.  $\lambda p \exists x \exists y [p(w) \ \& \ p = \lambda w'[\text{lady}(w')(x) \ \& \ \text{want}(w')(x, \lambda w''[\text{unicorn}(w'')(y) \ \& \ \text{catch}(w'')(x, y)]]]]]$

Since there is no reason to assume that the N' *unicorn* is moved outside the scope of *want*, (17a) should have the interpretation indicated in (17b,c). It may be useful to contrast *which*-phrases in the scope of intensional verbs with *how many*-phrases. A plausible interpretation for one reading of (18a) is given in (18b,c) (Frampton 1990, Cresti 1995, Rullmann 1995). 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.

- (18) a. How many unicorns does Bill want to catch?  
 b. For which n: Bill wants there to be n unicorns y such that he catches y.  
 c.  $\lambda p \exists n [p(w) \ \& \ p = \lambda w' [\text{want}(w')(bill, \lambda w'' \exists y [\text{unicorns}(w'')(y) \ \& \ \text{card}(y) = n \ \& \ \text{catch}(w'')(bill, y)]]]]]$

A second problem with the naive approach has been observed by Reinhart (1992, 1997). She argues against LF movement of in situ *wh*-phrases because of the fact that such movement would have to violate standard island constraints. However, she points out that in situ interpretation of *wh*-phrases leads to semantic problems in cases where the *which*-phrase is embedded in a conditional clause or in the restrictor of a universal quantifier. Example (19) illustrates her point:

- (19) a. Which linguist read every book by which philosopher?  
 b. 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.  
 c.  $\lambda p \exists x \exists y [p(w) \ \& \ p = \lambda w' [\text{linguist}(w')(x) \ \& \ \forall z [\text{philosopher}(w')(y) \ \& \ \text{book}(w')(z) \ \& \ \text{by}(w')(z, y) \rightarrow \text{read}(w')(x, z)]]]]]$

Note that in the translation (19) the subformula '*philosopher*(w')(y)' occurs in the antecedent of the material implication. This means that the implication as a whole will be true for any choice of y which is not a philosopher in w'. Now suppose that (in the actual world) William is a linguist and Donald Duck is not a philosopher. Then the proposition 'William read every book by Donald Duck' will be true, and hence will be a member of the set denoted by (19). But intuitively, of course, this proposition is not a true answer to the question. (20) is another example illustrating the same problem:

- (20) Who will be offended if we invite which philosopher?

A third problem for the naive approach that we would like to mention resides in the fact that in a question like (21a) the predicate '*philosopher*' is given the same status as the predicate '*linguist*'. This means that (21a) will be equivalent to (21b), namely (21c):

- (21) a. Which philosopher is a linguist?  
 b. Which linguist is a philosopher?  
 c.  $\lambda p \exists x [p(w) \ \& \ p = \lambda w' [\text{linguist}(w')(x) \ \& \ \text{philosopher}(w')(x)]]]$

This problem was pointed out by Irene Heim (1995). She also gives a minimal pair with a clear difference in truth conditions:

- (22) a. This algorithm decides which even numbers are multiples of three.  
 b. This algorithm decides which multiples of three are even.

(22a) can be true while (22b) is false, but if the embedded questions in (21a,b) denote the same set of propositions, this is impossible to predict.

#### 4. Presupposition Projection

We seem to be in a dilemma: on the one hand, the N' sister of *which* behaves as if it is part of the question nucleus; on the other hand, if we treat it as on a par with the other material in the nucleus, we run into the problems mentioned above. How do we reconcile these two sets of facts? We propose that *which*-phrases are presuppositional. They are definites, and their presuppositions project like the presuppositions of ordinary definites. This will solve the problems in the preceding section, while allowing us to interpret the *which*-phrase in situ.

##### 4.1. *Non-wh* definites

Before we demonstrate the parallel behavior of *which*-phrases and definites, let's first examine the presupposition projection behavior of ordinary definites. One of the problems we had concerned the propositional argument of intensional verbs like *want*. Compare (16) to (23):

- (23) John wants to catch the unicorn.

