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Syntax and Semantics of Questions

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This paper presents a novel account of the syntax and semantics of questions, making use of the framework for linguistic description developed by Richard Montague (1974). Certain features of the proposal are based on work by N. Belnap (1963), L. Åqvist (1965), C. L. Baker (1968, 1970), S. Kuno and J. Robinson (1972), C. L. Hamblin (1973), E. Keenan and R. Hull (1973), J. Hintikka (1974), Lewis and Lewis (1975), and D. Wunderlich (1975), but it differs from all of its predecessors in one way or another. I will start with a number of observations which provide the basis for the treatment of questions presented in the second part of the paper and conclude with a summary and a brief discussion of how the proposed description compares with recent transformational analyses.

1 Introduction

1.1 Direct and indirect questions

There are two kinds of interrogative clauses: direct (*Is it raining? Which book did Mary read?*) and indirect (*whether it is raining, which book Mary read*). Any reasonable analysis of questions should relate questions of one sort to the corresponding questions of the other type. Proposals to this effect have been presented by Belnap, Åqvist, Hintikka, and others. The basic idea in their analyses is to assimilate direct questions to indirect questions. A direct question can be treated as semantically equivalent to a certain kind of declarative sentence containing the corresponding indirect question embedded under a suitable "performative" verb. For example, the direct questions in (1) can be regarded as expressing the same proposition as the corresponding sentences in (2).

(1) (a) Is it raining?
(b) Which book did Mary read?

(2) (a) I ask you (to tell me) whether it is raining.
(b) I ask you (to tell me) which book Mary read.

This reduces the problem of the semantics of direct questions to the problem of how indirect questions are interpreted. There are two alternative ways of making this reduction. One way is to do it as part of the syntax by deriving the questions in (1) from the sentences in (2) by a meaning-preserving transformation. Alternatively, one could generate the questions in (1) directly and set up a suitable interpretive rule which makes them semantically equivalent to the corresponding sentences in (2). I will not take a stand on which alternative should be chosen. In the following I will concentrate exclusively on indirect questions. I assume that any adequate solution for them can, in one way or another, be extended to cover direct questions as well.

This approach has a consequence which at first seems very counterintuitive. If direct questions are semantically equivalent to declarative sentences of a certain kind, then direct questions, too, will have a truth value. How can this be reconciled with the fact that it is pointless, even nonsensical, to inquire about the truth of *Is it raining?* One way to counter this objection is this. The conventions of our language are such that any felicitous utterance of (1a) is a request to tell whether it is raining. On any occasion where (1a) is uttered, (2a) expresses a true proposition. Consequently, the fact that it is nonsensical to inquire about the truth value of (1a) can be explained by the fact that (1a) is, so to speak, pragmatically self-verifying. Whenever it is uttered, it is true. (See Lewis 1972, Lewis and Lewis 1975, Cresswell 1973 for further discussion of the matter.)

1.2 Alternative questions and wh-questions

There is another distinction to be made. We have two kinds of questions: alternative questions (e.g. *Does Mary like John or does Mary like Bill?*), which in their indirect form are prefixed with *whether* (or *if*), and so-called wh-questions, which begin with an interrogative noun phrase or adverb such as *which girl, who, why, how*, etc.[1] So-called yes/no questions (e.g. *whether Mary likes Bill*) can be considered as syntactically "degenerate" alternative questions (*whether Mary likes Bill or Mary doesn't like Bill*).[2] These two types of questions have virtually the same syntactic distribution. Nearly all verbs which take indirect wh-questions as complements also take embedded alternative questions. A verb which doesn't allow embedded wh-questions in general doesn't complement with whether-questions either. This is illustrated in (3) and (4).

(3) (a) John knows what they serve for breakfast.
(b) John knows whether they serve breakfast.
(4) (a) *John assumes what they serve for breakfast.
(b) *John assumes whether they serve breakfast.

There are two classes of exceptions to this generalization, both of which seem marginal to me. So-called "emotive factives", such as *be amazing, be surprising*, and *bother* take wh-questions but do not allow whether-questions. Dubitative verbs, such as

doubt, question, and *be dubious*, have the opposite characteristic. This is shown in (5) and (6).

(5) (a) It is amazing what they serve for breakfast.[3]
(b) *It is amazing whether they serve breakfast.
(6) (a) *I doubt what they serve for breakfast.
(b) I doubt whether they serve breakfast.

The ungrammaticality of (5b) and the grammaticality of (6b) pose problems for me and require some special treatment. Nevertheless, it seems correct to assume, in the light of the great majority of cases of overlapping distribution, that wh-questions and whether-questions should be assigned to the same syntactic category. (In this respect my proposal differs from those offered by Cresswell 1973 and Wunderlich 1975.) Adopting a different policy on this matter results in an undesirable duplication of syntactic categories and rules. For instance, unless wh-questions and whether-questions constitute one syntactic category, the verb *depend on* must be assigned to four different syntactic categories to generate the examples in (7).

(7) (a) Whether Mary comes depends on who invites her.
(b) Whether Mary comes depends on whether Max invites her.
(c) Who is elected depends on who is running.
(d) Who is elected depends on whether Connally is running.

Having a single syntactic category for both kinds of embedded questions entails that they should also have the same kind of meaning. This conclusion is particularly relevant in a framework such as Montague Grammar, where semantic interpretation is accomplished via translation of syntactic analysis trees to expressions of intensional logic. If wh-questions and whether-questions belong to the same syntactic category, they translate to expressions of intensional logic which are of the same logical type. From this it follows that they should denote things of the same sort.

1.3 Question embedding verbs

Our next problem is to decide what kind of denotation would be appropriate for expressing the meaning of embedded questions. For this purpose, it is useful to take a look at verbs which embed indirect questions. Whatever meanings we assign to questions, it is clear that they have to combine with meanings of such verbs in an appropriate way to yield interpretations for larger phrases, such as *to know whether it is raining, to bet on who wins the election*. The following list gives an overview of question embedding verbs.

(8) (a) verbs of retaining knowledge: *know, be aware, recall, remember, forget*
(b) verbs of acquiring knowledge: *learn, notice, find out, discover*
(c) verbs of communication: *tell, show, indicate, inform, disclose*
(d) decision verbs: *decide, determine, specify, agree on, control*
(e) verbs of conjecture: *guess, predict, bet on, estimate*

(f) opinion verbs: *be certain about, have an idea about, be convinced about*
(g) inquisitive verbs: *ask, wonder, investigate, be interested in*
(h) verbs of relevance: *matter, be relevant, be important, care, be significant*
(i) verbs of dependancy: *depend on, be related to, have an influence on, be a function of, make a difference to*

This is not an exhaustive classification of question embedding verbs. The purpose of it is to give us some criteria for evaluating proposals that have been made with regard to the meaning of embedded questions. An analysis which seems attractive for some of these classes may be inappropriate for others.

1.4 Hintikka semantics for questions

A case in point is Hintikka's (1976) game-theoretical analysis of indirect questions. Under his interpretation the sentences in (9) are equivalent, and so are those in (10).[4]

(9) (a) John remembers whether it is raining.
(b) If it is raining then John remembers that it is raining, and if it is not raining then John remembers that it is not raining.
(10) (a) John remembers who came.
(b) Any person is such that if he came then John remembers that he came.

Hintikka's game-theoretical technique of interpreting indirect questions involves, in essence, replacing the interrogative clause with the corresponding that-clause. In the context of Montague grammar, the same effect could be achieved by representing embedded questions in Montague's intensional logic in the way illustrated in (11). (I will use "α" to designate the formula which results from translating α to intensional logic.)

(11) (a) $\text{whether-it-is-raining}' \equiv$
$\lambda\mathcal{W}\hat{x}\,[[\text{it-is-raining}' \rightarrow \mathcal{W}\{x, \hat{}\text{it-is-raining}\}] \wedge$
$[\neg\,\text{it-is-raining}' \rightarrow \mathcal{W}\{x, \hat{}\neg\,\text{it-is-raining}'\}]]$
(b) $\text{who-came}' \equiv \lambda\mathcal{W}\hat{x} \bigwedge y[\text{came}'(y) \rightarrow \mathcal{W}\{x, \hat{}\text{came}'(y)\}]$
(Here $\mathcal{W}$ is a variable (of type $\langle s, \langle\langle s, t\rangle, \langle\langle s, e\rangle, t\rangle\rangle\rangle$)
ranging over possible intensions of question embedding verbs.)

If so analyzed, an embedded question denotes a certain kind of function which takes as arguments intensions of question embedding verbs, such as *remember*, and yields as its value denotations of intransitive verb phrases.

One of the attractive features of Hintikka's approach is that it entails that the meaning *remember* has in (9a), where it syntactically combines with an embedded question, is the same it has in (9b), where it occurs with a that-clause. (As a matter of fact, it is slightly misleading to talk about question embedding verbs in this connection; as the translations in (11) show, when *remember* combines with *whether it is raining*, the indirect question is treated as the functor expression and the verb as its argument.) However, this aspect of Hintikka's analysis is also its weakness. It turns

out that not all verbs listed in (8) take that-clauses as complements, and for some of them, the supposed paraphrase means something different. Consider the verb *wonder*. The examples in (12) do not have the same meaning as the corresponding sentences in (13).

(12) (a) John wonders whether it is raining.
(b) John wonders who came.
(13) (a) If it is raining then John wonders that it is raining, and if it is not raining then John wonders that it is not raining.
(b) Any person is such that if he came then John wonders that he came.

There are two senses of *wonder* involved here. In (12), *wonder* means "wish to know", in (13) "be amazed at". In the first sense *wonder* embeds only questions, in the second sense only that-clauses. To make Hintikka's program work, we must "lexically decompose" *wonder* in (12) to a phrase like *wish to know*. By employing a similar method of lexical decomposition, we can also make verbs such as *ask, investigate*, perhaps even *be interested in*, fit into Hintikka's paradigm. The sentences in (14) cannot as such be paraphrased with *that* clauses by Hintikka's principles, but if *ask* is replaced by *ask someone to tell* and *investigate* by *attempt to find out*, we get marginally satisfactory results, as shown in (15).

(14) (a) John asked whether it was raining.
(b) Bill investigated what crimes had been committed.
(15) (a) If it was raining then John asked someone to tell him that it was raining, and if it was not raining then John asked someone to tell him that it was not raining.
(b) Any crime is such that if it was committed then Bill attempted to find out that it was committed.

It is clear that this necessary complication detracts considerably from the initial attractiveness of the proposal.

But this is not all. As far as I can tell, the verbs in (8i) do not lend themselves to this kind of treatment. I cannot conceive of any lexical decomposition of *depend on* which would enable us to account for the meaning of (16) along the lines Hintikka suggests.

(16) Whether Mary comes to the party depends on who invites her.

The crucial point here is that Hintikka does not assign any meaning to indirect questions as such. Instead, they are interpreted "contextually", that is, as a part of a larger construction which in addition contains a verb. Some radically different technique must be adopted for sentences like (16) which feature two indirect questions with only one verb. I conclude from this that, although Hintikka's solution works reasonably well for the cases he considers, it is not general enough to enable us to deal with all indirect questions in a uniform way. For this reason, I will not try to pursue it further.

1.5 Hamblin semantics for questions

In the following, I will adopt, with some modifications, Hamblin's (1973) semantics for questions. The main difference is that I will regard indirect questions as having the sort of denotation Hamblin proposed for direct questions. (He did not discuss indirect questions at all.) Hamblin's idea was to let every direct question denote a set of propositions, namely, the set of propositions expressed by possible answers to it. Under his analysis, a direct wh-question such as *Who came?* denotes the set of propositions expressed by sentences like "John came," "Bill came," "Mary came," and so on. Similarly, *Is it raining?* under Hamblin's account denotes the set containing the two contradictory propositions expressed by "It is raining" and "It is not raining."

