III

INTERROGATIVE QUANTIFIERS AND SKOLEM-FUNCTIONS

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0. Introduction

This paper discusses a particular problem in the analysis of questions: the proper account of what we will call the 'functional' reading of questions. The analysis we will propose is a further refinement of an analysis of questions in the framework of Montague Grammar which we have presented elsewhere (see G & S 1981b, 1982). Although we will make use of that analysis at some points, the contents of this paper will pretty much stand on their own.

Our interest in the problem of functional readings of questions was raised by Elisabet Engdahl's discussion of it in her dissertation (Engdahl 1980). To our knowledge, she was the first to discuss this phenomenon in any detail.

The notion of connectedness, though not treated explicitly, comes in at several points. The connectedness of questions and answers is used as a heuristic means in the analysis of questions. This in its turn may eventually contribute to an account of the question-answer relationship itself, which can be regarded as one of the fundamental types of connected discourse. Furthermore, some of the constructions which we will discuss exhibit an interesting kind of binding pattern, being a form of connectedness at sentence level. Lastly, the phenomenon of functional readings is, we will argue, also to be observed with certain kinds of indicative sentences, as appears from the various ways in which such sentences can be continued in a larger discourse. Here connectedness at discourse level comes in again.

The particular problem we want to discuss in this paper concerns questions like (1) and (2) in connection with answers of type (a), (b) and (c):

(1) Which woman does every man love?

(a) Mary *[individual answer]*

(b) John loves Mary, Bill loves Suzy, ... *[pair-list answer]*

(c) His mother *[functional answer]*

(2) Which of his relatives does every man love?

(a) *Mary

(b) John loves (his wife) Mary, Bill loves (his sister) Suzy, ...

(c) His mother

With respect to these examples, two facts call our attention. First of all, a question like (1) allows for three different types of answers. The first type is an answer like (a), which specifies a particular individual that is the woman that is universally loved by the men. This we call an individual answer[1]. The second type of answer is exemplified by (b): it gives a list of all pairs of men and women such that the man loves the woman. This we call a pair-list answer. Answers of the third type (c), finally, specify a function, in this case one which for every man x, when applied to x gives the woman x loves as value. Answers such as (c) are the ones we are interested in here. We will refer to them as functional answers. The main points to be discussed are whether functional answers are a separate type of answers, and if so how this can be accounted for in the analysis of questions.

The second fact concerning the examples given above that we want to point out is that a question like (2) allows for only two types of answers: pair-list answers such as (b) and functional ones such as (c). An individual answer like (a) is excluded[2]. Question (2) differs from (1) in that the wh-term <u>which of his relatives</u> contains a pronoun, <u>his</u>, that seems to be bound by the term <u>every man</u>. Not in all cases, however, this binding relation is of the usual sort, as we shall see below.

Before turning to the main topic of this paper, an account of functional answers, we will first say a few words about the difference between individual answers and pair-list answers.

1. Scope-ambiguities in questions

An obvious way to deal with the difference between individual answers and pair-list answers is to relate them to different readings of a question like (1). These readings can be accounted for in terms of a scope-ambiquity. The reading corresponding to the individual answer is the one in which the wh-term which woman has wide scope with respect to the quantified term every man. The reading corresponding to the pair-list answer is the one where every man has wide scope over which woman. These two readings of (1) can be paraphrased as (1a) and (1b) respectively:

(1a) Which woman is such that every man loves her?
(1b) For every man, which woman does he love?

If an account along these lines is to work, two conditions have to be fulfilled. First, wh-terms have to be treated as scope-bearing elements, just as normal quantified terms. Second, questions have to be derivable in (at least) two different ways.