This sentence does not mean that John wants it to be the case that there is a unique unicorn *u* and he catches *u*. The existence of a unique unicorn is not part of what John wants, but rather a presupposition that is associated with the use of the definite description. We assume a Fregean analysis of definites, according to which *the unicorn* carries the presupposition that there is a unique unicorn. This presupposition is introduced in the infinitival clause by the definite NP and somehow projects up to the main clause.

As is well known, the way in which presuppositions are projected is a far from trivial matter. Some expressions act as 'holes' in that they let the presuppositions of their complement freely project up. Other expressions are 'plugs' which block presuppositions projection altogether. The most interesting is a third class, called 'filters', which allow the presuppositions of their complement to be projected, but change them in certain ways. The verb *want* belongs to this third class. Karttunen (1974) and Heim (1992) have observed that the presuppositions of the complement of *want* get projected as presuppositions about the beliefs of the subject of *want*. 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 (1992)):

- (24) a. Patrick believes that it raining and he wants it to stop (raining).  
 b. Patrick is under the misconception that he owns a cello, and he wants to sell his cello.  
 c. John believes he saw a unicorn and an elephant. He wants to catch the unicorn.

In each example the second sentence carries a presupposition which is satisfied by the context created by the first sentence. Take (24a). 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* implies that 'Patrick wants it to stop raining' presupposes 'Patrick believes that it is raining'. This is confirmed by the fact that in (24a) the conjunction as a whole does not presuppose anything. Similarly in (24b) and (24c). '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.

Going back to (23) we can observe that when this sentence read without context it may appear that the presupposition that there is a unique unicorn is simply inherited by the main clause. However, in a discourse such as (25) it turns out that the actual presupposition is filtered by *want* in the way described by Karttunen and Heim:

- (25) John thinks he saw an elephant and a unicorn. He wants to catch the unicorn.

Here the presupposition of the second sentence is not that there is a unique unicorn, but merely that John believes so. Since the first sentence of (25) asserts that John believes there a unicorn, the discourse as a whole does not have any presuppositions.

#### 4.2. *Which-phrases*

We can now use the presupposition projection behavior of *which*-phrases as a diagnostic for their semantics. Before we proceed to do that, let's clarify which presupposition we're talking about.

There is a presupposition or implicature associated with questions that we are not primarily concerned with here. This is the fact that a question like 'Who left?' seems to presuppose that somebody left. In the Karttunen framework this presupposition can be captured by requiring the set of propositions denoted by the question to be non-empty, which means that there must be at least one true answer to the question. Turning to *which*-questions this would mean that 'Which man left?' presupposes that at least one proposition of the form 'x left and x is a man' must be true (assuming for the moment the naive approach of section 3).

There is a further complication due to number. The singular 'Which man left?' seems to presuppose not only that at least one man left, but moreover that at most one man did. For the plural 'Which men left?' on the other hand the appropriate presupposition seems to be that at least two men left.

In what follows we will abstract away from the effects of number marking in *which*-questions. See Dayal (1996) for a treatment of number in *which*-questions which is compatible with our analysis, and which addresses the point that singular *which*-questions seem to have a uniqueness presupposition. We will make use of the existence presupposition later, and we hope that it is safe to ignore the uniqueness presupposition for our purposes. What we really want to focus on is a different kind of presupposition associated with the N' sister of *which* (rather than the question as a whole). Later on, in section 5, we will then come back to the existential presupposition and show how the two are related.

Consider the simple question in (26). This question presupposes that there are unicorns; in other words, there are objects of which the property expressed by

the N' sister of *which* is true. Now compare this to (27), where *which unicorn* has been extracted from the complement of *want*.

- (26) Which unicorn did Bill catch?  
 (27) Which unicorn did Bill want to catch?