I think that Hamblin's suggestion is not the best one for explicating the meaning of direct questions, since it does not provide any straightforward semantic account of the intuitive paraphrase relations discussed earlier in connection with the examples in (1) and (2). However, I believe that his idea of what questions mean can be developed to yield the right kind of model-theoretic interpretation for indirect questions. In order to implement Hamblin's original idea in the framework of Montague (1974), we could translate these indirect questions in the manner shown in (17).[5]

(17) (a) $\text{whether-it-is-raining}' \equiv$
$\hat{p}[p = \hat{}\text{it-is-raining}' \vee p = \hat{}\neg\text{it-is-raining}']$
(b) $\text{who-came}' \equiv \hat{p} \bigvee x\,[p = \hat{}\text{came}'(x)]$

I will not adopt the Hamblin treatment in quite this form. I choose to make questions denote the set of propositions expressed by their *true* answers instead of the set of propositions expressed by their possible answers. I do not have a knock-down argument against Hamblin's original proposal; as far as I can see, it could be made to work just as well as my own. However, under my analysis the meaning of verbs like *depend on* can be explicated in a more straightforward way than under his. For example, a sentence like

(18) Who is elected depends on who is running.

obviously says that the true answer to the question in the subject position depends on the true answer to the question in the object position. If indirect questions denote sets of propositions that jointly constitute a true and complete answer to the question, it is a relatively simple matter to assign the appropriate interpretation to the verb *depend on*.[6] But if we make *depend on* express a relation between possible answers, as we would have to do on Hamblin's original account, the task of defining this relation in the appropriate way becomes unnecessarily cumbersome.

Another point in favor of letting questions denote a set of true propositions is provided by verbs such as *tell, indicate*, etc. in (8c). The verb *tell* with a that-complement does not entail that what is told is true; with an indirect question it does. Consider the examples in (19).

(19) (a) John told Mary that Bill and Susan passed the test.
(b) John told Mary who passed the test.

Unlike (19a), (19b) definitely says that John told the truth. Letting the embedded question *who passed the test* in (19b) denote a set of true propositions makes it possible to explicate the meaning of *tell* in (19b) in a straightforward way. That is, we can say that (19b) is true just in case John told Mary every proposition in the set denoted by the indirect question. Having the denotation of *who passed the test* contain all the false answers as well is of no use to us; on the contrary, it introduces a complication in relating the question embedding verb *tell* to its that-complement taking counterpart. The same point can be made with regard to other question embedding verbs such as *be interested in, investigate, wonder*, etc. In all of these cases, it appears that the meaning of the verb can be satisfactorily explicated on the basis of the more restrictive hypothesis adopted here that indirect questions denote sets that only contain the propositions that jointly constitute a true and complete answer.

1.6 More on wh-questions

I will conclude this introduction with a couple of observations on wh-questions. First, there is the problem of multiple wh-questions. As illustrated in (20), there is no upper limit on the number of interrogative noun phrases that can occur in the same question.

(20) (a) Which boys date Mary?
(b) Which boys date which girls?
(c) Which boys date which girls for what reasons?

The syntactic distribution of multiple wh-questions is the same as that of single wh-questions. There is no justification for creating a special syntactic category for them. Having only one syntactic category for all indirect questions rules out any semantic interpretation of multiple wh-questions that assigns to them some different type of denotation than what is assigned to single wh- and whether-questions. For instance, it is not feasible to adopt the suggestion that has sometimes been made (e.g. Wachowicz 1974) according to which (20a) should denote a set of boys while (20b) should denote a set of boy-girl pairs. One of the advantages of Hamblin-style semantics for questions – letting questions stand for sets of propositions – is that it accommodates multiple wh-questions just as easily as questions with a single wh-phrase. Under the analysis adopted here, (20b), for example, denotes a set which contains, for each boy who loves a girl, the proposition that he loves her. The only difficulty we face is a technical one: how should we set up the syntax and the meanings of interrogative noun phrases so that the desired semantic result is obtained? Since the method has to work irrespective of the number of such noun phrases, a certain amount of ingenuity is required here. (I will return to this in section 2.8.)

The last observation in this section has to do with the relation of wh-questions and whether-questions. If they belong, as we assume here, to the same syntactic category, one might expect to find questions such as those in (21), where a wh-phrase occurs in a yes/no question.

(21) (a) *Mary isn't sure about whether to read which book.
(b) *Did Mary read which book?

However, all sentences of this kind are manifestly anomalous, unless taken as echo-questions, as questions about what was just said.[7] ((21a) could also be a quiz-show or courtroom type of "leading question".) In the light of this, it seems that we should not permit any wh-phrases to occur in a whether-question. Yet there are well-formed questions which are exactly like (21a) except that the wh-phrase is preposed, as illustrated in (22).

(22) Which book isn't Mary sure about whether to read?

I will show later how this apparent puzzle is resolved (section 2.9).

2 A Montague Analysis of Questions

After these preliminaries I will now proceed to the substantive part of this paper. The syntactic rules that I will present and the corresponding translation rules to intensional logic are intended to augment the grammatical sketch presented by Montague in his paper. "The Proper Treatment of Quantification in Ordinary English" (hence-forth, "*PTQ*"). By choosing the *PTQ* fragment as the basis, I do not mean to endorse Montague's original work over the alternative Montague-style descriptions of English worked out by B. Partee, R. Thomason, M. Bennett, and others. I choose the original as my frame of reference only because it is, at this time, more widely known than any of the later versions of Montague grammar. In the following, I will presuppose some familiarity with the syntactic categories, rules, and translations of the *PTQ* grammar.

As a first step, we need to add a new syntactic category to those discussed in *PTQ*. This category, let us call it "Q", is the category of indirect questions. We define it as $t/\!/t$, in order to get indirect questions to translate to expressions of intensional logic that denote sets of propositions (that is, to expressions of type $\langle\langle s,t\rangle,t\rangle$). This syntactic definition of the category Q does not mean that there is some syntactic rule which combines questions with sentences to make sentences. Instead, indirect questions enter into larger constructions by combining with question embedding verbs, such as *know, remember, tell, wonder*, etc. The resulting phrases are intransitive verb phrases. Correspondingly, the category of question embedding verbs is IV/Q.[8]

2.1 Proto-questions

As one might expect, I propose to derive each indirect question from a declarative sentence. The first step in generating an indirect question of whatever kind is to apply a rule which I call the Proto-Question Rule. This rule is given in (23) together with the corresponding translation rule which translates the resulting phrases to expressions of intensional logic.

(23) PROTO-QUESTION RULE (*PQ*): If $\phi \in P_t$ (that is, if ϕ is a phrase of category t), then $^{\ulcorner}?\phi^{\urcorner} \in P_Q$ (that is, $^{\ulcorner}?\phi^{\urcorner}$ is a phrase of category Q).
If ϕ translates to ϕ', then $^{\ulcorner}?\phi^{\urcorner}$ translates to $\hat{p}[\check{p} \wedge p = \hat{\ }\phi']$.

Examples: *Mary cooks* and *John eats out* are t-phrases (declarative sentences) which translate to $\text{cook}'_*(m)$ and $\text{eat-out}'_*(j)$, respectively. Consequently, *?Mary cooks* is an indirect question with the translation $\hat{p}[\check{p} \wedge p = \hat{}\text{cook}'_*(m)]$, and *?John eats out* is an indirect question with the translation $\hat{p}[\check{p} \wedge p = \hat{}\text{eat-out}'_*(j)]$.

Obviously the indirect questions generated by the above rule (let us call them proto-questions) are not proper expressions of English. They are just embryonic structures which exist in order to be developed into genuine indirect questions by rules that are yet to follow (the Alternative Question Rule, the Yes/No Question rule, and the *WH*-Quantification Rule). For reasons that will become apparent later (see section 2.7), setting up this abstract level makes it easier to generate and to assign correct meanings to indirect questions that actually do occur in English.

Before going on I will comment briefly on the translation part of (23). The translation it assigns to the proto-question *? Mary cooks*, $\hat{p}[\check{p} \wedge p = \hat{}\text{cook}'_*(m)]$ (?-Mary-cooks′ for short), is an expression of Montague's intensional logic which denotes a function from propositions to truth values, or equivalently, a set of propositions. If Mary cooks, then the denotation of ?-Mary-cooks′ is the unit set whose only member is the proposition that Mary cooks, but in case Mary doesn't cook, ?-Mary-cooks′ denotes the empty set. The purpose of translating proto-questions to intensional logic in this manner is to provide a suitable semantic basis for the derivation of the various kinds of "real" indirect questions.

2.2 Alternative questions

Indirect alternative questions such as *whether Mary cooks or John eats out* and *whether Mary likes John or Mary likes Bill* are formed from sequences of proto-questions by the rule given in (24).

(24) ALTERNATIVE QUESTION RULE (*AQ*): If $\ulcorner ?\phi_1 \urcorner, \ulcorner ?\phi_2 \urcorner, \ldots, \ulcorner ?\phi_n \urcorner \in P_Q$, then $\ulcorner$*whether* ϕ_1 *or* $\phi_2 \ldots$ *or* $\phi_n \urcorner \in P_Q$.
If $\ulcorner ?\phi_1 \urcorner, \ulcorner ?\phi_2 \urcorner, \ldots, \ulcorner ?\phi_n \urcorner$ translate to $\psi'_1, \psi'_2, \ldots, \psi'_n$, respectively, then $\ulcorner$*whether* ϕ_1 *or* $\phi_2 \ldots$ *or* $\phi_n \urcorner$ translates to $\hat{p}[\psi'_1(p) \vee \psi'_2(p) \ldots \vee \psi'_n(p)]$.

Example: *?Mary cooks* and *? John eats out* are indirect proto-questions. Consequently, by the *AQ* rule *whether Mary cooks or John eats out* is an indirect question. The translation of this alternative question, whether-Mary-cooks-or-John-eats-out′, is obtained from the translations of its constituents, that is, from ?-Mary-cooks′ and ?-John-eats-out′, by combining them in the manner specified by the translation part of the *AQ* rule. It follows from this that whether-Mary-cooks-or-John-eats-out′ $= \hat{p}$ [?-Mary-cooks′ (p) $\vee$?-John-eats-out′ (p)]. In its non-abbreviated form, the latter is $\hat{p}[\hat{p}[\check{p} \wedge p = \hat{}\text{cook}'_*(m)](p) \vee \hat{p}[\check{p} \wedge p = \hat{}\text{eat-out}'_*(j)](p)]$, which in turn is equivalent to $\hat{p}[\check{p} \wedge [p = \hat{}\text{cook}'_*(m) \vee p = \hat{}\ \text{eat-out}'_*(j)]]$. (The proof of this equivalence is trivial; I omit it here.)

What does this say about the meaning of alternative questions? The translation assigned by the *AQ* rule to the phrase *whether Mary cooks or John eats out* turns out to be equivalent to the formula $\hat{p}[\check{p} \vee [p = \hat{}\text{cook}'_*(m) \vee p = \hat{}\text{eat-out}'_*(j)]]$. This expression, and hence the English phrase it is a translation of, denotes a set of propositions

which may have zero, one, or two members depending on what the world is like. There are four possible cases: (i) if Mary doesn't cook and John doesn't eat out, then this alternative question denotes the empty set; (ii) if Mary cooks and John doesn't eat out, then it denotes the unit set containing only the proposition that Mary cooks; (iii) if Mary doesn't cook and John eats out, it denotes the unit set containing the proposition that John eats out, and (iv) if Mary cooks and John eats out it denotes the set containing both of these propositions.

In one respect this is not a completely satisfactory account of the meaning of *whether Mary cooks or John eats out*. In the intuitive sense of the term "presuppose", sentences such as those in (25) presuppose that one and only one of the presented alternatives is actually true.

(25) (a) It doesn't matter whether Mary cooks or John eats out.
(b) Does Mary cook or does John eat out?

That is, (25a) and (25b) both seem to express the speaker's belief that cases (i) and (iv) above have already been excluded from consideration and that the actual state of affairs corresponds to either (ii) or (iii). This is an important aspect of the meaning of alternative questions but it does not seem possible to account for it within the present framework of model-theoretic interpretation. In a sequel to this paper (Karttunen and Peters 1976), an extended analysis of questions is presented which is designed, among other things, to correct this shortcoming. (See section 3.3 for further discussion.)

2.3 Yes/no questions

As we pointed out earlier, yes/no questions can be considered as a subclass of alternative questions. To generate and interpret them, we need a rule similar to (24) which can apply to a single proto-question. This rule is given in (26).

(26) YES/NO QUESTION RULE (*YNQ*): If $[?\phi] \in P_Q$ then $\ulcorner$*whether* $\phi \urcorner$, $\ulcorner$*whether or not* $\phi \urcorner$, and $\ulcorner$*whether* ϕ *or not*$\urcorner \in P_Q$.
If $\ulcorner ?\phi \urcorner$ translates to ψ', then $\ulcorner$*whether* $\phi \urcorner$, $\ulcorner$*whether or not* $\phi \urcorner$, and $\ulcorner$*whether* ϕ *or not*$\urcorner$ translate to $\hat{p}[\psi'(p) \vee [\neg \bigvee q\psi'(q) \wedge p = \hat{}\neg \bigvee q\psi'(q)]]$.