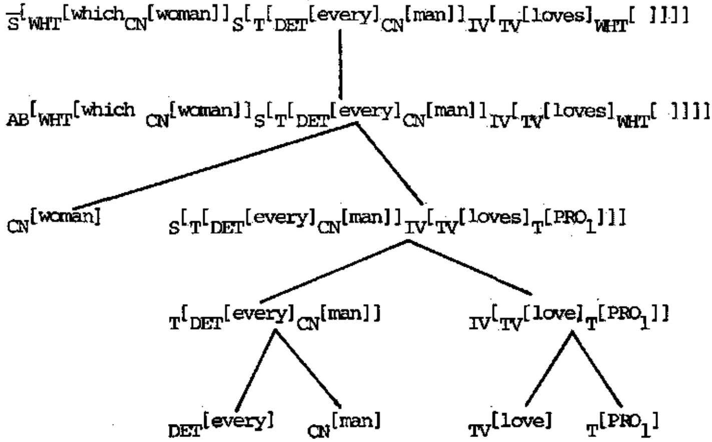
In the analysis developed in G & S 1981b, 1982, these two conditions are fulfilled as far as wh-complements, i.e. indirect questions, are concerned. In the present paper we will assume that at least as far as the problems we want to discuss here are concerned, the semantics of indirect and direct questions is the same. Therefore, we feel free to analyse direct questions via their indirect counterparts. Our analysis is carried out within the framework of a modified Montague grammar. Syntactically the grammar is enriched with an account of constituent structure, more or less along the lines pointed out by Partee (see Partee 1973, 1979). As for the semantics, the usual logical language of intensional type theory is replaced by a language of twosorted type theory. In this language explicit reference to and quantification over indices is allowed. What necessitates this change of translation medium is explained in G & S 1982, section 6.2.

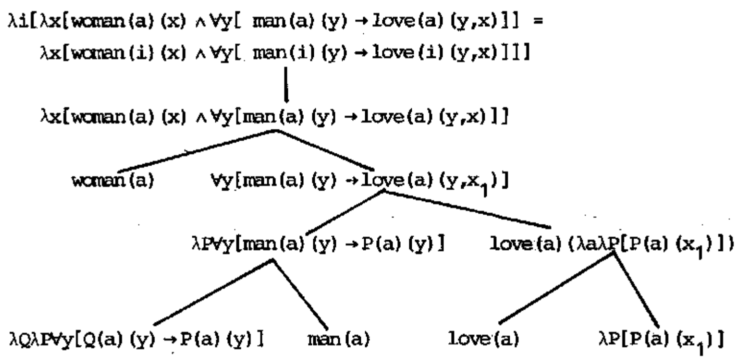
The main features of our syntactic analysis of constituent questions are the following. We start with a sentence with one of more free term variables PRO_n, PRO_k, ... Choosing one of these variables, say PRO_n, the sentence is transformed into a so-called *abstract* by 'preposing' a wh-term and replacing certain occurrences of PRO_n by a trace, and others, if any, by suitable anaphoric pronouns. What happens with an occurrence of PRO_n depends on its structural position in the original sentence. Next other wh-terms may be introduced, choosing other variables, by a similar process. After that, the abstract is transformed into a wh-complement by a category changing rule.

Semantically, we regard questions as proposition denoting expressions. Of particular importance is the index dependent character we ascribe to the denotation of questions. Which proposition a question denotes at an index depends on what is the case at that index. Loosely speaking, the proposition denoted by a question at some index is the true exhaustive answer to that question at that index.

Let us illustrate these general remarks by considering a concrete analysis tree plus translation of (the wh-complement corresponding to) question (1):[4]

(3)





The abstract which woman every man loves is constructed from the common noun woman and the sentential structure every man loves PRO_1. In this process the wh-term which woman is formed and 'preposed'. The occurrence of PRO_1 is replaced by a wh-trace, i.e. an empty node labelled WHT. What semantically corresponds to this process of abstract formation is λ-abstraction over the free variable which occurs in the translation of the syntactic variable PRO_1. This makes wh-terms scope-bearing elements. In the structure given above, the scope of which woman includes the universal quantifier in the translation of every man. The translation of the entire abstract denotes at an index i the set of women x such that for every man y at i, y loves x at i. The abstract is transformed into a proposition denoting complement. The distinction between abstracts and complements is not needed for syntactic purposes, but is semantically motivated. Since the distinction is not essential to the problems discussed in this paper, we will not motivate it here, but refer the reader to G & S 1982. The complement which woman every man loves denotes at an index a the proposition which holds at precisely those indices i in which the set of women who are loved by every man is the same as at a. If at an index a Mary is the only woman whom is universally loved by the men, then the complement denotes at a the proposition that Mary, and only Mary, is loved by every man. In that situation, the answer Mary would be the 'true, complete answer' to question (1). On this reading the question can be answered by what we have called an individual answer. We therefore call this reading of question (1) its *individual reading*.