At first sight, (27) seems to carry the same presupposition as (26), namely that there are unicorns. However, when we put (27) in a context like (28) it turns out that the presupposition of (27) is actually not that there are unicorns, but that Bill believes that there are unicorns.

- (28) Bill thought he saw two unicorns, a green one and a blue one.  
 Which unicorn did Bill want to catch?

(28) can be uttered felicitously by a speaker who does not believe in the existence of unicorns but only ascribes such a belief to Bill. Thus, in the context of the verb *want* the presupposition associated with the *which*-phrase is projected as a presupposition about the beliefs of the individual denoted by the subject of *want*. The parallelism with the case of regular definites is obvious (cf. (25)).

Even without offering a detailed analysis of the phenomenon at this point, it is clear from this example that the property expressed by the N' sister of *which* must have the status of a presupposition. Only presuppositions are affected in exactly this way by the presence of the verb *want*. Only presuppositions are filtered like that. The parallelism between (23) and (27) is therefore evidence for the presuppositionality of the *which*-phrase. There is a second conclusion that can already be drawn at this point. Verbs like *want* only act like presupposition filters with respect to their complements. Thus, the fact that the presupposition associated with the *which*-phrase is gets filtered as a presupposition about the beliefs of the subject of *want*, demonstrates that for the purposes interpretation the *which*-phrase must be part of the complement of *want*. This confirms that *which*-phrases must be interpreted in their base position, a conclusion we had already reached when we tried to account for Groenendijk and Stokhof's de dicto reading in the Karttunen framework.

The parallelism between definites and *which*-phrases extends to other propositional attitude verbs. As observed by Karttunen and Heim, factive verbs like *know* act as holes for presupposition projection. For instance, (29) presupposes that there is a unique unicorn:

- (29) 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 (23), (30) presupposes that Bill believes there is a unique unicorn:

- (30) Bill thought he had caught the unicorn.

The facts we find in *which*-questions are completely parallel. (31) presupposes that there are unicorns and (32) that Bill believes there are unicorns:

- (31) Which unicorn did Bill know he caught?  
 (32) Which unicorn did Bill think he caught?

## 5. *Which*-phrases as definites

### 5.1. *Partial propositions*

We now proceed to give a further explication of the presupposition associated with the *which*-phrase. Let us first give an intuitive idea of what our proposal amounts to. The naive approach outlined in section 3 assigns to the question in (33) a set of propositions of the form "Meg saw *x* and *x* is a man", such as (34):

(33) Which man did Meg see?

(34) {Meg saw Sam and Sam is a man, Meg saw Ian and Ian is a man,  
Meg saw Carl and Carl is a man }

To solve the problems for the naive approach and to explain the presupposition projection effect observed above, we want to make the information that *x* is man something that is presupposed rather than asserted. We propose that (33) denotes a set of propositions of the form 'Meg saw the man *x*', such as (35):

(35) {Meg saw the man Sam, Meg saw the man Ian, Meg saw the man Carl }

To make sense of this, we have to make precise what an NP like *the man Sam* means. We assume a Fregean treatment of *the*, where *the man* is defined iff there is exactly one man, and if defined, denotes that man. The precise semantics of *the* is spelled out in (36):

(36) For any  $g$   $[[\text{the } \alpha]]g$  is defined iff there is exactly one individual  $a$  such that  $[[\alpha]]g(a) = 1$ . If this is the case, then  $[[\text{the } \alpha]]g = a$ .

We will assume that names are rigid designators and pick out a unique individual. Hence *the man Sam* denotes Sam if Sam is a man, and is undefined otherwise. The translation of *the man Sam* is given in (37):

(37) *the man Sam*  $\Rightarrow$  the  $(\lambda y[\text{man}(w)(y) \ \& \ y=\text{Sam}])$

Since we model presuppositionality by means of partiality, a sentence containing a definite description or other presupposition inducing expressions will denote a (possibly) partial proposition which has no truth value in certain worlds. For instance, 'Meg saw the man Sam' will denote the proposition given in (38):