Example: *? Mary cooks* is a proto-question. Consequently, *whether Mary cooks, whether or not Mary cooks* and *whether Mary cooks or not* are indirect questions. The translation part of the *YNQ* rule assigns to all of these three yes/no questions the same translation, that is, it makes them semantically equivalent. The resulting translation, $\hat{p}$[?-Mary-cooks′$(p) \vee [\neg \bigvee q$?-Mary-cooks′$(q) \wedge p = \hat{}\neg \bigvee q$?-Mary-cooks′$(q)]]$ is rather complicated; however, it can be shown that this formula is equivalent to $\hat{p}[\check{p} \wedge [p = \hat{}\text{cook}'_*(m) \vee p = \hat{}\neg\text{cook}'_*(m)]]$. It designates the unit set containing either the proposition that Mary cooks or the proposition that Mary doesn't cook, whichever happens to be the true one. (This is not obvious but I omit the proof here.) This result is precisely what we were aiming for.

Note that one of the consequences of the above analysis is that the yes/no question *whether Mary cooks* comes to be semantically equivalent to the alternative question

whether Mary cooks or *Mary doesn't cook*, although they are syntactically generated by different rules. Another point worth mentioning is that alternative questions such as (27) have, under this analysis, two syntactic derivations which result in nonequivalent translations.

(27) whether Mary smokes or Bill drinks

First of all, (27) can be derived by the *AQ* rule from the two proto-questions *?Mary smokes* and *?Bill drinks*, in which case (27) translates to intensional logic in the manner shown in (28a). (27) can also be generated from the proto-question *?Mary smokes or Bill drinks* by the *YNQ*-rule. This latter derivation results in the translation given in (28b).

(28) (a) whether-Mary-smokes-or-Bill-drinks′ (*AQ*) ≡
$\hat{p}[\check{p} \wedge [p = \hat{}\text{smoke}'_*(m) \vee p = \hat{}\text{drink}'_*(b)]]$
(b) whether-Mary-smokes-or-Bill-drinks′ (*YNQ*) ≡
$\hat{p}[\check{p} \wedge [p = \hat{}[\text{smoke}'_*(m) \vee \text{drink}'_*(b)] \vee p = \hat{}[\neg\text{smoke}'_*(m) \wedge \neg\text{drink}'_*(b)]]]$

Under the *AQ*-analysis, (27) denotes the set containing either the proposition that Mary smokes or the proposition that Bill drinks or neither or both of these depending on what the world is like. Under the *YNQ*-analysis, (27) denotes the set containing either the proposition that Mary smokes or Bill drinks or the proposition that Mary doesn't smoke and Bill doesn't drink depending on which of these is the true one. This is exactly as it should be. Note that the request in (29) requires a different kind of response depending on which of the two readings is assigned to the embedded question.[9]

(29) Tell me whether Mary smokes or Bill drinks.

If the addressee interprets the embedded interrogative as an alternative question, he might respond with "Bill drinks". Under the other interpretation, a plain "Yes" or "No" would be an appropriate response.[10]

2.4 Question embedding

The rule for embedding "real" indirect questions (excluding proto-questions) under appropriate verbs is given in (30) together with the corresponding translation rule.

(30) QUESTION EMBEDDING RULE (*QE*): If $\delta \in P_{IV/Q}$ and $\phi \in P_Q$ and ϕ does not begin with "?", then $\ulcorner\delta\phi\urcorner \in P_{IV}$.
If δ translates to δ' and ϕ to ϕ', $\ulcorner\delta\phi\urcorner$ translates to $\delta'(\hat{}\phi')$.

Example: *know* is a question embedding (a *IV/Q*-phrase) and *whether John walks* is an indirect question (a *Q*-phrase). Consequently, *know whether John walks* is an intransitive verb phrase (an *IV*-phrase). It translates to know′ $(\hat{p}[\check{p} \wedge [p = \hat{}\text{walk}'_*(j) \vee p = \hat{}\neg\text{walk}'_*(j)]]$.

By excluding proto-questions, the rule ensures that these never occur in any English sentence. Given the rule in (30) and Montague's rules for forming sentences from subject noun phrases and intransitive verb phrases, we can derive sentences such as (31a). (31b) is the corresponding translation.

(31) (a) Bill knows whether John walks.
(b) know′$(\hat{}b, \hat{p}[\check{p} \wedge [p = \hat{}\text{walk}'_*(j) \vee p = \hat{}\neg\text{walk}'_*(j)]])$

If we simplify matters a bit by ignoring intensions, what (31b) says is that a certain relation, expressed by know′, holds between Bill and the set containing either the proposition that John walks or the proposition that he doesn't walk, whichever is the true one.[11] The sentence is true just in case Bill knows that proposition.

2.5 WH-phrases

In order to generate wh-questions in this framework, one must make a number of decisions. First there is the question of what the syntactic category of interrogative noun phrases is: how should one characterize the class that contains phrases like *who, what, which man*, etc.? In Montague's system, this decision is based in part on semantic considerations. One must have an idea of how to assign appropriate meanings to wh-questions before one can decide on the syntactic classification of interrogative noun phrases. Secondly, there is the problem of setting up a suitable syntactic rule that accounts for the form of wh-questions.

What I propose to do is to treat interrogative noun phrases in a way which is similar to Montague's treatment of ordinary noun phrases. Wh-questions are to be derived by "quantifying" an interrogative noun phrase into a proto-question or a question that already contains an initial *WH*-phrase. Questions with a single interrogative noun phrase are thus derived from proto-questions which contain a subscripted pronoun (a free variable). Instead of being a simple replacement rule, as Montague's quantification rules, the new rule will in this case have an effect similar to the effect of *WH*-Movement in transformational analyses. The semantic effect of quantifying into a question with an interrogative noun phrase parallels the effect of Montague's quantification rule for common nouns in *PTQ*. This solution has a number of advantages which will become apparent as I spell out the details of the proposal.

The syntactic category of interrogative noun phrases, let us call it "*WH*", is defined as t//IV. One immediate consequence of this definition is that *WH*-phrases come to have the same type of denotation as ordinary noun phrases (Montague's T-phrases). Furthermore, for semantic reasons, we make *WH*-phrases equivalent to existentially quantified noun phrases. For example, *who* and *what*, which are basic *WH*-phrases, will have the same translation as *someone* and *something*, which are basic noun phrases.[12] Assuming that the animate/non-animate distinction is ignored, they all translate to $\hat{P} \bigvee xP\{x\}$. For non-basic *WH*-phrases, we need a rule such as (32).

(32) *WH*-PHRASE RULE (*WHP*): If $\zeta \in P_{CN}$ then $\ulcorner$*which* $\zeta\urcorner$ and $\ulcorner$*what* $\zeta\urcorner \in P_{WH}$. If ζ translates to ζ', then $\ulcorner$*which* $\zeta\urcorner$ and $\ulcorner$*what* $\zeta\urcorner$ translate to $\hat{P} \bigvee x[\zeta'(x) \wedge P\{x\}]$.

Example: Since *man* is a common noun (*CN*-phrase), *which man* is a *WH*-phrase whose translation is $\hat{P} \bigvee x[\text{man}'(x) \wedge P\{x\}]$. (This is identical to the translation of *a man*).

2.6 WH-quantification rule

Having decided on the syntactic and semantic characteristics of *WH*-phrases, let us now turn to the rule that makes use of them in forming wh-questions. A preliminary formulation of this rule is given in (33).

(33) *WH*-QUANTIFICATION RULE (*WHQ,n*): If $\alpha \in P_{WH}$ and $\phi \in P_Q$ containing an occurrence of PRO_n (i.e. either he_n, him_n, or his_n) and ϕ does not begin with *whether*, then $F_{WHQ,n}(\alpha, \phi) \in P_Q$, where $F_{WHQ,n}(\alpha, \phi)$ is defined in the following way.

A. If ϕ begins with "?", then $F_{WHQ,n}(\alpha, \phi)$ is derived by performing the following operations:
   (i) substitute α for the initial "?" in ϕ;
   (ii) delete the first occurrence of PRO_n in ϕ.

If α translates to α' and ϕ translates to ϕ', then $F_{WHQ,n}(\alpha, \phi)$ translates to $\hat{p}[\alpha'(\hat{x}_n[\phi'(p)])]$.

Examples: $F_{WHQ,1}$ (*who*, ? he_1 *dates Mary*) = *who dates Mary*; $F_{WHQ,0}$ (*which girl*, ? he_0 *sleeps*) = *which girl sleeps*; $F_{WHQ,2}$ (*what*, ? *John reads* him_2) = *what John reads*.

The syntactic part of the rule in (33) is trivial. It replaces the initial "?" with an interrogative noun phrase and deletes the first occurrence of a pronoun which has the specified subscript. This formulation of the rule is obviously much too simplistic, but let us not worry about that for the moment. The translation part of the rule is less transparent. But if you are familiar with Montague's work, you will notice a close family resemblance to the rule T15, which gives the translation resulting from quantifying into a common noun. A sample of translations resulting from the application of *WH*-Quantification is given in (34).

(34) (a) who′ (i.e. the translation of *who*) $\equiv \hat{P} \bigvee xP\{x\}$,
?-he_1-dates-Mary′ $\equiv \hat{p}[\check{p} \wedge p = \hat{}\text{date}'_*(\check{}x_1, m)]$,
who-dates-Mary′ $\equiv \hat{p}[\text{who}'(\hat{x}_1$?-he_1-dates-Mary′$(p))]$
$\equiv \hat{p} \bigvee x[\check{p} \wedge p = \hat{}\text{date}'_*(\check{}x, m)]$;

(b) which-girl′ $\equiv \hat{P} \bigvee x[\text{girl}'(x) \wedge P\{x\}]$,
which-girl-sleeps′ $\equiv \hat{p}$ [which-girl′$(\hat{x}_0$?-he_0-sleeps′$(p))]$
$\equiv \hat{p} \bigvee x[\text{girl}'(x) \wedge \check{p} \wedge p = \hat{}\text{sleep}'(x)]$;

(c) what-John-reads′ $\equiv \hat{p} \bigvee x[\check{p} \wedge p = \hat{}\text{read}'_*(j, \check{}x)]$.

I will comment briefly on the last two translations in (34). Just as in the case of whether-questions, a wh-question translates to an expression which denotes a set of propositions. Roughly speaking, the propositions in this set jointly constitute a true and complete answer to the question. Thus the translation of *what John reads*, $\hat{p} \bigvee x[\check{p} \wedge p = \hat{}\text{read}'_*(j, \check{}x)]$, denotes a set which contains, for each thing that John reads, the proposition that he reads it. If John happens to read only the New York Times and Playboy, then the indirect question *what John reads* denotes a set containing only the two propositions expressed by "John reads the New York Times" and "John reads Playboy". Correspondingly, the translation of *which girl sleeps* denotes a set which contains, for each sleeping girl, the proposition that she sleeps. In case there are no sleeping girls at all, this indirect question denotes the empty set.[13]

The formulation of the *WH*-Quantification rule in (33) is not intended as final. Several improvements and restrictions are needed to make the syntax of wh-questions to come out right. For example, Ross' (1967) Pied Piping conventions should be built into the rule to generate sentences such as the examples in (35).

(35) (a) Bill remembers to whom John gave the book.
(b) Mary asked which child's cat John rescued.

I will not elaborate on such syntactic refinements here. (For an example of how that could be done, see Thomason's (1976) relative clause rule.) I will mention only one additional specification which is required for sentences where the inserted *WH*-phrase binds a pronoun somewhere else in the sentence. An example of this type is given in (36).

(36) Which girl dislikes her mother?

For such cases, the specification of $F_{WHQ,n}(\alpha, \phi)$ given in (33) must be augmented with a third clause, spelled out in (37).

(37) – amendment to (33) –
(iii) replace each subsequent occurrence of PRO_n in ϕ with an unsubscripted pronoun whose case matches that of the replaced pronoun and whose gender matches the gender of α.

Example: $F_{WHQ,0}$ (*which girl*, ? he_0 *dislikes* his_0 *mother*) = *which girl dislikes her mother*. The translation rule in (33) is not affected by this modification.

2.7 Comments on the semantics of Wh- and whether-questions

The central idea in the preceding sections is that wh-questions are to be derived from proto-questions by a quantification rule. This rule, (33), is especially formulated in such a way that it does not apply to whether-questions. This restriction deserves an explanation. Syntactically it would be just as easy to derive *who dates Mary* from *whether* he_0 *dates Mary* as it is to derive it from? he_0 *dates Mary*. However, the meaning of the wh-question would come out wrong. Let us first recall that these questions translate into intensional logic in the manner shown in (38).