So, the first condition for questions to exhibit a scope ambiguity, i.e. that wh-terms have scope, is fulfilled. The second condition was that there be two ways to construct questions, that there be two derivations for them. This requirement is an immediate consequence of the central methodological principle of Montague grammar (and logical grammar in general): the principle of semantic compositionality. This principle says that the meaning of an expression is a function of the meanings of its parts and the way in which these parts are put together. In other words, the meaning of an expression is a function of the meaning of its parts and the way in which it is derived. Save for cases of lexical ambiguity, the principle of semantic compositionality therefore requires: different meanings, different derivations. If an expression is ambiquous between n readings, there have to be (at least) n different ways to derive it.

As we have indicated above, the derivation of question (1) given in (3) is the one which gives the reading that corresponds to individual type answers. It is the reading we paraphrased as (1a):

(1a) Which woman is such that every man loves her?

The proposition denoted by (1) on this derivation specifies women who are universally loved by the men. It remains to be shown that we can create another way to derive questions which gives the type of reading that corresponds to the pair-list type answers. As we have already remarked above, the obvious way to do this is to allow wh-terms and other terms to have different scope with respect to one another.

The usual way to create a scope ambiguity in Montague grammar is illustrated by the two derivations plus translations of the sentence <u>every man loves a woman</u> given in (4) and (5): [5]

(4) $_S[_T[\text{every man}]_{IV}[_{TV}[\text{loves}]_T[\text{a woman}]]]$

$_T[\text{every man}]$ $\quad$ $_{IV}[_{TV}[\text{love}]_T[\text{a woman}]$

$_{TV}[\text{love}]$ $\quad$ $_T[\text{a woman}]$

$\forall x[\text{man}(a)(x) \rightarrow \exists y[\text{woman }(a)(y) \wedge \text{love}(a)(x,y)]]$

$\lambda P \forall x[\text{man}(a)(x) \rightarrow P(a)(x)]$

$\text{love}(a)[\lambda a \lambda P \exists y[\text{woman}(a)(y) \wedge P(a)(y)]]$

$\text{love}(a)$ $\quad$ $\lambda P \exists y[\text{woman}(a)(y) \wedge P(a)(y)]$

(5) $$_S[_T[\text{every man}]_{IV}[_{TV}[\text{loves}]_T[\text{a woman}]]]$$

$$_T[\text{a woman}] \qquad _S[_T[\text{every man}]_{IV}[_{TV}[\text{loves}]_T[PRO_1]]]$$

$$\exists y[woman(a)(y) \wedge \forall x[man(a)(x) \rightarrow love(a)(x,y)]]$$

$$\lambda P \exists y[woman(a)(y) \wedge P(a)(y)] \qquad \forall x[man(a)(x) \rightarrow love(a)(x,x_1)]$$

The derivation in (4) results in the so-called 'direct' reading, in which <u>every man</u> has wide scope over <u>a woman</u>. The 'indirect' reading, in which <u>a woman</u> has widest scope, is obtained by quantifying in the term <u>a woman</u> into the sentence <u>every man loves PRO_1</u>. This derivation is given in (5). Notice by the way that both derivations assign one and the same constituent structure to the sentence in question. Derivational ambiguities do not necessarily result in structural ambiguities, i.e. in different constituent structures.

