AN ALTERNATIVE ANALYSIS OF WH-QUESTIONS IN MONTAGUE SEMANTICS[1]

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In recent years, numerous articles in linguistics have been devoted to the semantic analysis of the question sentences. Among the most recent ones are the works by Hamblin (1976), Bennett (1976), Karttunen (1977) and Peters (1979), all of whom proposed an analysis of the interrogative in the kind of model theory developed by Richard Montague (1970, 1973). Among philosophers of natural language, too, the intriguing character of the interrogative has captured many, who produced a number of interesting analyses on this subject. Åqvist (1971, 1972, 1973), Belnap (1969), Hintikka (1974) are some of the most prolific philosophers in this area. Earlier analyses of the interrogative have also been carried out by Bach (1970), Baker (1970), and Katz (1968), mostly in the generative-transformational framework.

This paper focuses on a particular treatment of the interrogative by Karttunen in his 1977 paper entitled 'Syntax and Semantics of Questions,' primarily because it is the most comprehensive and workable analysis of all. In the course of analysis, I hope to show some of the underlying notions of Karttunen's approach, outline a number of rules he employs, and illustrate a certain problematic solution he adopts. In the second half of this paper, I will propose a modification of Karttunen's model. It should be noted at the outset that the analysis presented here deals only with indirect questions, leaving behind equally interesting, but probably more complicated, areas of direct questions.

Karttunen's analysis of indirect questions is built on the syntax, translation rules, and the semantics of Montague's PTQ, by adding several more syntactic and translation rules of his own, so that, as in PTQ, each syntactic rule corresponds one to one to the translation rule. The semantic component of PTQ is carried over into Karttunen's model without any modification whatsoever.

Before going any further, let us briefly examine what a question sentence is. Åqvist (1971, 1972, 1973) and Hintikka (1974) appear to hold that a question sentence is a kind of imperative with an epistemic operator. In other words, the question of the form 'Who came to the party?' can be equivalently paraphrased as 'Bring it about that I know who came to the party.' It is interesting to note that both of these (one a direct question and the other an imperative) have no truth values. As it is intuitively obvious, the imperative and interrogative do not have a truth value, but they are self-verifying by virtue of the fact that they are uttered. If we take this paraphrasing to be plausible starting point for a semantic analysis, a direct question is, in effect, an indirect question. It follows that any reasonable

analysis of the interrogative must account for indirect questions first.

A very important matter that should be settled first is the question of what a question sentence denotes. Consider the following questions (1)-(3) and the answers (4) through (7) to (3).

(1) Who came to the party?
(2) Who loves whom?
(3) What is true of Kansas?
(4) The sunflower is the state flower of Kansas.
(5) I-70 runs through Kansas.
(6) It is not the case that the sunflower is the state flower of Kansas.
(7) Kansas is in Canada.

As has been pointed out earlier, it is quite absurd to speak of a question as having some kind of truth value. Wachowicz (1975) has suggested that a question like (1) should denote a set of individuals who came to the party, and (2) should denote a set of pairs of individuals in which the first element of each pair has a love-relationship to the second element. If she is correct in this respect, the denotation of the phrase 'came to the party' and the denotation of the entire question should have the same denotation set. Likewise, the denotation sets of 'love'and (2) are equivalent. That is to say, there is no way of distinguishing the denotations of a verb phrase and a question as a whole. This is clearly untenable.

An alternative solution has been proposed by Hamblin (1976). He noted that a question like (1) can be satisfied (properly answered) by providing a statement of the sort 'John did'or 'No one did.' In other words, the denotation of a question can be construed as a set of propositions expressed by statements that are complete answers to it.[2] In a similar manner (2) denotes a set of propositions expressed by answers like 'John loves Lisa' or 'Pat loves Bruce,' whatever might be the case in a given model. This approach has more bearing on our intuition as to what a question might 'mean,' but it is not without problems. This shortcoming is illustrated by the fact that not only (4) and (5) can serve as answers to (3), but the denotation set of (3) should also contain the propositions expressed by a contradictory statement like (6) and a false statement (7).

In view of these deficiencies, Karttunen adds a new stipulation to the denotation set of a question, i.e., he proposes that a question denotes a set of true propositions that are complete answers to it, thus eliminating absurd answers like (6) and (7). This is, in fact, the view we shall adopt here.