(38) (a) ?-he$_0$-dates-Mary$' \equiv \hat{p}[\check{p} \wedge p = \hat{}\text{date}'_*(\check{x}_0, m)]$
(b) whether-he$_0$-dates Mary $\equiv \hat{p}[\check{p} \wedge [p = \hat{}\text{date}'_*(\check{x}_0, m) \vee p = \hat{} \neg \text{date}'_*(\check{x}_0, m)]]$

By applying the *WHO*-rule as it is stated in (33) to *who* and? *he$_0$ dates Mary* we obtain for *who dates Mary* the translation in (39a). If we were to quantify *who* into *whether he$_0$ dates Mary*, the resulting translation would be equivalent to (39b).

(39) (a) $\hat{p} \bigvee x[\check{p} \wedge p = \hat{}\text{date}'_*(\check{x}, m)]$
(b) $\hat{p} \bigvee x[\check{p} \wedge p = \hat{}\text{date}'_*(\check{x}, m) \vee p = \hat{} \neg \text{date}'_*(\check{x}, m)]]$

As we have said, (39a) denotes the set containing all true propositions expressed by sentences of the form "x dates Mary". (39b), on the other hand, picks out the set containing all true propositions expressed by sentences of the form "x dates Mary" and "x doesn't date Mary". In other words, (39b) denotes a set which contains, for each person who dates Mary, the proposition that he dates Mary, and, for each person who doesn't date Mary, the proposition that he doesn't date Mary. This is not a suitable denotation for *who dates Mary* for the following two reasons.

First of all, if *who dates Mary* had the same denotation as (39b), it would have to be semantically equivalent to *who doesn't date Mary*, which also would come to denote the set which contains, for each person, either the proposition that he dates Mary or the proposition that he doesn't date Mary, whichever is the true one. This is not a desirable result, considering the fact that (40a) and (40b) intuitively do appear to be synonymous.

(40) (a) Bill wonders who dates Mary.
(b) Bill wonders who doesn't date Mary.

Secondly, having *who dates Mary* translate to (39b) would have the consequence that (41) would be true just in case John knows of every person whether or not this person dates Mary.[14]

(41) John knows who dates Mary.

But this would lead to the unacceptable conclusion that, in order to know who dates Mary, John must have some knowledge about all the individuals including those he has never heard of and whose very existence is unknown to him.

On the basis of such considerations, it seems best to set up the rules, as we have done, in such a way that wh-questions have the sort of denotation illustrated in (39a). This assures that the meanings of pairs like *who dates Mary* and *who doesn't date Mary* do not collapse to the same and we avoid the difficulties pointed out in connection with (41). A natural way to achieve this result is to restrict the *WH*-Quantification rule to apply only to proto-questions and not the whether-questions. (The fact that proto-questions provide us with a suitable syntactic and semantic base for the generation of alternative questions, yes/no questions, and wh-questions is precisely the reason for setting up this abstract level in the first place.)

2.8 Multiple Wh-questions

Let us now turn to cases where there are several interrogative noun phrases occurring in the same question. It turns out that only trivial modifications are needed to make (33) generate questions like the one in (42).

(42) Who dates which girl?

As it is stated in (33), the *WH*-Quantification rule only applies to questions which begin with an initial "?". The rule is undefined for questions which begin with a *WH*-phrase, such as (43).

(43) who dates him$_1$

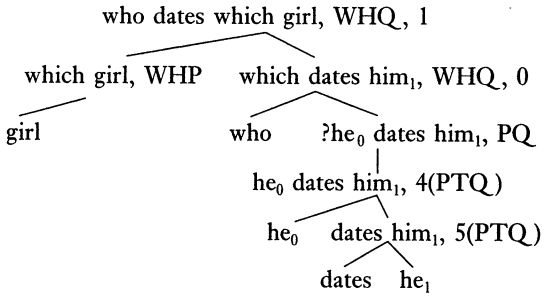
The required modification is a simple one. In case the question we want to quantify into already contains a *WH*-phrase, that is, begins with something other than "?", there is no movement. The new incoming *WH*-phrase simply replaces the specified pronoun in its original place. What we need to add to (33) for multiple wh-questions is the clause in (44).

(44) –amendment to (33), as amended in (37):
B. If ϕ does not begin with "?" then $F_{WHQ,n}(\alpha, \phi)$ is derived from ϕ by performing the following operations:
(iv) substitute α for the first occurrence of *he$_n$*, *him$_n$*, of *his$_n$* in ϕ;
(v) do as told in (iii) (given in (37)).

Example: $F_{WHQ,1}$(*which girl*, *who dates him$_1$*) = *who dates which girl*.

What about the meaning? It turns out that the translation rule originally given in (33) can be left as it is. It assigns appropriate translations to all wh-questions irrespective of how many times the *WH*-Quantification rule is iterated. This is illustrated in (45) in some detail.

(45) (a) Syntactic analysis tree:



(b) Some of the corresponding translations:
he$_0$-dates-him$'_1 \equiv \text{date}'_*(\check{x}_0, \check{x}_1)$

?-he$_0$-dates-him$_1'$ $\equiv \hat{p}[\check{}p \wedge p = \hat{}\text{date}'_*(\check{}x_0, \check{}x_1)]$
who$'$ $\equiv \hat{P} \bigvee x P\{x\}$
who-dates-him$_1'$ $\equiv \hat{p}[\text{who}'(\hat{x}_0\ ?\text{-he}_0\text{-dates-him}_1'(p))]$
$\equiv \hat{p} \bigvee x[\check{}p \wedge p = \hat{}\text{date}'_*(\check{}x, \check{}x_1)]$
which-girl$'$ $\equiv \hat{P} \bigvee y[\text{girl}'(y) \wedge P\{y\}]$
who-dates-which-girl$'$ $\equiv \hat{p}$ [which-girl$'(\hat{x}_1$ who-dates-him$_1'(p))]
$\equiv \hat{p}[\bigvee y \bigvee x[\text{girl}'(y) \wedge \check{}p \wedge p = \hat{}\text{date}'_*(\check{}x, \check{}y)]]$

As we see in (45), *who dates which girl* translates to $\hat{p}[\bigvee y \bigvee x[\text{girl}'(y) \wedge \check{}p \wedge p = \hat{}\text{date}'_*(\check{}x, \check{}y)]]$. Just as it should, according to our previously stated goal, this expression denotes the set of all true propositions expressed by sentences of the form "x dates y" where "y" picks out a girl. Increasing the number of *WH*-phrases creates no difficulties at all. For example, it is easy to see that (46a), which is derived by four applications of the *WH*-Quantification rule, translates to (46b).

(46) (a) which farmer sells which horse to which customer for what price
(b) $\hat{p} \bigvee w \bigvee z \bigvee y \bigvee x[\text{price}'(w) \wedge \text{customer}'(z) \wedge \text{horse}'(y) \wedge \text{farmer}'(x) \wedge \check{}p \wedge p = \hat{}\text{sell}'_*(\check{}x, \check{}y, \check{}z, \check{}w)]$

This concludes the first part of our discussion of the syntax of *WH*-Quantification. In the following sections we will look at some further consequences of this rule. For easier reference, the rule in (33), including the amendments in (37) and (44), is restated in (47). This new formulation also incorporates one additional principle, namely, that the inserted *WH*-phrase assumes the case of the replaced pronoun.

(47) *WH*-QUANTIFICATION RULE (*WHQ*, *n*): If $\alpha \in P_{WH}$ and $\phi \in P_Q$ containing an occurrence of PRO_n (i.e., either he_n, him_n, or his_n) and ϕ does not begin with *whether*, then $F_{WHQ,n}(\alpha, \phi) \in P_Q$, where $F_{WHQ,n}(\alpha, \phi)$ is defined in the following way.

A. If ϕ begins with "?" then $F_{WHQ,n}(\alpha, \phi)$ is derived from ϕ by performing the following operations in the given order:
(i) substitute $\bar{\alpha}$ for the initial "?" in ϕ, where $\bar{\alpha}$ comes from α by adjusting the case of α to match the case of the first occurrence of PRO_n in ϕ;
(ii) delete the first occurrence of PRO_n in ϕ;
(iii) replace each subsequent occurrence of PRO_n in ϕ by an unsubscripted pronoun whose case matches that of the replaced pronoun and whose gender matches the gender of α.

B. If ϕ does not begin with "?" then $F_{WHQ,n}(\alpha, \phi)$ is derived from ϕ by performing the following operations:
(iv) substitute $\bar{\alpha}$ for the first occurrence of PRO_n in ϕ, where $\bar{\alpha}$ is defined as in (i);
(v) do as told in (iii).

If α translates to α' and ϕ translates to ϕ' then $F_{WHQ,n}(\alpha, \phi)$ translates to $\hat{p}[\alpha'(\hat{x}_n[\phi'(p)])]$.

2.9 Excluding whether from Wh-questions

It is a direct consequence of the proposed syntactic derivation of English wh-questions that a simple wh-question cannot begin with *whether*. Consequently, neither one of the examples in (48) is derivable within the system. (Echo-questions and "leading questions" are not considered here. Cf. Note 7.)

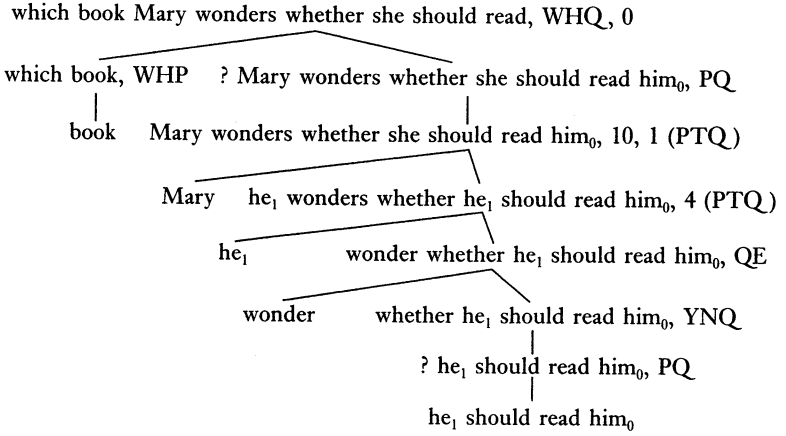
(48) (a) *Bill knows whether Mary read which book.
(b) *Did Mary read which book?

However, the *WH*-Quantification rule in (47) allows the derivation of questions such as (49), where the preposed interrogative noun phrase extracts a pronoun from an embedded whether-question.

(49) Which book does Mary wonder whether she should read?

The derivation of the corresponding indirect question is pictured by the analysis tree in (50).

(50)



Assuming that *he$_1$ should read him$_0$* translates to should$'$ ($\hat{}\text{read}'_*(\check{}x_1, \check{}x_0)$), the top line of the above analysis tree translates to an expression equivalent to the one given in (51).

(51) which-book-Mary-wonders-whether-she-should-read$'$ $\equiv$
$\hat{q} \bigvee x[\text{book}'(x) \wedge \check{}q \wedge$
$q = \hat{}\text{wonder}'(\hat{}m, \hat{p}[\check{}p \wedge p = \hat{}\text{should}'(\hat{}\text{read}'_*(m, \check{}x))])]$

It is a point in favor of the proposed analysis that the derivation of questions like (49) poses no difficulty either syntactically or semantically. However, it should also be noted

that the *WH*-Quantification rule is much too powerful in its present form. Not only can (49) be generated but so can questions such as (52).

(52) *Which man does Mary wonder whether should read *PTQ*?

That is, the rule does not take into account the fact that the extraction of the subject pronoun from the embedded whether-question in (52) results in a clearly ill-formed sentence while the extraction of the object pronoun in (49) is acceptable. Problems of this kind have been discussed in the literature (Kuno and Robinson 1972; Chomsky 1973; Hankamer 1974) in connection with the *WH*-Movement transformation, which in its unconstrained form also fails to distinguish between (49) and (52). I will return to the problem of limiting the power of the *WH*-Quantification rule in section 2.13.

2.10 Ambiguity in multiple Wh-questions

In his dissertation (1968), C. L. Baker observed that questions of the sort in (53) are ambiguous; they can be answered in two ways.