The same kind of procedure can be followed in the case of questions. In (6) a second way to derive question (1) is given, in which the term <u>every man</u> is quantified into the complement <u>which woman PRO_1 loves</u>:[6]

(6) $$_{\bar{S}}[_{WHT}[\text{which woman}]_S[_T[\text{every man}]_{IV}[_{TV}[\text{loves}]_{WHT}[\ ]]]]$$

$$_T[\text{every man}]$$

$$_{\bar{S}}[_{WHT}[\text{which woman}]_S[_T[PRO_1]_{IV}[_{TV}[\text{loves}]_{WHT}[\ ]]]]$$

$$\lambda i[\forall y[man(a)(y) \rightarrow [\lambda x[woman(a)(x) \wedge love(a)(y,x)] = \lambda x[woman(i)(x) \wedge love(i)(y,x)]]]]$$

$$\lambda P \forall y[man(a)(y) \rightarrow P(a)(y)] \qquad \lambda i[\lambda x[woman(a)(x) \wedge Love(a)(x_1,x)] = \lambda x[woman(i)(x) \wedge love(i)(x_1,x)]]$$

As is evident from the corresponding translation, the derivation process exemplified in (6) results in a reading of question (1) in which the term every man has wide scope over the wh-term which woman. The proposition denoted at an index a by the complement thus constructed, is the set of indices i such that for every man y at a it holds that the set of women that y loves at i is the same as the set of women y loves at a. Clearly, on this derivation, question (1) receives the reading paraphrased as (1b) above:

(1b) For every man, which woman does he love?

Such a question is answered by specifying for every man the woman (or women) he loves, i.e. by giving a list of pairs of men and women such that the man loves the woman. So, on this second reading question (1) is answered by what we have called a pair-list answer, hence this reading is called the *pair-list reading*.

Summing up our results, we conclude that individual answers and pair-list answers correspond to different readings of questions. These different readings stem from a scope ambiguity: wh-terms and normal quantified terms may stand in different scope relations to one another. Within the framework of Montague grammar it is possible to account for this ambiguity since wh-terms can be treated semantically as scope-bearing elements and since the usual 'quantifying in' device for handling scope ambiquities can be extended to questions.

Finally let us point out that the account just given of the ambiguity of questions between an individual and a pair-list reading enables one to explain why there is no individual reading for question (2):[7]

(2) Which of his relatives does every man love?

This question cannot be answered by specifying an individual, as in the individual answer Mary, thus (2) lacks what we have called the individual reading. The reason for this is the following. In Montague grammar the standard way to deal with anaphoric pronouns is also by means of quantification rules. Sentence (7), for example, is derived by quantifying in the term every man in the sentence $\underline{PRO_1\ loves\ PRO_1's\ mother}$:

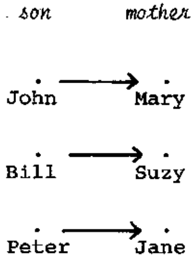
(7) Every man loves his mother

In the quantification process one of the occurrences of the syntactic variable which is quantified is replaced by the term which is quantified in, while any other occurrences become suitable anaphoric pronouns. Semantically, they turn up as bound variables. If the grammar is enriched with an account of constituent structure, various structural conditions may be formulated which govern this process (for a theory along these lines, see Landman & Moerdijk 1981, 1983).

As for question (2), it seems that in order to get an anaphoric pronoun his in the wh-term which of his relatives, the term every man should have wide scope. I.e. it has to be quantified in into the question $\underline{which\ of\ PRO_1's\ relatives\ PRO_1\ loves}$. But, as we have seen with regard to question (1), this would result in a pair-list reading. So, there is no way to derive (2) with his bound by every man which assigns it an individual reading. And this accounts for the impossibility of individual answers such as Mary to questions such as (2).