(38)  $\lambda w[\text{saw}(w)(\text{Meg}, \text{the}(\lambda y[\text{man}(w)(y) \ \& \ y=\text{Sam}]])$  denotes that proposition  $p$  such that:  
- $p$  is true in  $w$  if Sam is a man in  $w$  and Meg saw Sam in  $w$   
- $p$  is false in  $w$  if Sam is a man in  $w$  and Meg did not see Sam in  $w$   
- $p$  is undefined otherwise

A *which*-question will denote a set of such partial propositions, such as for instance (35). The propositions in this set are all of the form 'Meg saw the man *x*'. In the translation of the question this is captured by using an individual variable in the slot where the propositions vary from each other (viz. the slot occupied by a proper name in the members of (35)). This variable is to be bound 'upstairs' by the question operator in Comp. In contrast to translating *which man* as the open

formula 'man(x)' like we did in the naive approach, we will translate *which man* as the open formula 'the man x' or, more formally, (39):

$$(39) \quad \textit{which man}_i \quad ==> \quad \text{the}(\lambda y[\text{man}(w)(y) \ \& \ y=x_i])$$

We continue to assume that the free variable introduced in the wh-phrase gets bound by the question operator in Comp, just as in the naive approach. The resulting translation for (33) is given in (40):

$$(40) \quad \begin{array}{l} \text{a.} \quad \lambda p \exists x [p(w) \ \& \ p = \lambda w' [\text{Meg saw the man } x \text{ in } w']] \\ \text{b.} \quad \lambda p \exists x [p(w) \ \& \ p = \lambda w' [\text{saw}(w') (\text{Meg}, \text{the}(\lambda y [\text{man}(w')(y) \ \& \ y=x]])]] \end{array}$$

### 5.2. Deriving the presupposition

We observed above that a *which*-question presupposes that there must be individuals that have the property expressed by the N' sister of *which*; in the case of (33) this means that there must be men. How exactly is this fact explained in our analysis? The denotation of the question will be a set of partial propositions "Meg saw the man x", so each individual proposition that is a member of the question denotation presupposes that x is a man, and hence that there is at least one man. But there is still a step missing in our explanation: How do we derive the fact that the question itself presupposes that there are men? That is, how do we get from the presuppositions of the propositions in the question denotation to the presupposition of the question itself? Here we exploit the fact noted above that a question presupposes that there is at least one true answer to the question; that is, the denotation of the question set must not be empty. (33) denotes a set of partial propositions. The propositions are undefined in worlds in which the relevant individuals are not men. Hence in order for the question to have a true answer in the real world, there must be men in the real world. Thus, if the question carries a presupposition that there is a true member in the question set, this combines with the presuppositionality of *which*-phrases so that the question presupposes that there are actually individuals that meet the description provided by the N'.

This is similar to the way factives act as holes (Karttunen (1974)). Factives presuppose truth of their complement clause. If that complement clause is only defined, i.e. can only be true if a certain presupposition is met, then the whole sentence must inherit that presupposition. Hence we take questions to be similar to factives in that they are holes for presuppositions, and we suggest to derive the hole status on the basis of further presuppositions introduced higher up that make the whole structure inherit the presuppositions of certain proper parts.

Actually, it may be argued that this result is not strong enough. What we said above is that (33) presupposes that there are men (plural), but what we have derived is the presupposition that there is at least one man (singular). We suggest that the stronger presupposition that there are at least two individuals instantiating the property expressed by the N' can be derived from the requirement that a question must have more than one defined answer. By a defined answer we mean an answer (partial proposition) that is either true or false in the actual world. The intuitive idea behind this is that asking a question would simply be pointless if there were only one defined answer. Questions, like focus, set up a choice between alternatives. Just like focus is only possible if there is more than one alternative, in the case of a question too, there must be more than one possible answer.