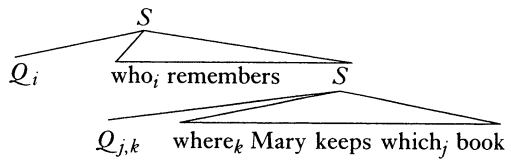
(53) Who remembers where Mary keeps which book?

The two kinds of admissible answers are exhibited in (54).

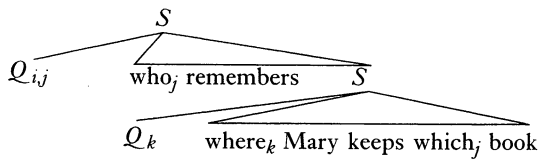
(54) (a) Bill remembers where Mary keeps which book.
(b) Joe remembers where Mary keeps *Aspects* and Max remembers where Mary keeps *Syntactic Structures*.

There have been some dissenting opinions (Kuno and Robinson 1972), but the majority of linguists (Bach 1971; Chomsky 1973; Hull 1974; Langacker 1974; Hankamer 1974) and native speakers seem to agree that Baker was right in regarding (53) as ambiguous. To account for the ambiguity, Baker proposed that each *WH*-phrase be associated with some higher *S*-node by means of indexed *Q*-markers. He represented the two readings of (53) in the manner shown in (55).

(55) (a)

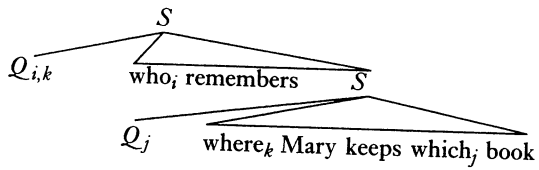


(b)



In Baker's system, a preposed *WH*-phrase moves next to the *Q*-operator which carries a matching index. This conception of *WH*-Movement rules out (56) as a possible representation of (53).

(56)



The structure in (56) cannot be generated because *where* and the *Q*-operator to which it has been moved do not have matching indices. In addition to the indexing of *WH*-phrases and *Q*-markers (or, alternatively, *WH*-phrases and *S*-nodes, as in Hankamer 1974), Baker's system requires some interpretive principle such as (57).

(57) In answering a direct question, *WH*-phrases indexed to the *Q* of the root *S* are to be replaced by non-interrogative *NP*'s.

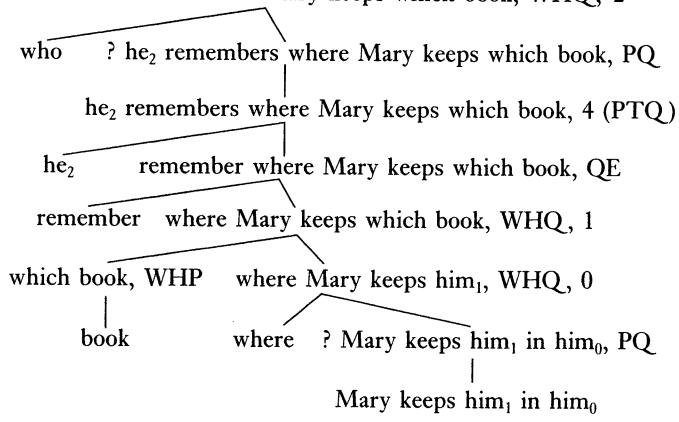
This principle pairs the structure in (55a) with answers like (54a), and (55b) with answers of the kind given in (54b). It also accounts for the intuition that neither one of the two examples in (58) is an appropriate reply to (53).

(58) (a) Joe remembers which book Mary keeps in the drawer and Max remembers which book Mary keeps under her pillow.
(b) Joe remembers that Mary keeps *Syntactic Structures* in the drawer and Max remembers that she keeps *Aspects* under her pillow.

(58a) is inappropriate because (53) does not have a reading which associates *where* with the highest *S*-node and *which book* with the embedded clause, as implied by the answer. (58b) is also inappropriate as an answer to (53); it presupposes a non-existent reading of (53) where all the three *WH*-phrases are bound to the root *S*.

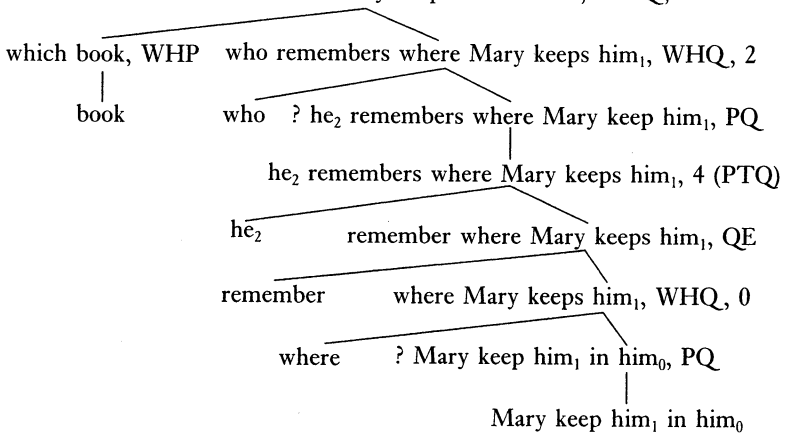
In the following I will show that, under the analysis proposed in this paper, it is not necessary to assign any indices to *WH*-phrases in order to account for the ambiguity of (53). There is also no need for additional interpretive principles such as (57). In fact, the rules given above account for the two readings of (53) without any substantive modification. We only need to improve the *WH*-Quantification rule in some appropriate way to deal with interrogative adverbs such as *where*. The two analysis trees corresponding to (55a) and (55b), respectively, are given in (59) together with their translations. (Let us assume here that *where* translates to $\hat{P} \bigvee x[\text{place}'(x) \wedge P\{x\}]$, i.e. that it has the same translation as *what place*, and let us also adopt the convenient fiction that *where* is a noun phrase rather than an interrogative adverb. This distortion has no bearing on the main issue and saves us the trouble of having to introduce new syntactic rules.)

(59) (a) who remembers where Mary keeps which book, WHQ, 2



who-remembers-where-Mary-keeps-which-book′ $\equiv \hat{q} \bigvee z[\check{}q \wedge q =$ ^remember′ $(z,$ ^where-Mary-keeps-which-book′)] $\equiv \hat{q} \bigvee z\,[\check{}q \wedge q =$ ^remember′$(z, \hat{p} \bigvee y \bigvee x[\text{book}'(y) \wedge \text{place}'(x) \wedge \check{}p \wedge p =$ ^keep′$_*(m, \check{}y, \check{}x)])]$

(b) who remembers where Mary keeps which book, WHQ, 1



who-remembers-where-Mary-keeps-which-book′ $\equiv \hat{q} \bigvee y \bigvee z\,[\text{book}'(y) \wedge \check{}q \wedge q =$ ^remember′ $(z,$ ^where-Mary-keeps-y′)] $\equiv \hat{q} \bigvee y \bigvee z\,[\text{book}'(y) \wedge \check{}q \wedge q =$ ^remember′ $(z, \hat{p} \bigvee x[\text{place}'(x) \wedge \check{}p \wedge p =$ ^keep′$_*(m, \check{}y, \check{}x)])]$

(Here keep′$_*(m, \check{}y, \check{}x)$ translates *Mary keeps y in x*.)

As shown in (59), the indirect question corresponding to (53) can be derived in two ways which differ with respect to the point at which the *WH*-phrase *which book* is introduced. It can be inserted either into the *Q*-phrase *where Mary keeps him*$_1$, as in (59a), or into the *Q*-phrase *who remembers where Mary keeps him*$_1$, as in (59b). Since *which book* is not preposed in (53), there are no other possible derivations for this sentence which would differ with respect to the order in which the three *WH*-phrases are introduced.

The two analysis trees in (59) produce two non-equivalent translations for *who remembers where Mary keeps which book*. The top line of (59a) denotes a set of all true propositions expressed by sentences of the form "*z* remembers where Mary keeps which book". The top line of (59b) picks out all true propositions expressed by "*z* remembers where Mary keeps *y*", where "*y*" denotes a book. These are just the two readings we wanted. What this example shows is that the analysis I am proposing accounts for all of Baker's observations about the syntax and meaning of (53). There is no need for additional indexing of *WH*-phrases or interpretive principles of the kind in (57).

It is important to note that it is the syntactic part, not the semantics of *WH*-Quantification, which disallows the third reading of (53), the one represented by (56) in Baker's framework. When applied to a proto-question, the quantification rule produces the same effect as the *WH*-Movement transformation. Subsequent applications of *WH*-Quantification to what now has become a wh-question only result in the replacement of pronouns by *WH*-phrases. Consequently, in (53) the preposing of *where* in the embedded wh-question indicates that *where* was quantified into a proto-question and thus has "minimal scope" with respect to the two other *WH*-phrases.

In languages, such as Turkish and Japanese, where there is no preposing of *WH*-phrases, we can expect to find more ambiguities. An example of this (due to Hankamer 1974) is given in (60a). According to Hankamer, it has all the three readings jointly possessed by the two possible English translations in (60b) and (60c).

(60) (a) Charley'nin kimi nerede vurduğunu kim hatirliyor?
Charley who were shot who remembers
(b) Who remembers where Charley shot who?
(c) Who remembers who Charley shot where?

Hankamer comments on (60a) as follows (p. 70): "even though no *WH* has undergone *WH* movement in the embedded *Q* clause, we know that one of them must be indexed to that clause; it is just impossible to tell which one."

In other words, since there is no preposing of *WH*-phrases in Turkish, the surface structure of (60a) does not betray how the embedded wh-question became a wh-question. Under my analysis, the only way to get a wh-question is to form it form a proto-question by quantifying in a *WH*-phrase. Here it could be either *kimi* "who" or *nerede* "where". A Turkish version of the *WH*-Quantification rule, which differs from the one in (47) only in how $F_{WHQ,n}(\alpha, \phi)$ is defined, can thus account for both the facts that Hankamer described in terms of Baker's indexing mechanism:

(i) at least one of the two *WH*-phrases in the embedded question in (56) has "minimal scope" (= is indexed to the embedded *Q* clause).
(ii) it can be either one (or both).

The analysis predicts, without any additional interpretive principles, that (61) is not an answer to any of the questions in (60).

(61) Bill remembers that Charley shot Orhan in the garden and Hasan remembers that Charley shot Mehmet in the forest.

2.11 Universality of the WH-Quantification rule

There is an implicit assumption in the above discussion that the basic concept of the *WH*-Quantification rule (that wh-questions are derived from proto-questions) and the associated translation rule are universal. It is worth noting here that this view leaves wide room for language-specific variations. By defining $F_{WHQ,n}(\alpha, \phi)$ in a suitable way, one can describe languages where the syntactic interaction of *WH*-phrases and other question markers differs considerably from their behaviour in English. In Russian, for instance, all wh-phrases are preposed in multiple wh-questions, as illustrated in (62). (The example is from Wachowicz 1974).

(62) Kto čto kogda skazal? "Who said what when?"
who what when said

In Japanese there is no preposing (or postposing) at all and the question particle, *ka*, which by itself marks yes/no questions, is also retained in wh-questions. (Examples from Kuno 1973, p. 13.)

(63) (a) Kore wa hon desu *ka*? "Is this a book?"
this book is
(b) John ga dare o butta *ka* siranai. "I don't know whom John hit?"
John who hit know-not

Variation of this kind is easily accommodated under the proposed analysis.

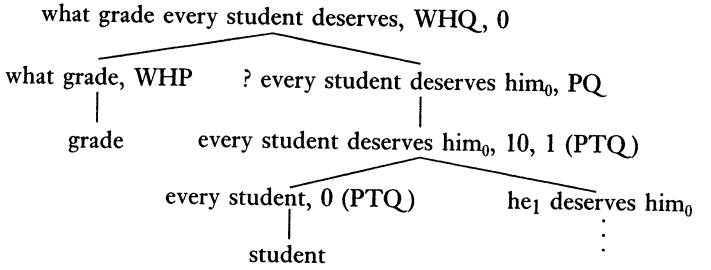
2.12 Other scope ambiguities

One of the consequences of treating *WH*-phrases in the proposed manner is that, in a simple wh-question, the interrogative noun phrase always has wider scope than any non-interrogative noun phrase. For example, in (64) *what grade* has wider scope than *every student*.

(64) what grade every student deserves

This indirect question can only be derived in the manner shown in (65a); the resulting translation is given in (65b).