(8) below shows a list of new categories that are necessary for Karttunen's proposed analysis. A few words will suffice to illustrate the purposes of these new categories. First, Q is the category of indirect questions, with the categorial definition t//t, a set of propositions. This is in accordance with our earlier assumption that a question sentence

(8)

Category name	Definition	Description
Q	t//t	set of propositions
IV/Q	IV/(t//t)	function from sets of propositions to sets of individuals
WH	t//IV	set of properties of individuals
cf. T	t/IV	set of properties of individuals

denotes a set of propositions. The category IV/Q is the category of question-taking verbs, mostly epistemic, such as 'know', 'ask', 'wonder', 'question', etc. They take a proposition as an argument, and return an IV-phrase like 'ask what John ate this morning.' WH is the category of WH-expressions like 'what armadillo' or 'which lobster,' defined categorially as t//IV, a set of properties of individuals. Bare WH-expressions like 'what' and 'which' are not well-formed WH-expressions in Karttunen's model, but this is a small shortcoming that can be easily remedied. It should be noted that all WH-expressions are of the same intensional logic type as non-interrogative T-phrases in Montague's PTQ (thus sharing a similar meaning). In Karttunen's translation rules, 'what man' and 'which man' has the same intensional logic translation as 'a man.' This might sound rather peculiar, but is in fact a sound characterization as we shall see later.[3] Informally, such WH-expressions may be thought of as unbound variables, in a very intuitive sense, into which a T-phrase may be quantified. The reader might think that 'someone' and 'something' are also unbound variables in the same sense, but technically, they contain only bound variables.

Having given the categorial definitions, he procedes to define some new syntactic rules and their corresponding translation rules, as seen below.

(9) WH-Phrase Rule (WHP)

If $\alpha \in P_{CN}$, $F_{WHP}(\alpha) = \ulcorner$which $\alpha\urcorner$ and $\ulcorner$what $\alpha\urcorner$, where $F_{WHP}(\alpha) \in P_{WH}$.

T_{WHP}: If $g(\alpha) = \alpha'$, $g(F_{WHP}(\alpha)) = \hat{P}\exists x[\alpha'(x) \wedge P\{x\}]$

(10) WH-Quantification Rule (WHQ)

If $\alpha \in P_{WH}$, $\varphi \in P_Q$ containing an occurrence of PRO_n and φ does not begin with <u>whether</u>, $F_{WHQ,n}(\alpha,\varphi)$ comes from φ by performing the following operations.

A. If φ begins with <u>?</u>, $F_{WHQ,n}(\alpha,\varphi)$ comes from φ by:

i) substituting $\bar{\alpha}$ for the initial <u>?</u> in φ, where $\bar{\alpha}$ comes from α by adjusting the case of α to match the case of the first PRO_n in φ.

ii) deleting the occurrence of PRO_n in φ.

iii) replacing each subsequent occurrence of PRO_n in φ by the unsubscribed pronoun whose case matches the gender of α.

B. If φ does not begin with ?, then $F_{WHQ,n}(\alpha,\varphi)$ is derived from φ by:

iv) substituting $\overline{\alpha}$ for the first occurrence of PRO_n in φ where $\overline{\alpha}$ is as defined in i) above.
v) same as iii) above.

$T_{WHQ,n}$: If $g(\alpha) = \alpha'$, and $g(\varphi) = \varphi'$, then $g(F_{WHQ,n}(\alpha,\varphi)) = \hat{P}[\alpha'(\hat{x}_n[\varphi(P)])]$.

(11) Proto-Question Rule (PQ)

If $\varphi \in P_t$, $F_{PQ}(\varphi) = {}^{\ulcorner}?\varphi^{\urcorner}$ where ${}^{\ulcorner}?\varphi^{\urcorner} \in P_Q$.
T_{PQ}: If $g(\varphi) = \varphi'$, then $g(F_{PQ}(\varphi)) = \hat{p}[\check{p} \wedge p = \hat{}\varphi']$.

(12) Question Embedding Rule (QE)

If $\varphi \in P_Q$, $\delta \in P_{IV/Q}$ and φ does not begin with ?, then $F_{QE}(\delta,\varphi) = {}^{\ulcorner}\delta\,\varphi^{\urcorner}$
T_{QE}: functional application.

To see exactly how they work together, consider (13), a sample derivation of 'John asks which man works hard.'

(13) John asks which man works hard.