2. Functional readings of questions

We now turn to the third type of answers to questions which we distinguished: functional answers. With many others, we believed for a long time that answers like his mother to questions like (1) and (2) are just a kind of abbreviation, a more economic way of expressing pair-list answers.[8] For suppose that things are as in the situation depicted in figure 1:



(fig. 1)

The arrow represents the love-relation. In this situation, the question Which woman does every man love? or Which of his relatives does every man love? can be answered by means of a pair-list answer as well as by means of a functional answer. The pair-list answer would be (8), the functional answer would be (9):

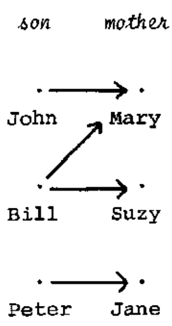
(8) John loves Mary, Bill loves Suzy and Peter loves Jane
(9) Every man loves his mother

Both answers cover the situation in question. This is not surprising, of course, for extensionally a function is just a list of pairs. So, if one answers the question by (9) instead of by (8), this seems to be merely for reasons of convenience. If the list of pairs gets longer, abbreviating the list by means of a function becomes more attractive. But that would be a fact of language use, not one of semantics. Both a pair-list answer and a functional answer would express the same complete true answer. And as far as the semantics of questions is concerned, there would be no reason to distinguish between the two.

But can functional answers and pair-list ones really always be equated? There seem to be several reasons to doubt this.

First of all, someone may know the answer His mother to the question Which woman does every man love? without being able to present the corresponding pair-list answer. This may happen simply because he does not know of every man which woman is his mother. And vice versa, someone might be able to present a complete list of pairs of men and women such that the first loves the second, without knowing that in each case the woman is the mother of the man. So, it may be true that John knows which woman every man loves in the functional sense (he knows that every man loves his mother), without him knowing this in the pair-list sense. And vice versa, he may know it in the pair-list sense (he can give an exhaustive list of pairs of men and women such that the man loves the woman), without knowing it in the functional sense. This means that in a given situation, the sentence *John knows which woman every man loves* may be true "in a certain sense", but false "in another". One way to account for this possibility is to ascribe two senses, i.e. two readings, to this sentence.[9] And it seems plausible that if the sentence in question is ambiguous in this way, this ambiguity stems from the complement. For the same ambiguity can be observed in case of the corresponding direct question *Which woman does every man love?*.

A second argument for the non-equivalence of functional and pair-list answers is the following. Suppose we change the situation of figure 1 into that of figure 2:



(fig. 2)

In this new situation, the complete pair-list answer to the question _Which woman does every man love?_ has to be extended with the pair <Bill,Mary>:

(10) John loves Mary, Bill loves Mary and Suzy, and Peter loves Jane

Since Mary is not Bill's mother (Suzy is), the extension of the function _his mother_ is no longer identical with the list of pairs that constitutes a complete pair-list answer. Still it seems that if someone asks the question _Which woman does every man love?_, the functional answer _His mother_, in this situation too, may constitute a fully satisfactory _and complete_ answer. If this is true (as we think it is) it means that the question can be understood in different ways. Sometimes we use it to ask for a functional answer, and sometimes it serves to elicit a pair-list answer. If we use it in the first way in the situation described by figure 2, the functional answer _His mother_ is the true complete answer. If we use it in the second way, the pair-list answer (10) is the true complete answer. Since the two are not equivalent, it follows that the question should have two non-equivalent readings corresponding to these two different kinds of answers. The functional answer cannot be regarded systematically as a mere abbreviation of the pair-list answer.[10]
If a question at an index a denotes the proposition to be expressed by what at a is a complete and true answer to it, and if there are two non-equivalent but equally satisfactory complete and true answers, then the conclusion must be that the question is ambiguous.

Perhaps the strongest arguments for distinguishing a separate functional reading of questions stem from examples such as (11)-(16):

(11) Which woman does no man love?
- (a) Mary
- (b) *John loves Mary, Bill loves Suzy, ...
- (c) His mother

(12) Which of his relatives does no man love?

(a) *Mary

(b) *John loves Mary, Bill loves Suzy, ...

(c) His mother

(13) Which woman do few men love?

(a) Mary

(b) *John loves Mary, Bill loves Suzy, ...

(c) Their mother

(14) Which woman do many men love?