(65) (a)

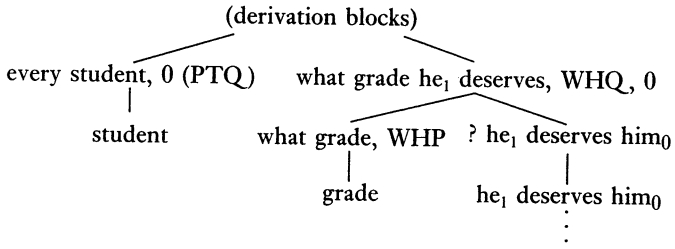


(b) what-grade-every-student-deserves $' \equiv \hat{p} \bigvee x[\text{grade}'(x) \wedge \check{}p \wedge p = \hat{} \bigwedge y\ [\text{student}'(y) \rightarrow \text{deserve}'_*(\check{}y, \check{}x)]]$

In other words, (64) denotes the set of all true propositions expressed by sentences of the form "every student deserves grade x." This set is non-empty just in case there is a grade that every student deserves.

Any attempt to reverse the scope of quantifiers in (64) fails. This is shown in (66).

(66)



In (66), *he*$_1$ cannot be replaced by *every student* because *what grade he*$_1$ *deserves* belongs to the category of indirect questions and, therefore, is not of the sort required by the quantification rules in *PTQ* for ordinary noun phrases (S14, S15, and S16). Furthermore, for semantic reasons these rules cannot be generalized to permit quantification into *Q*-phrases.[15]

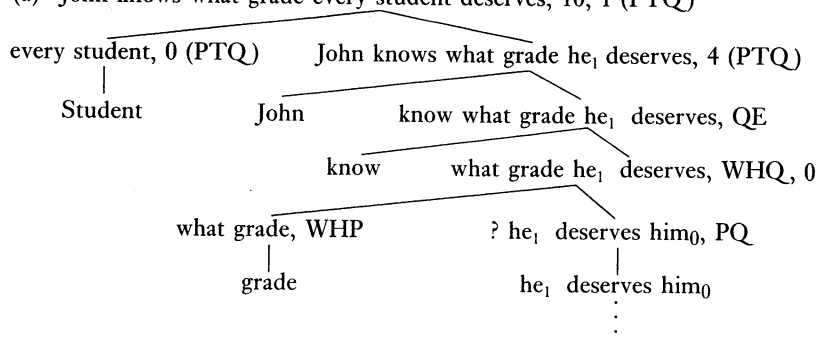
This result seems at first problematic because sentences such as (67) are clearly ambiguous with respect to quantifier scope.

(67) John knows what grade every student deserves.

On one of its readings, which we can easily obtain by embedding (64) under *know* and connecting the result with *John*, (67) means that John knows what grade it is that every student deserves. However, (67) also has another reading which does not imply such uniformity of student performance – in fact this is the more natural one of the two. In the second sense of (67), *every student* is understood to have wider scope than *what grade*.

This second reading cannot be derived in the manner illustrated in (66). Under the proposed analysis, it can only be obtained by quantifying in *every student* at the very last stage of the derivation. This is shown in (68a) and the resulting translation is given in (68b).

(68) (a) John knows what grade every student deserves, 10, 1 (PTQ)



(b) John-knows-what-grade-every-student-deserves′ ≡ $\bigwedge y$[student′(y) → know′ ($\hat{}j, \hat{p} \bigvee x$[grade′(x) ∧ $\check{}p \wedge p = \hat{}$deserve′$_*$($\check{}y$, $\check{}x$)])]

As (68b) shows, under this analysis (67) is true just in case John knows, for each student y, the true propositions expressed by "y deserves grade x". Obviously this does not implicate that every student deserves the same grade, like the first reading does, although it does implicate that every student deserves some grade or other.

It is interesting to observe in this connection that direct questions exhibit just the sort of ambiguity discussed above. Although (64) seems unambiguous, the corresponding direct question, (69) is ambiguous in exactly the same way as (67). (This observation is due to Hull 1974.)

(69) What grade does every student deserve?

In one of its two senses, (69) requests information as to the membership of the set of true propositions expressed by sentences like "every student deserves grade x." In this sense, (69) can be answered by saying, for example, "Every student deserves a *C*–," or simple, "*C*–." Under the second interpretation, (69) is not one but several requests for information at once. It can be paraphrased roughly as "For every student y, I ask you (to tell me) what grade y deserves." This reading of (69) requires multiple answers; for example, "Mary deserves an *A*, Bill deserves a *B*, ... " and so on for each of the students.

The existence of this second reading for (69) is consistent with the views expressed in section 1.1 about the relation between direct and indirect questions. If direct questions are equivalent to declarative sentences of a certain kind containing the corresponding indirect question, we should indeed find that (69) is ambiguous with respect to quantifier scope in the same way as (67).

2.13 Island constraints on WH-Quantification

When applied to a proto-question, the *WH*-Quantification rule of English has the same effect as the *WH*-Movement transformation. An adequate formulation of the syntactic part of the rule, therefore, should incorporate all the "island constraints" on movement transformations discussed in Ross (1967) and in many subsequent studies. The

examples in (70) illustrate the kind of ungrammatical sentences that are excluded by Ross' constraints.

(70) (a) *Mary found out what subject Bill wants to meet a girl who studies.
(b) *John wonders who that the president fired was not mentioned in the press.
(c) *Max discovered which boy Bill met Jane and.

Relative clauses, sentential subjects, and coordinate constructions are islands from which no constituent can be extracted by movement rules.

However, it will not suffice to invoke Ross' constraints just in cases where *WH*-Quantification results in the extraction of a pronoun from an island. In the above constructions, replacement of a pronoun by a *WH*-phrase results in questions of dubious grammaticality even in cases where no "movement" is involved. This is shown by the strangeness of the multiple wh-questions in (71). (N.B. Here "#" is a mark of dubious grammaticality.)

(71) (a) # Who wants to meet a girl who studies what subject?
(b) # Where was that the president fired whom not mentioned?
(c) # Who met Jane and which boy?

This correspondence between extraction possibilities and quantifying in ("quantifier lowering" in the terminology of generative semantics) was first noticed by J. D. McCawley (in 1968) and it has been discussed at length in Lakoff 1970, Postal 1974, and other works (though not with respect to interrogative noun phrases). R. Rodman (1976) has proposed a way to introduce island constraints into Montague grammar. His solution is to let Montague's relative clause and conjunction rules mark all the unbound pronouns in the resulting constructions in such a way that they cannot be extracted or replaced by quantification rules. The only quantification-type operation affecting such island pronouns ("superscript *R* variables", as he calls them) is binding. The same technique could also be used to capture the effect of Ross' Sentential Subject Constraint. Since the *WH*-Quantification rule in (47) is like Montague's quantification rules in all the relevant respects, by adopting Rodman's proposal, all sentences of the type in (70) and (71) can be excluded. As Rodman points out, the fact that Montague grammar makes it easy to associate constraints on extraction to restrictions on quantifier scope gives it the same advantage that generative semantics has over the standard version of transformational grammar.

Unfortunately, it is not clear that the connection between extraction constraints and scope phenomena is as close as Rodman and generative semanticists have claimed. There are apparent counterexamples, at least in the case of relative clauses. One such example (due to Cooper 1975) is given in (72).

(72) John wants to date every girl who goes out with a professor who flunked him out of Linguistics 101.

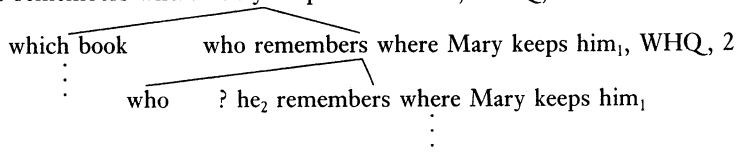
(72) seems to have a reading where the existential quantifier has wider scope than *every*, contrary to what Rodman's constraint predicts. In other words, the quantification rule

for noun phrases should permit the replacement of *him*$_1$ in *he*$_0$ *wants to date every girl who goes out with him*$_1$ by *a professor who flunked him*$_0$ *out of Linguistics 101*. The extraction constraints are stricter; there is no question about the ungrammaticality of (73).

(73) *The professor whom John wants to date a girl who goes out with is a boring lecturer.

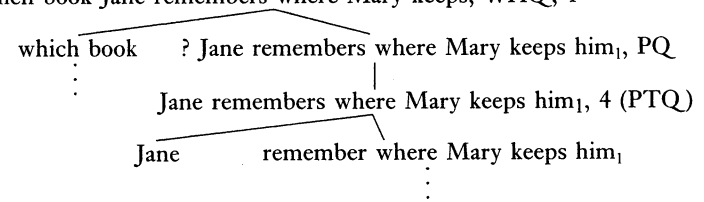
In the case of *WH*-Quantification, it also appears that the constraints on extraction are stricter than the constraints on replacement. The examples in (70) seem a lot worse than those in (71). Consider also the kind of examples discussed in section 2.10. Example (53) seems to have a reading where *which book* has wide scope, that is, an analysis tree like (74), which duplicates the top part of (59b), should be permissible.

(74) who remembers where Mary keeps which book, WHQ, 1



Here there is no movement because the main clause already begins with a wh-phrase. However, in a case like (75), where the application of *WH*-Quantification results in the extraction of a pronoun from an embedded wh-question, the rule perhaps should be prevented from applying. (76) is the corresponding direct question.

(75) which book Jane remembers where Mary keeps, WHQ, 1



(76) # Which book does Jane remember where Mary keeps?

Although there clearly is a great similarity between extraction constraints and restrictions on quantifier scope, this connection seems too imperfect to justify the adoption of a policy on quantification which is as inflexible as Rodman's "superscript *R* variable"-convention. There is also another reason to be skeptical of it. Recent work on extraction islands (Erteschik 1973; Rodman 1975) suggests that there is little hope for finding clear-cut criteria for grammaticality even in the extraction cases. It is now proposed that there is no sharp distinction between islands and non-islands, that islandhood is a graded notion. Furthermore, the acceptability of a given extraction also seems to depend on the "primacy" of the extracted term. Consider the contrast between (77a) and (77b).

(77) (a) Which book does Mary wonder whether she should read?
(b) *Which man does Mary wonder whether should read *PTQ*?

(77a) sounds marginally acceptable, which presumably indicates that whether-clauses are "weak extraction islands". The fact that (77b) is so much worse is said to indicate that subject terms are higher on the "primacy scale", hence less extractable, than objects. It is not clear how the interplay of such factors is to be taken into account in a formal description of English syntax. In any case, it is not evident that a transformational approach to this problem is superior to the one proposed here.

2.14 Other constraints on WH-Quantification

In addition to island constraints, there may be other restrictions on *WH*-Quantification. Kuno and Robinson (1972), who present their findings in Baker's framework, propose the three constraints given in (78), (82), and (89).

(78) CLAUSE MATE CONSTRAINT: Multiple *WH*-phrases bound by the same *Q* must be clausemates at the time of application of *WH*-Movement.

This is designed to account for the sort of data displayed in (79).

(79) (a) Tell me who is a better linguist than who.
(b) *Tell me who is a better linguist than who is.
(c) Tell me what seemed to whom to be idiotic.
(d) *Tell me to whom it seemed (that) what was idiotic.

As Hankamer (1974) points out, there are many counterexamples to (78); most speakers don't find anything wrong with examples such as (80), which is ruled out by this constraint.

(80) Tell me which student expects that he will pass which exam.

The Clause Mate Constraint would also disallow one of the two readings of (53). (Kuno and Robinson find (53) unambiguous.)

Although it is clear that the Clause Mate constraint is too general, there are cases, such as those in (79), where it makes correct predictions. However, if one thinks of the matter in the Montague framework, it seems that these examples do not show anything more than what we observed above: the restrictions on the replacement of pronouns by *WH*-phrases are similar (although weaker) than the constraints on extraction. The extraction cases corresponding to the bad examples in (79) also have to be ruled out, as shown in (81).

(81) (a) Tell me who Bill is a better linguist than.
(b) *Tell me who Bill is a better linguist than is.
(c) Tell me what seemed to Harry to be idiotic.
(d) *Tell me what it seemed to Harry (that) was idiotic.

The ungrammaticality of (81b) and (81d) presumably is due to some combination of island constraints and primacy considerations. If we can make the *WH*-Quantification rule work correctly in the case of (81), then the examples in (79) are easily accounted for. Consequently, there does not seem to be any need for a special constraint of the sort proposed in (78).

The second one of the three Kuno and Robinson constraints is given in (82).

(82) CROSSING CONSTRAINT: No *WH*-phrase can be preposed crossing over another *WH*-phrase except that *when* and *where* can cross over a *WH*-phrase which is not in the subject position.