$PTQF_4(john, F_{QE}(ask, F_{WHQ,7}(F_{WH}(man),(F_{PQ}(PTQF_4(he_7, PTQF_7(work, hard)...$

First of all, Karttunen derives 'he_7 works hard' using PTQ functions 7 and 4. The proto-question rule, PQ, takes this as an argument and produces a proto-question of the form '?he_7 works hard,' prefixed with a '?' in front of the derived string. This is not a proper structure of English, but a theoretical construct from which a genuine 'embeddable' sentence of the form 'which man works hard' is derived. The proto-question is then supplied as one of the arguments to the quantification rule, where the initial '?' is removed, he_7 is replaced by 'which man', and results in the phrase 'which man works hard.' The next step is to concatenate the question-taking verb 'ask' with 'which man works hard' to result in 'ask which man works hard,' which is then strung together with 'John' to render the final product 'John asks which man works hard.'

The translation rules proposed Karttunen gives us the following intensional logic translation at the last stage of the derivation, as shown in (14), where g is the translation function into intensional logic.

(14) g(john asks which man works hard) =

$$ask'(j,\hat{p}\exists x[man'(x) \wedge \check{p} \wedge p = \hat{}hard'(work')(x)])$$

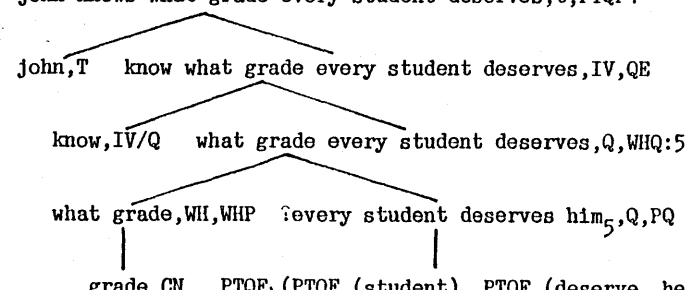
This translation says informally that John asks for that set of answers expressing the true propositions, in which, for some man x, x works hard is true. This is just as it should be and seems to capture our understanding of the question.

Although his analysis is capable of accounting for many interesting cases, it falls short in some respects. In the syntactic rules and the derivation, an alert reader might have noticed that the only opportunity for a WH-expression to be introduced is when it is quantified into a Q-phrase. It may also be recalled from PTQ that a T-phrase may either be introduced directly by a rule (direct introduction) or by quantification into a t-phrase (quantification introduction). As far as a T-phrase is concerned, therefore, the last chance for it to be introduced is when there is a t-phrase to be quantified in. This would mean that a WH-expression, which can only be introduced into a Q-phrase, will be invariably introduced later than any other non-interrogative T-phrases. In terms of scope relationship, the scope of the non-interrogative noun phrases 'every man', 'some sardines',for example, will always be smaller than that of WH-expressions. Any attempt to reverse this scope relationship fails as Karttunen notes. He, however, neglects to provide an appealing solution to this problem.

The effect of this scope ambiguity becomes very clear when we consider a sentence like 'John knows what grade every student deserves.' This sentence is two-way ambiguous: the first reading is that John knows that there is some grade, C- for example, that everyone deserves; and another is that John knows, for every student, that there is a grade everyone deserves (John, F; Lynn, A+; ...). In terms of a logical formula, the first reading corresponds to having the existential quantifier before the universal quantifier in 'every student'(i.e., the latter is included in the scope of the former). The second reading exhibits the scope of the existential quantifier in 'what grade' in the scope of the universal quantifier in 'every student.' This phenomenon is illustrated by (15), where (15b) shows the derivation for the first reading, and (15c) for the second.

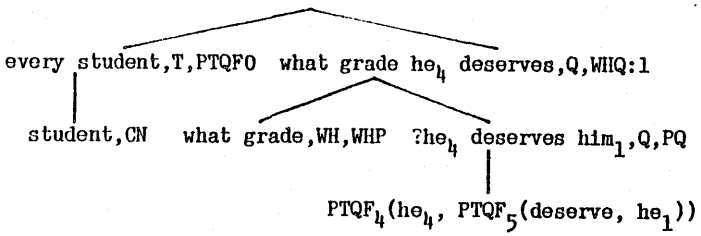
(15) a. John knows what grade every student deserves.

b. john knows what grade every student deserves,t,PTQF4



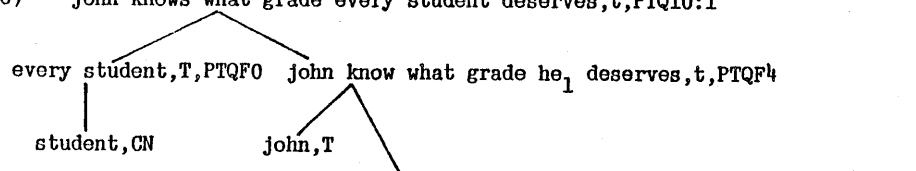
Translation: know'(j,$\hat{p}$ $\exists$x[grade'(x)$\wedge\check{p}$ $\wedge$ p = $\hat{}\forall$y[student'(y) $\rightarrow$ deserve'(y,x)]

c. (blocked)



It is immediately apparent from (15c) that 'every student' cannot be quantified into a Q-phrase, simply because there is no rule that provides for it. Having noticed this, Karttunen resorted to some other means to reverse the scope relationship, and this was done by quantifying in 'every student' at the very last stage of derivation, as shown in (16).