To formalize this idea we slightly modify our analysis. Following Karttunen we have assumed so far that the denotation of a question is a set of propositions that are true in the actual world. One way to make it possible to state the presupposition that a question have at least two defined answers is to include in the question denotation also propositions that are false in the actual world (but not those that are undefined in the actual world). The translation of (33) should then be (41) rather than (40):

$$(41) \quad \lambda p \exists x [(p(w) \vee \neg p(w)) \& \\ p = \lambda w' [\text{saw}(w') (\text{Meg}, \text{the}(\lambda y [\text{man}(w')(y) \& y=x]])]]$$

This change makes our analysis closer to that of Hamblin (1973) (it is in fact identical to Hamblin if we exclude undefinedness from consideration), but is otherwise inessential. The set of true answers can be always be obtained from the set denoted by (41) by restricting it to propositions that are true in the actual world. To be a bit more precise about what we assume with regard to the presuppositions of a question as a whole, let's assume that  $Q(w)$  is the extension of a question (this being a set of possible, defined answers like in the example (41)) in world  $w$ . Then  $Q(w)$  is associated with (42a), the existence presupposition (the requirement that there must be at least one true answer), and (42b), the presupposition that there must be at least two alternatives (note that we disregard the uniqueness presupposition - in the case of singular *which*-phrases, to add it will imply that all other alternatives are false).

$$(42) \quad \text{a.} \quad \{p: p \in Q(w) \& p(w)\} \neq \{\} \\ \text{b.} \quad \text{card}(Q(w)) \geq 2$$

By requiring that the set denoted by (41) must contain least two distinct propositions we can now derive the presupposition that there are at least two men in the actual world. Since at least two propositions of the form "Meg saw the man  $x$ " must be defined in  $w$ , there must be at least two individuals  $x$  such that  $\text{man}(w)(x)$  is true.

Let's now look at how our proposal deals with the presupposition projection data which motivated treating *which*-phrases as definites. (43a) will be translated as (43b,c):

$$(43) \quad \text{a.} \quad \text{Which unicorn did Bill want to catch?} \\ \text{b.} \quad \lambda p \exists x [(p(w) \vee \neg p(w)) \& \\ p = \lambda w' [\text{in } w' \text{ Bill wanted to catch the unicorn } x]] \\ \text{c.} \quad \lambda p \exists x [(p(w) \vee \neg p(w)) \& p = \lambda w' [\text{want}(w')(\text{Bill}, \\ \lambda w'' [\text{catch}(w'')(bill, \text{the}(\lambda y [\text{unicorn}(w'')(y) \& y=x]])]]]$$

In a concrete situation, this formula will - in intuitive terms - denote a set of propositions such as (44):

$$(44) \quad \{\text{Bill wanted to catch the unicorn Xavier}, \\ \text{Bill wanted to catch the unicorn Isabella}\}$$

What sort of semantic objects are the members of this set? Or in other words, which (partial) function from possible worlds to truth values is denoted by a sentence like

'Bill wanted to catch the unicorn Isabella'? The answer to this question depends of course on how the presupposition associated with the definite description 'the unicorn Isabella' projects up to the level of the matrix clause. We will not try to provide a solution for the general problem of presupposition projection in propositional attitude contexts (see Heim (1992) for a promising approach in terms of dynamic semantics). In that respect our analysis remains incomplete. However, on an observational level we know that the presuppositions of the complement of *want* project up as presuppositions about the beliefs of the subject, as was shown by Karttunen and Heim (recall for instance examples (24a)-(24c)). Thus, we may assume that 'Bill wanted to catch the unicorn Isabella' is going to be the partial proposition given in (45):

- (45) 'Bill wanted to catch the unicorn Isabella' is that proposition  $p$  such that
- $p$  is true in  $w$  if in  $w$  Bill believed that Isabella is a unicorn and in  $w$  Bill wanted to catch Isabella
  - $p$  is false in  $w$  if in  $w$  Bill believed that Isabella is a unicorn and in  $w$  Bill did not want to catch Isabella
  - $p$  is undefined otherwise

Once more, we assume that a question must have at least two possible answers to be felicitous, so the set denoted by (43) must have at least two members. This means there must be at least two individuals  $x$  such that Bill believed that  $x$  is a unicorn. We thus derive the effect that the question presupposes that Bill believes there are unicorns.