This is designed to account for the kind of data illustrated in (83).

(83) (a) Tell me who killed whom.
(b) *Tell me whom who killed.
(c) Tell me who went where.
(d) *Tell me where who went.
(e) Tell me what you bought where.
(f) Tell me where you bought what.

This constraint also seems too general. Many speakers who reject (83b) and (83d) nevertheless accept sentences like (84) which are similar in other respects except that interrogative pronouns are replaced by longer *WH*-phrases.

(84) # Which girl did which boy kiss?

Furthermore, as Hankamer notes, all examples of the sort in (85), where a pronoun is extracted from an embedded wh-question, are counterexamples to the Crossing Constraint.

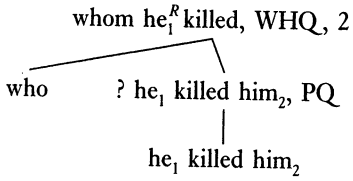
(85) (a) Tell me which book Bill said he couldn't remember who wrote.
(b) I wonder what Bill was saying he didn't know what to do about.
(c) Can you guess which crimes the FBI doesn't know how to solve?

However, it appears that (82) is at least partially correct. It turns out that, in the framework proposed here, one can easily reformulate the Crossing Constraint in such a way that it rules out (83b) and (83d) but permits the grammatical examples in (83) as well as those in (85). (This was pointed out to me by Stanley Peters.) In its new form the constraint of course does not pertain to crossover; instead, it is a restriction on quantifying in. The following change in (47) has the intended effect of (82).

(86) – amendment to (47): replace (ii) by
(ii)′ delete the first occurrence of PRO_n in ϕ and replace all unbound pronouns to the left of it by the corresponding restricted pronouns (Rodman's superscript *R* variables) unless α is an interrogative adverb (*when, where, how*, etc.) in which case only the pronoun in the subject position is so affected.

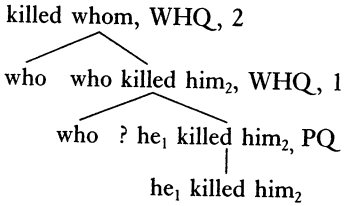
The gist of this amended version of (ii) is that, once a wh-question is formed from a proto-question by replacing "?" with a *WH*-phrase which is not an interrogative adverb, then all the remaining pronouns to the left of the deletion site become "closed", as far as quantifying in or extraction is concerned. An attempt to derive (83b), for example, blocks at the point shown in (87).

(87)



Given Rodman's convention, the restricted pronoun he_1^R, in the top line of (87) cannot be replaced by a *WH*-phrase, hence there is no way to derive (83b).[16] On the other hand, the change from (ii) to (ii)′ has no effect as far as the derivation of (83a) is concerned. This is shown by the analysis tree in (88).

(87)



Since the *WH*-phrase here are inserted "from left to right", no restricted pronouns are created. It is easy to see that the same is true of the derivations of (85a) and (85b). The reason why (85c) is not blocked is that the insertion of *how* leaves a pronoun in the object position unrestricted. All things considered, it seems that the statement in (86) is a more adequate formulation of the constraint than what Kuno and Robinson originally proposed.

The last of the three constraints Kuno and Robinson discuss is given in (89).

(89) DOUBLE DISLOCATION CONSTRAINT: No more than one constituent can be moved from its original location.

In the data they discuss, there are only two examples where this restriction plays an essential role. These are given in (90).

(90) (a) *What did John say where he bought?
(b) *Where did John say what he bought?

According to their interpretation, sentences of this sort are bad because two interrogative noun phrases have been moved away from their original location in the embedded question. Note that these are just the sort of examples we discussed earlier in section

2.13 (76). Since there are clear counterexamples to the double dislocation constraint, such as (85b) and (85c) above, I don't think it is the right explanation. The difference is that in (90) the embedded wh-question contains a finite verb, in (85b) and (85c) the final extraction is from an infinitival complement. The best I can suggest here is that it is this feature of (90a) and (90b) which makes them unacceptable. That is, as far as extraction goes, wh-questions with a finite verb are stronger islands than those without one. The same is true of whether-questions as well. Although both examples in (91) are acceptable, (91b) is less so than (91a).

(91) (a) Which book does Mary wonder whether to read?
(b) Which book does Mary wonder whether she should read?

In conclusion, of the three constraints proposed by Kuno and Robinson, only the second one, the Crossing Constraint, looks basically correct as a syntactic principle for English, though not in the form they state it. A more adequate formulation of the constraint has been proposed above. There are, however, many additional problems concerning *WH*-Quantification that still remain to be solved. See Chomsky (1973) for a comprehensive survey of problematic data and for discussion of other proposals for constraining *WH*-Movement in a transformational framework.

3 Discussion

In the following I will first briefly summarize the main points of my analysis of questions and then comment on its relation to previous analyses.

3.1 Summary

I start by accepting the common view that indirect questions are best analyzed by relating them to declarative (alternatively, imperative) sentences of a certain kind which contain the corresponding indirect question. Consequently, my major objective is to give an adequate account of indirect questions. I leave open for the time being the problem of exactly how direct questions are to be derived.

I consider indirect alternative and yes/no questions and single and multiple wh-questions as belonging to the same syntactic category. According to Montague's theory of grammar, it follows from this that all indirect questions should be semantically interpreted in a uniform way; they must have the same type of meaning. Modifying a suggestion by C. L. Hamblin, I propose that indirect questions denote sets of propositions. Roughly speaking, the meaning of an indirect question is identified with a function which picks out, for any given situation, the set of propositions which in that situation jointly constitute a complete and true answer to the question. The denotation of *whether John walks* in a given situation, is a set whose only member is either the proposition that John walks or the proposition that John doesn't walk depending on which of these happens to be the true one. The denotation of *who walks* is the set of true propositions expressed by sentences of the form "*x* walks". This

semantic analysis seems to have the right degree of generality to enable us to account for the meaning of all kinds of constructions that embed indirect questions.

The syntax of English questions is described by extending the description of English given by Montague in *PTQ* with the following syntactic categories and rules (here informally outlined):

New syntactic categories:

$Q(= t//t)$ – category of indirect questions
IV/Q – category of question embedding verbs (*know, remember, wonder, ask, decide, investigate, determine*, etc.)
$WH(= t//IV)$ – category of interrogative noun phrases (*who, what, which boy, what book*, etc.)

New syntactic rules:

PROTO-QUESTION RULE (*PQ*) – forms indirect proto-questions from declarative sentences by prefixing them with "?".
ALTERNATIVE QUESTION RULE (*AQ*) – forms alternative whether-questions from sequences of proto-questions by removing "?"'s and inserting *whether* and *or* in appropriate places.
YES/NO QUESTION RULE (*YNQ*) – forms yes/no whether-questions by substituting *whether* (*or not*) for "?".
WH-PHRASE RULE (*WHR*) – forms interrogative noun phrases from common nouns by prefixing them with *which* or *what*.
WH-QUANTIFICATION RULE (*WHQ*, *n*) – forms wh-questions by inserting a *WH*-phrase into a proto-question or a wh-question that contains an occurrence of the corresponding unbound pronoun (that is he_n, him_n, or his_n). The pronoun is either replaced in its original location by the incoming *WH*-phrase or deleted in case the *WH*-phrase is preposed. The rule also makes a number of other changes which involve gender agreement of anaphoric pronouns, case assignment, and restrictions on further applications of *WH*-Quantification.
QUESTION EMBEDDING RULE (*QE*) – forms intransitive verb phrases by combining question embedding verbs with whether- and wh-questions.

As in *PTQ*, each of the six syntactic rules above is accompanied by a translation rule which assigns to each resulting English construction an appropriate expression of intensional logic as a representation of its meaning.

The main innovation in the proposed syntactic analysis is the derivation of wh-questions. The category of interrogative noun phrases (*WH*-phrases) is syntactically distinct from Montague's category of ordinary noun phrases (*T*-phrases). However, semantically they are of the same type. In fact, the meaning assigned to *WH*-phrases such as *who* and *which man* is the same as the meaning of the existentially quantified noun phrases *someone* and *a man*. The *WH*-Quantification rule is syntactically more complicated than Montague's quantification rules, because it also does the work of the *WH*-movement transformation, but its semantic effect is similar to the effect of Montague's rules for quantifying into common nouns and intransitive verb phrases.

3.2 Comments on previous analyses of Wh-questions

The main advantage of treating *WH*-phrases in this manner is that the derivation of single and multiple wh-questions poses no problems either syntactically or semantically. The proposal accounts in a very natural way for many properties of such questions which under previous analyses require additional descriptive apparatus. It also makes it relatively easy to relate the island constraints on extraction to facts about the scope of *WH*-phrases, which the standard transformational analysis cannot do.

In spite of its unfamiliar appearance, this new analysis of English wh-questions is in many respects similar to the transformational description first developed by J. Katz and P. Postal (1964) and subsequently improved in Baker (1968). In fact, Baker's two rules for deriving wh-questions constitute a close analogue to what is proposed here. His first rule applies to sentences prefixed with the symbol *Q* and inserts a *WH*-marker to a constituent containing the element *some* (or THAT). The rule also marks the scope of the resulting *WH*-phrase by assigning matching indices to the *Q* and *WH*-symbols. The second rule moves a *WH*-phrase to the beginning of the sentence that constitutes its maximal scope. The only substantive syntactic difference, aside from those that come from doing the analysis in Montague's framework, is that my description makes it possible to dispense with Baker's ad hoc convention for indicating the scope of *WH*-phrases. Since the two descriptions are so close in other respects, it is not surprising that the new analysis is just as successful as Baker's in accounting for the range of possible readings of multiple wh-questions.

The idea that wh-phrases are quantifier-type expressions is not in itself new; it has been discussed by Baker (1968) and Chomsky (1975), among others, who, however, do not concern themselves with the semantic interpretation of wh-quantifiers. The semantics of wh-quantification has been discussed by Hintikka (1974, 1976) and Hull (1974), but the new proposal seems superior to theirs in the following respects:

(i) it relates wh-questions to yes/no questions in a very natural way.
(ii) it enables us to generate and interpret multiple wh-questions with the same rules that are needed anyway for single wh-questions, and
(iii) it accounts for some of the puzzling properties of multiple wh-questions in an especially natural way with less descriptive apparatus than any of the previous proposals.

3.3 Outstanding problems

The analysis of questions proposed in this paper is in some respects tentative. The specific formulations of the syntactic rules undoubtedly can be improved with further work. This is especially true of the *WH*-Quantification rule. The present shortcomings of that rule are mostly due to our current ignorance concerning the proper syntactic constraints on quantifier scope and movement transformations, not to carelessness or to the choice of the particular descriptive framework.

The relation between direct and indirect questions yet remains to be spelled out in detail. The view advocated in section 1.1 is essentially the traditional "performative hypothesis," which receives some support from the facts about scope ambiguity discussed in section 2.12. The details, however, need to be worked out, and there remain other viable alternatives (e.g. see Cresswell 1973) that should be explored. Some difficulties can be expected in the case of direct negative yes/no questions. Under the analysis proposed here for indirect questions, *whether this isn't a pretty dress* is semantically equivalent to *whether this is a pretty dress.*[17] The corresponding direct questions, *Isn't this a pretty dress?* and *Is this a pretty dress?* are quite different in meaning. Depending on intonation, direct negative yes/no questions conventionally implicate (in the sense of Grice 1975) that the speaker has or used to have a definite opinion on the matter. The present version of model-theory makes no provision for describing this aspect of meaning.

Further thrust in this direction beyond current model theory is provided by the problems mentioned earlier (sections 2.2 and 2.6) in connection with indirect questions. As it stands, the analysis does not cover what has often been referred to as "presuppositions of questions;" namely, it does not incorporate the following two intuitions. First, alternative questions (*whether Mary loves Bill or Mary loves John*) implicate that one and only one of the presented alternatives is true. Secondly, wh-questions (or search questions, as I would now prefer to call them, see fn. 1) give rise to an existential implicature. For example, *which linguist Mary loves* implicates that the set of propositions denoted by the indirect question is non-empty, i.e. that Mary loves some linguist.