(16) john knows what grade every student deserves,t,PTQ10:1



Translation: $\forall y[\text{student}'(y) \rightarrow \text{know}'(j,\hat{p}\exists x[\text{grade}'(x)\wedge\check{p}\wedge p = \hat{}\text{deserve}'(y,x)$

Notice that this is possible because only indirect questions are being dealt with in which there is a higher structure beyond the Q-level. As shown in the translation of (16), Karttunen arrives at the second reading of (15a). Under this analysis, then, the sentence is true if and only if John knows, for every student, what grade he deserves.

Let us pause here for a moment and reflect on what is at stake here. As I have pointed out earlier in the paper, a successful semantic theory of the interrogative should and must account for both direct and indirect questions. For this reason, it would be theoretically very plausible, as well as intuitively appealing, to be able to relate the semantic representation (whatever it is) of a direct question to that of the corresponding indirect question, and vice versa. So far, Karttunen has failed to give us an insight regarding how direct and indirect questions are related. More crucially, we are no better equipped than before to determine how we should deal with exactly the same scope ambiguity we find in the corresponding direct question 'What grade does every student deserve?' If we were to take the same approach Karttunen took for the analysis of indirect questions, we would have no plausible way of deriving the second reading.

There appear to be a few ways of avoiding this problem. One is to allow

the quantification of 'every man' into a Q-phrase by redefining the quantification rule. As Karttunen is well aware of, however, this produces a highly undesirable result. Another approach might be to take advantage of Hintikka's notion of direct questions. If this alternative is pursued, the question under analysis 'What grade does every student deserve?' would roughly have the following logical translation of the desideratum (Hintikka 1974:124).

(17) $(\exists x)K_{sp}(\forall y(\text{student}(y) \rightarrow \text{deserve}(y,x)) \ \& \ \text{grade}(x))$

In this formulation, K_{sp} may be read 'I (the speaker) know that.' If this approach is correct, every direct question would have a higher structure, since all direct questions will be embedded in the epistemic operator K_{sp}. In this way, it may be possible to quantify 'every student'(more generally, any quantified non-interrogative expression) into the epistemic context, so that the desired scope relationship is attained. Unfortunately, however, this cannot be done because of the way it is formulated in Hintikka's work. In short, Hintikka's approach to direct and indirect questions also fails to account for this ambiguity.[4]

The third, and the simplest, way of solving this problem is to allow the introduction of WH-expressions directly by the rules, keeping, at the same time, Karttunen's WH Quantification Rule. In this way, it is possible to relate indirect and direct questions in a straightforward manner, as well as disambiguating the sort of scope ambiguity that has been discussed here.

Having adopted this position, our new set of syntactic categories will now include the following.

(18)

Category name	Definition	Description
WH-DET	(t//IV)/CN	function from properties of individuals to sets of properties of individuals

The category WH-DET is the set of WH-determiners like 'what' or 'which' in phrases 'what man' or 'which student'. In syntactic terms, they combine with common nouns to produce WH-expressions. Semantically, they denote a function from properties of individuals into sets of properties of individuals. The following rule, shown in (19), is the formal rendition of WH-DET Rule, which performs the desired concatenation. The corresponding translation rule into intensional logic is that of a simple functional application.

(19) WH-DET Rule (WH-DET)

If $\alpha \in P_{WH}$, and $\beta \in P_{CN}$, then $F_{WH\text{-}DET}(\alpha,\beta) = \ulcorner \alpha\beta \urcorner$ where $\ulcorner \alpha\beta \urcorner \in P_{t//IV}$.

$T_{WH\text{-}DET}$: Functional application.

It is important to note that, by the addition of this rule, there is a possibility of generating an otherwise unacceptable t-phrase, 'Which man

works hard with which student', for example. It is therefore necessary to add a stipulation in our relevant syntactic rules that these strings be disallowed as genuine t-phrases, unless they are going to be embedded into a question-taking verb.

In (20), the two possible readings of (20a) (the same as (15a)) are shown, in which (20b) represents the analysis tree of the first reading, and (20c), the second.