### 5.3. Problems of the naive approach are avoided

Let's briefly check that our presuppositional account of *which*-phrases actually avoids the semantic problems that were lethal to the naive approach, and still captures a de dicto interpretation.

It is fairly obvious that the interpretation we get is still de dicto. Suppose John knows which students called, and Sue is a student who called. On our analysis, John must know the following proposition:

- (46)  $\lambda w$ [the student ( $w$ ) Sue called in  $w$ ]

That is, John's belief-worlds must be such that in all of them, this proposition is true. It can only be true if Sue is a student in his belief-worlds.

Turning to the problems we observed for the naive approach, notice first that the failure of the intensional variable of the *which*-phrase to get bound is, in our analysis, only an apparent failure: that variable does get bound inside the complement of *want*, as we can see from the fact that the property denoted by the  $N'$  has to hold of entities in the subjects belief-worlds. The apparent failure is due to the presuppositionality of the *which*-phrase.

With respect to Reinhart's problem, let's focus on our predictions regarding (19a). Our semantics of (19a) is given in (19'):

- (19')  $\lambda p \exists x \exists y [(p(w) \vee \neg p(w)) \ \& \ p = \lambda w' [\text{the linguist } x \text{ read every book by the philosopher } y]]$

The restrictor of a universal quantifier is a hole for presupposition projection. Hence a proposition can only be true and a member of (19') if we pick an actual philosopher to fill the slot of the *y* variable. We avoid the Donald Duck problem.

Finally, (21a) and (21b) no longer have the same meaning. They are different sets of partial propositions. Hence, embedding verbs can be sensitive to the difference.

#### 5.4. *Philosophical problems*

There is a potential philosophical problem for this analysis of *which*-questions that concerns the binding of the individual variable *x* into the intensional context. Suppose that the variable *x* in (43) could only range over actual individuals, i.e. individuals that exist in the actual world. Then a true answer to the question would be a proposition which is true iff Bill believes of an actual individual that it is a unicorn and wants to catch it. This would be a *de re* belief on Bill's part. However, observe that in a context like (30) it does not have to be the case that Bill believes of any actually existing individuals that they are blue or green unicorns. Of course it could be true that Bill saw two moose which he mistakenly takes to be unicorns (maybe he only caught a brief glimpse of the animals). But it could equally well be the case that Bill simply thinks he saw two unicorns without there being anything of which he believes that it is a unicorn (maybe he is hallucinating under the influence of drugs). There may be unicorns in Bill's belief-worlds, but these need not exist in the actual world, not even in a different guise. The most convenient solution for us at this point might simply be to assume that there are actual as well as non-actual individuals, and that we can freely quantify over the latter. In that case, Bill could have *de re* beliefs about individuals that are unicorns in his belief worlds but which do not exist in the actual world. However, this ontological assumption might not be universally popular. In the next section we will discuss an alternative approach the semantics of *which*-questions which avoids ascribing to Bill *de re* attitudes about non-existent objects. As we will see, there is some independent motivation for this alternative, but it also has certain problems of its own.

### 6. An alternative analysis involving properties

The alternative analysis we want to explore in this section also is based on the idea that *which*-phrases are definites and are interpreted in their base position. The difference to the analysis outlined above is that the free variable inside the translation of the *which*-phrase (or, intuitively, the open slot in which the propositions in the question denotation vary) will range over properties rather than individuals. This idea is rooted in the intuition that the answer to a question like (27) seems to specify a property that allows one to uniquely identify an individual unicorn. A possible answer to (27) would for instance be 'the blue unicorn'. So suppose that the translation of 'Which unicorn does Bill want to catch?' was as in (48), with the translation of the *which*-phrase given in (47).