The problem of the conventional implicatures of indirect questions has been successfully treated in an already published sequel to this paper (Karttunen and Peters 1976). This new analysis extends the present semantic description of indirect questions by means of the techniques first proposed in Karttunen and Peters (1975) for obtaining model-theoretic interpretations that recognize two aspects of meaning: what is directly expressed by a phrase and what is conventionally implicated by it. Further, the new analysis also solves in part the so-called projection problem for conventional implicature. It shows in an explicit and precise way how the conventional implicatures that accompany embedded questions can be "inherited" or "filtered" by the constructions that embed them. By so doing, it also paves the way for assigning correct implicatures to direct questions. The special difficulties posed by direct negative yes/no questions can hopefully also be solved along the same lines.

Notes

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1 Alternative questions have also been called nexus-questions; another name for wh-questions is *x*-questions (Jespersen 1924). The term "wh-question" is somewhat misleading because the presence or absence of this marker does not precisely correlate with the intended division. Note that whether-questions are alternative questions, not wh-questions, and that questions beginning with *how* are wh-questions. A better term for wh-questions might be "search questions", since semantically these questions involve a search for a suitable value for a variable (single search questions) or a set of variables (multiple search questions), not a choice between alternative propositions. One might also consider using the contrasting term "choice question" for alternative questions. In this article, however, I will stick to the current terminology.

2 In written English, questions like *Do you want tea or coffee?* can be interpreted either as simple yes/no questions ("Do you want either tea or coffee?) or as elliptic forms for longer alternative questions ("Do you want tea or do you want coffee?"). See section 2.3 for a discussion of this type of ambiguity.

3 One might argue that the phrase *what they serve for breakfast* in (5a) is not an indirect question at all but an entirely different construction called the free relative, as in

(i) What they serve for breakfast is too fattening for me.

One characteristic of indirect *wh*-questions which distinguishes them from free relatives (see Baker 1968) is that they may contain more than one wh-phrase. The fact that sentences like

(ii) It is amazing who they nominated for which office.

are grammatical seems to indicate that *be amazing* indeed embeds indirect wh-questions.

4 Actually Hintikka thinks that (10a) – and wh-questions in general – are ambiguous between a universal and an existential reading of the interrogative quantifier. In the latter sense (10a) would be equivalent, not to (10b) but, to the sentence.

(i) Someone came and John remembers that he came.

It appears that Hintikka is mistaken on this point. If (10a) had such a reading, it should be possible to say without any contradiction

(ii) John remembers who came although he doesn't remember that Mary came.

However, sentences of the above sort are generally felt to be contradictory (cf. Baker 1968, p. 50). In other words, (10a) is true just in case John remembers of all the people who came that they came.

Hintikka may have been misled by the fact that *direct* wh-questions often get asked with the understanding that an exhaustive answer is not expected. This a person who asks

(iii) Who, for instance, came to the party last night?

may be perfectly satisfied with an answer that lists some but not all of the people who came to the party. (The phrase *for instance* seems to be a conventional device for indicating that exhaustiveness is not desired.) Since indirect wh-questions do not admit any "for instance"-interpretation, I am inclined to think that there is no semantic ambiguity of the sort Hintikka postulates. What we do need, of course, is an account of the pragmatic fact that direct wh-questions can be used to solicit more or less complete answers depending on the particular question and the circumstances of its use. As far as I can see, this task is not facilitated at all by postulating a strict semantic dichotomy between universal and existential wh-questions. Besides, in the case of indirect wh-questions, this would lead to wrong results. Multiple wh-questions in particular do not seem to have as many possible interpretations as Hintikka assumes.

In this paper wh-questions are always interpreted "universally" although the wh-words themselves are interpreted as existential quantifiers. (See the next section for details.)

5 As (17) indicates, Hamblin interprets questions "universally" i.e. as denoting all propositions of a certain kind. This feature of his treatment is implicit in (17) in the use of "$\hat{p}$", which abbreviates "λp". Note that the quantifier corresponding to *who* in (17b) is the existential quantifier. (Cf. fn. 4.).

6 For example, this could be done in the following way. Let depend-on′ be the translation of *depend on*, let $\mathcal{F}$ and $\mathcal{H}$ be variables ranging over intensions of indirect questions, i.e. over properties of propositions, and let g be a variable over functions from sets of propositions to sets of propositions. As the first approximation, let us consider the possibility of constraining the interpretation of depend-on′ with the meaning postulate in (i).

(i) $\text{depend-on}'(\mathcal{F})(\mathcal{H}) \leftrightarrow \bigvee g \Box g(\check{}\mathcal{F}) = \check{}\mathcal{H}$

This meaning postulate says, in essence, that the denotation of the question in the subject position of *depend on* is determined in all possible worlds by the denotation of the question in the object position. For example, (18) would come out true just in case the election has a certain necessary outcome for each selection of people that might be running. That is, in any two situations where the same people are running, the same person wins.

The above meaning postulate is undoubtedly too strong for the verb *depend on*, although it might be appropriate for a phrase like *be determined by* or *depend exclusively on*. Sentence (18), for example, does not rule out the possibility that the outcome of the election might also depend on, say, when the election is held in addition to being dependent on who the candidates are. To do justice to the intuition that *depend on* only means something like "be determined in part by", we must replace (i) with

(ii) $\text{depend-on}'(\mathcal{F})(\mathcal{H}) \leftrightarrow \bigvee g \bigvee \mathscr{C}[\Box g(\check{}\mathcal{F}, \check{}\mathscr{C}) = \check{}\mathcal{H} \wedge \neg \bigvee f \Box f(\check{}\mathscr{C}) = \check{}\mathcal{H}]$,

where $\mathscr{C}$ is of the same type as $\mathcal{F}$ and $\mathcal{H}$ representing whatever other factors might influence the extension of $\check{}\mathcal{H}$ in addition to the membership of $\check{}\mathcal{F}$. (The second conjunct in (ii) is needed to make sure that these other factors are not by themselves decisive, i.e. that the answer to the question in the subject position indeed in part depends on the answer to the question in the object position.)

7 In echo-questions the wh-phrase has the widest possible scope. As an echo-question, (21a) is equivalent to

(i) Which book isn't Mary sure about whether to read?

This involves taking (21a) as a whole to be a direct question, not a declarative sentence containing an indirect question, as indicated here. Note that an acceptable answer to (21b) – taken as an echo-question – must itself be a question, e.g. "Did Mary read *Syntactic Structures*?". The analysis of such "second order" questions lies outside the scope of this paper.

8 For the sake of making the presentation shorter and easier to follow, I will discuss here only verbs which embed indirect questions in the object position. More syntactic categories are obviously needed to accommodate verbs like *be important* and *depend on*.

9 In spoken English (29) can be disambiguated by a rising intonation contour on *smokes* followed by a drop in pitch and a falling intonation on *or Bill drinks*. This marks the embedded clause as an alternative question. Some languages make the corresponding distinction morphologically. Finnish, for example, marks alternative questions with a special form of "or" (*vai* in alternative questions, *tai* elsewhere).

10 Due to the shortcomings on Montague's syntactic framework, the present analysis cannot account for the related ambiguity in sentences such as

(i) Tell me whether Bill wants coffee or tea.

In order to produce the alternative question reading for (i) one ought to have a transformational rule which generates *whether Bill wants coffee or tea* from *whether Bill wants coffee or Bill wants tea*, where the latter has been derived by the *AQ* rule. There are no syntactic operations of this kind in *PTQ*. By treating *coffee or tea* as a disjunctive noun phrase, as Montague does, we can generate *whether Bill wants coffee or tea* only by the *YNQ* rule from *?Bill wants coffee or tea*. In other words, the only reading we get for (i) is the one which calls for a simple yes/no answer.

11 Actually we should distinguish here between the question embedding verb $know_{IV/Q}$ and its that-clause embedding counterpart $know_t$. These are distinct lexical items under the proposed analysis and belong to different syntactic categories. To assign proper semantic interpretations to sentences containing $know_{IV/Q}$, we need a meaning postulate that relates their translations, $know'_{IV/Q}$ and know', in the appropriate way. As the first approximation, let us consider the following proposal.

$$\bigwedge x \bigwedge \mathcal{F} \Box[\text{know}'_{IV/Q}(x, \mathcal{F}) \leftrightarrow [\bigwedge p[\mathcal{F}\{p\} \rightarrow \text{know}'_t(x, p)] \wedge [\neg \bigvee q \mathcal{F}\{q\} \rightarrow \text{know}'_t(x, \hat{}\neg \bigvee q \mathcal{F}\{q\})]]$$

The effect of this meaning postulate is to make *John knows whether Mary cooks or Bill eats out* true just in case John knows every proposition in the set denoted by *whether Mary cooks or Bill eats out* provided that the set is non-empty, and in the event it is, just in case John knows that it is empty, i.e. knows that Mary doesn't cook and Bill doesn't eat out. The problem of the indirect question possibly denoting an empty set does not arise in connection with simple yes/no questions. Thus *John knows whether Mary cooks* is true just in case John either knows the proposition that Mary cooks or the proposition that Mary doesn't cook.

12 This is as one might expect, given the fact that in transformational treatments (e.g. Katz and Postal 1964) *who* and *what* have been thought of as being transformationally derived from *wh + someone* and *wh + something*.

13 Direct wh-questions and sentences containing indirect wh-questions are commonly said to have existential presuppositions. For example, *What does John read?* and *It doesn't matter what John reads* implicate that John reads something, i.e. that the set denoted by *what John reads* is non-empty. This aspect of the meaning of wh-questions is not accounted for by the present analysis. It is the topic of Karttunen and Peters (1976), which also presents a solution to a similar problem concerning alternative questions that was mentioned at the end of section 2.2 See section 3.3 for further discussion.

14 This analysis of indirect wh-questions has in fact been proposed by Baker (1968, p. 50) with the difference that Baker (like Hintikka) interprets indirect questions only "contextually", that is, as part of a larger construction. Baker regards (41) as equivalent to

(i) For all x, John knows whether x dates Mary.

15 If we were to generalize our quantification rules in such a way as to allow quantifying *every student* into the indirect question *what grade* he_1 *deserves*, the resulting translation would presumably be

(i) $\hat{p} \bigwedge y[\text{student}'(y) \rightarrow \bigvee x[\text{grade}'(x) \wedge \check{p} \wedge p = \hat{}\text{deserve}'_*(\check{y}, \check{x})]]$

Under any reasonable interpretation of English, this formula is totally inappropriate as a semantic representation for (64). In any world where there is more than one student (i) denotes the null set.

16 I am assuming here that restricted variables are only used to restrict wh-quantification, not quantification with ordinary noun phrases as Rodman proposed. Otherwise we could not generate analysis trees such as (68a).

17 It is not entirely clear whether this is the correct result, given the fact that negative whether-questions sound awkward in many contexts (cf. # *it isn't entirely clear whether this isn't the correct result*). Furthermore, in some cases where they do sound natural (e.g. *I wonder whether we shouldn't try another approach.*) one can plausibly argue that the negative questions is accompanied by some sort of conventional or conversational implicature which the affirmative counterpart lacks.

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Type-shifting Rules and the Semantics of Interrogatives

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0 Introduction

The aim of this paper is a modest one. In what follows, we will argue that if one takes into consideration certain constructions involving interrogatives, a flexible approach to the relationship between syntactic categories and semantic types may be of great help. More in particular, we will try to show that if one uses something like an orthodox intensional type theory as one's semantic tool, a more liberal association between syntactic categories and semantic types becomes imperative. However, we will also see that such flexibility is by no means easily introduced into the grammar, and that it needs to be properly checked in order to avoid undesirable consequences.

The paper tries to make both a descriptive and a methodological point. First of all, we want to demonstrate that type-shifting rules, when combined with general notions of coordination and entailment, are useful tools in the semantic description of various constructions involving interrogatives. And second, we hope to show that they are important methodological tools as well, which can guide us in finding the proper semantic types for interrogatives, and in arriving at a "unification" of the two major approaches to the semantics of interrogatives: the categorial approach and the propositional approach.

The constructions involving interrogatives which we will be concerned with in this paper, are mainly coordination of interrogatives and entailment relations between them. Coordinated interrogatives, i.e. conjunctions, sequences, and disjunctions of interrogatives, may appear to be pretty rare phenomena and not be worthy of too much attention. Similarly, entailment between interrogatives may seem a questionable thing. Entailment is defined in terms of truth (conditions), and aren't questions the prime example of sentences that are not true or false? True, but there are many other kinds of expressions that, as such, cannot be said to be true or false either, but of which we can meaningfully say that the one does (or does not) entail the other. In fact, this holds for all conjoinable expressions, i.e. all expressions of a semantic type of the form $\langle \ldots t \rangle$. For all such types one can define in a general schematic way, what coordination, conjunction and disjunction, within such types amounts to. In a similar way, a general