(20) a. John knows what grade every student deserves.

b. john knows what grade every student deserves,t,PTQF4

john,T know what grade every student deserves,IV,QE

know,IV/Q what grade every student deserves,Q,PQ

every student deserves what grade,t,PTQ10:1

what grade,WHP,WH-DET every student deserves him_1,t,PYQF4

$PTQF_4(PTQF_0(student), PTQF_5(deserve, he_1))$

Translation: know'(j, $\hat{p}[\check{}p \wedge p = \hat{}\exists y[grade'(y) \wedge deserve'(\hat{P}\forall x$ [student'(x) $\rightarrow$ P{x}, y)]]).

c. john knows what grade every student deserves,t,PTQF4

john,T know what grade every student deserves,IV,QE

know,IV/Q what grade every student deserves,Q,PQ

every student deserves what grade,t,PTQ10:1

every student,T,PTQF0 he_1 deserves what grade,t,PTQF4

student,CN $PTQF_4(he_1, PTQF_5(deserve, F_{WH-DET}(what\ grade))$

Translation: know'(j, $\hat{p}[\check{}p \wedge p = \hat{}\forall x[student'(x) \rightarrow deserve'(x,$ $\hat{Q}\exists y[grade'(y) \wedge Q\{y\}])]]$).

As it is clear from the tree in (20c), the WH-DET-phrase 'what grade' is directly generated from the lexicon by WH-DET Rule, which is subsequently concatenated with 'deserve', and 'he$_1$' to result in 'he$_1$ deserves what grade.' The T-phrase,'every student', produced by PTQ function 0, is then allowed to be introduced into the t-phrase. In terms of translation, this amounts to a wider scope of the universal quantifier than the scope of the existential quantifier in 'what grade,' a result WH-DET Rule is designed to obtain.

The reader might have noticed that there is a slight difference between the translations of the second reading (see (16) and (20c)). In Karttunen's translation of the second reading, for instance, it is quite clear that this sentence is true if and only if, for all the students in the domain of discourse, John knows what grade each student deserves. A moment of reflection is sufficient to determine that it is very unlikely that John knows the grade of every student in the domain, some of whom he might not know (observe the positions of the universal quantifier and the epistemic predicate know'). A more reasonable interpretation may be that he knows the grade of every student he knows, rather than of every student in general. This observation reveals that Karttunen's version claims too much and leads us to a conclusion that the epistemic predicate must have, within its scope, the universal quantifier. This fact offers additional support for the derivation shown in (20c), congruent with the observation.

In summation, I have argued for the direct generation of WH-expressions from within the lexicon. The solution offered here is still very tentative and solves only a very small number of mounting problems we encounter in the analysis of the question. For example, if we choose to ignore the proposed existence of an embedded epistemic predicate, we cannot capture presupposition and other phenomena often seen in questions. Even if we accept the existence of such an operator, we still fail to arrive at those two readings we have been discussing in this paper. So far as this analysis goes, it appears that the problem of quantifier ambiguity is much more far-reaching than it initially appeared to be.

NOTES

[1]I have profited from many discussions with Professor Choon-Kyu Oh during the preparation of my MA thesis, which served as a basis for the present paper. I am also grateful to Liess Vantine who read an earlier version of this paper.

[2]Answers and replies should be clearly distinguished. Answers express complete propositions which satisfy the question, while a reply may be any utterance in response to a question. It may be thought that answers are special instances of replies.

[3]This approach may not first seem very appealing. In many genetically unrelated languages of the world, however, a striking morphological resemblance exists between indefinite pronouns and the corresponding interrogative

pronouns. English may be one of a few exceptional cases in which no such overt similarity is seen. See also Nara (1982).

[4] Hintikka contends that the structure of questions is determined by the interplay of quantifiers and the inherent epistemic predicate know. For example, the question like the following is multi-ambiguous.

Who remembers where she bought what?
(Bach 1970, Baker 1970, Hintikka 1974)

This is because, Hintikka believes, there are at least five epistemic-quantifier combinations, each of which contributes to a different reading. To put it informally, the combinations of the internal epistemic operator know, the quantifiers in who, where, and what will give rise to these distinct readings (See Hintikka 1974:123 et seq.). It should be carefully observed that, according to Hintikka, the question we are concerned with should never be ambiguous, but in fact, as we have noted throughout the paper, it is. In a quasi-logical notation, the question 'What grade does every student deserve?' would have the following desideratum:

$(\exists x)$(I know that (every student deserves x & x is a grade))

Notice that the existential quantifier is now allowed to come into the epistemic context, for this would represent another question 'What grade does what student deserve?'

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