(a) Mary

(b) *John loves Mary, Bill loves Suzy, ...

(c) Their mother

(15) Which of their relatives do few men love?

(a) *Mary

(b) *John loves Mary, Bill loves Suzy, ...

(c) Their mother

(16) Which of their relatives do many men love?

(a) *Mary

(b) *John loves Mary, Bill loves Suzy, ...

(c) Their mother

These questions differ from questions (1) and (2) in that they do not allow pair-list answers, where (1) and (2) do. Pair-list answers to these questions simply do not make sense.[11] This does not only hold for terms with the determiners _no_, _few_ or _many_ as in the examples above, it holds for many others besides. They are listed in the second column in figure 3:[12]

universal terms	*non-universal terms*
every man	no man
all men	any man
the man	few men
the men	many men
the two men	two men
both men	neither man
each man	a man
John	some man
John and Peter	some men
	most men
	at least one man
	at most one man
	exactly one man

(fig. 3)

If functional answers would be just alternative, more concise ways of expressing pair-list answers, it would be hard to explain why questions such as (11)-(16) can be answered in a functional way, but do not permit a pair-list answer. To prevent pair-list answers to them, we have to exclude their pair-list reading. But then, no reading is available to which the functional answers would correspond if the two were identified. This shows that we need to distinguish functional from pair-list answers, and hence to postulate a separate functional reading for questions.

Why is it impossible to answer these questions by giving a list? Intuitively, the reason seems to be the following. If we are to be able to give a list, the term in question has to be associated with a definite set, otherwise we would not know what to make a list of. If we are asked to give a list of pairs of men and women such that the man loves the woman, we are only able to do this if we can pick the men from a definite set. With a question like Which woman does every man love? it is clear what we should do, the definite set is the set of every man. And the same holds for e.g. Which woman do the two men love? In this case the set consists of the two men, identified or specified either by the non-linguistic context or by previous discourse. Things are completely different with a question like Which woman do few men love? There isn't any definite set of few men from which we can construct our list. And hence it is impossible to answer such a question by means of a pair-list answer.

In our analysis, the fact that questions with non-universal subject terms do not have a pair-list reading is mirrored by the fact that quantification of non-universal terms into questions is ruled out.[13] In order to derive questions with pair-list readings we need to quantify terms into questions. If we would apply this procedure in case of non-universal terms, we would wind up with completely wrong results. For example, quantifying in no man into which woman PRO_1 loves would result in the following translation, which does not represent a meaning of the question which woman no man loves:

(17) $\lambda i[\forall y[man(a)(y) \rightarrow \neg[\lambda x[woman(a)(x) \wedge love(a)(y,x)] = \lambda x[woman(i)(x) \wedge love(i)(y,x)]]]]$

At an index a this expression denotes the set indices i such that for no man x at a the set of women whom he loves at i is the same as the set of women he loves at a. For no man this proposition entails the proposition which identifies the woman (or women) he loves.

The explanation given above of why pair-list answers are not possible with questions like (11)-(16) seems reasonable enough. Since functional answers are possible, however, this constitutes a conclusive argument against the equation of functional answers with pair-list answers.

Where does all this leave us? We seem to be forced to distinguish, quite generally, three different readings for questions. In some cases some readings are excluded, for reasons which we have indicated. The individual reading of questions, i.e. the reading which gives rise to the individual type answers, corresponds to direct construction, exemplified in (3) above. The pair-list reading is the result of quantifying in. This construction is exemplified in (6). It is restricted to universal terms. At first sight the functional reading appeared to be a simple variant of the pair-list reading, but as we have argued above, it is not. This means that the functional reading cannot be derived by the quantifying-in process. On the other hand, though akin to it in some respect, the functional reading obviously is not equivalent to the individual reading either. Following the methodological principle of compositionality, we postulate a third way to derive questions.