(47) *which unicorn*<sub>*i*</sub>      ==>    the( $\lambda y$ [ $P_i(w)(y)$  & unicorn( $w$ )( $y$ )])

- (48) a.  $\lambda p \exists P[(p(w) \vee \neg p(w)) \ \& \ p = \lambda w'[\text{in } w' \text{ Bill wanted to catch the unicorn that was } P]]$   
 b.  $\lambda p \exists P[(p(w) \vee \neg p(w)) \ \& \ p = \lambda w'[\text{want}(w')(\text{Bill}, \lambda w''[\text{catch}(w'')(w''), \text{the}(\lambda y[\text{unicorn}(w'')(y) \ \& \ P(w'')(y)])]]]]]$

Thus, in the context provided by (28), the question will denote the following set of propositions:

- (49) { Bill wanted to catch the blue unicorn,  
 Bill wanted to catch the green unicorn }

This analysis obviously does not involve *de re* attitudes about non-existing individuals. Notice however that our previous analysis involving individuals can be seen as a special case of this property analysis, when the variable *P* is restricted to properties  $\lambda w \lambda x[x=d]$ , for particular individuals *d* (the property of being identical to Bill, the property of being identical to Mary, etc.). Thus, we can still get a question set consisting of *de re* propositions, assuming that contextual factors can be powerful enough to restrict the choices for *P* in this way (and note that we have to assume that the context plays a heavy role in restricting *P* anyway). (50) would be an example of a case where contextual restriction of this kind is at work:

- (50) There are three students who took the semantics seminar this term, Martha, Heather, and Eileen. Which student wrote the best paper?

In fact, it may very well be the case that restricting the values of *P* to the property of being identical to some individual should be regarded as the default case, and that real property readings are actually rather exceptional.

Interestingly, it turns out that there is some independent evidence that *which*-questions are indeed queries for intensional concepts, and that our property analysis is at least one possible way to capture this. Example (51) is given by Heim (1995), who uses it to suggest an intensional version of Reinhart's choice function approach:

- (51) Which of your classmates do you want to be friends with?  
 The one with the best grades.

(51) cannot be a query for an actual individual here. The property analysis would yield (52) as the interpretation of (51), which seems suitable enough.

- (52)  $\lambda p \exists P[(p(w) \vee \neg p(w)) \ \& \ p = \lambda w'[\text{want}(w')(w'), \lambda w''[\text{in } w'' \text{ you are friends with the}(\lambda y[\text{classmate\_of\_yours}(w'')(y) \ \& \ P(w'')(y)])]]]]]$

Unfortunately, the analysis is not without problems either. Suppose that (53a) is asked in a context in which there is one red car which also happens to be the most expensive car, and Cynthia bought that car. Then both (53b) and (53c) are true answers to the question, but on the property analysis they are actually distinct members of the question set.

- (53) a. Which car did Cynthia buy?  
b. Cynthia bought the red car.  
c. Cynthia bought the most expensive car.

The problem then arises what would constitute a complete answer to a question on the property analysis. Intuitively, we would want to say that somebody who knows either (53b) or (53c) is fully informed as to which car Cynthia bought. That is, in order to know the complete true answer to a question, you don't have to know the object that yields the true answer under all its different possible descriptions. However, as soon as we let the question be a query for an intensional concept, (53b) and (53c) are two different true answers. This is a difficult dilemma, since (52) seems to be good evidence in favor of letting *which*-questions ask for intensional concepts. We will have to leave the choice between the two versions of our presuppositional analysis for *which*-phrases open for the present.

## 7. Conclusion

We conclude that *which*-phrases are presuppositional beings, a particular kind of definite noun phrase. This allows us to reconcile the semantic evidence for interpreting *which*-phrases as part of the question nucleus with the apparent problems for this approach. We have not even addressed the syntactic evidence for an in situ interpretation (see e.g. Reinhart (1997)), but clearly this is one place where one ought to look for further confirmation of such an approach. We believe that our analysis superior to an analysis in terms of choice functions (again, compare Reinhart's work) in dealing with presupposition effects.

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