At this point an interesting phenomenon can be observed. As we said, the functional reading cannot be obtained by quantifying in since the wh-term has to have wide scope over the subject term, So, semantically the subject term cannot bind anything inside the wh-term. Syntactically, however, in such questions as (2), (12), (15) and (16), the subject term, in some way or other, has to bind the pronoun in the wh-term. Here semantic and syntactic binding are not parallel in the way they usually are, a fact that hitherto seems to have escaped attention.

3. Functional readings and Skolem-functions

In this section we will sketch our solution to the problem of functional readings of questions. In section 4 we will indicate some further uses of the apparatus in similar problematic cases.

Questions like (2) and (12) are discussed extensively by Elisabet Engdahl (Engdahl 1980). She does not discuss functional readings of questions such as (1), (11), (13)-(16). Her proposal for the analysis of the functional readings of (2) and (12) is not fully satisfactory, and moreover is not general enough to deal with the other cases.[14]

As for our own solution, since our framework is one in which we want to give an explicit model-theoretic semantics for natural language, there are two things which we will have to do. First of all, we will have to indicate what the interpretation of questions on their functional reading is. Secondly, if we have succeeded in this, we will have to provide explicit syntactic and semantic rules which, building up the interpretation of the whole from the interpretation of the parts, give us the required results.

Our proposal is to use so-called *Skolem-functions* in the analysis of functional readings of questions. Let us consider the simple question (18) in connection with the functional answer (c):

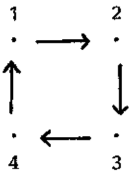
(18) Whom does every man love?
(c) His mother

The answer His mother specifies a function from individuals to individuals. When applied to an individual, say John, it gives the mother of that individual, say Mary, as its value. What answer (c) expresses is that this function, call it f, is such that for every man x when f is applied to x it gives as value an individual that x loves. So, on its functional reading question (18) asks which function f is such that for every man x, x loves f(x).

This suggests the following translation (19) for (18) on its functional reading. For comparison we add the translation (20) of the individual reading of (18):[15]

(19) $\lambda f[\forall x[man(a)(x) \rightarrow love(a)(x,f(x))]]$
(20) $\lambda y[\forall x[man(a)(x) \rightarrow love(a)(x,y)]]$

Functions from individuals to individuals like f used above, are called Skolem-functions. They can be used to change the order of quantifiers in a formula like $\forall x \exists y \phi(x,y)$ in order to obtain an equivalent formula $\exists f \forall x \phi(x,f(x))$. In order to illustrate this, look at the picture in figure 4:[16]

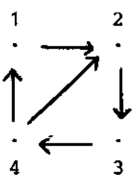


(fig. 4)

In the situation depicted in figure 4 it holds that $\forall x \exists y\ x \longrightarrow y$ and also that $\exists f \forall x\ x \longrightarrow f(x)$, viz. the following function :

(21) $g(1) = 2,\ g(2) = 3,\ g(3) = 4,\ g(4) = 1$

Of course, there may be more such functions as in the situation depicted in figure 5:



(fig. 5)

In this situation there are two functions that make $\exists f \forall x\ x \longrightarrow f(x)$ true, viz. g and h:

(22) $h(1) = 2,\ h(2) = 3,\ h(3) = 4,\ h(4) = 2$

Question (1) on its functional reading asks not for any function such that for every man x, x loves f(x), but for a function which always yields a woman as its value:

(1) Which woman does every man love?
 (c) His mother
 (c') *His father

Whereas question (18) can be answered functionally with His father, this answer is not possible for question (1), since the father-function is not a function into the set of women. So, a question like (1) restricts the set of possible functions that may constitute an answer to it on its functional reading. In the case of (1) this restriction on admissible functions f can be formulated as: $\forall x$ woman(a)(f(x)). As a whole, (1) may be translated into (23). For comparison we give again the translation of (1) on its individual reading as (24).

(23) $\lambda f[\forall x\ \mathrm{woman}(a)(f(x)) \wedge \forall x[\mathrm{man}(a)(x) \rightarrow \mathrm{love}(a)(x,f(x))]]$

(24) $\lambda y[\mathrm{woman}(a)(y) \wedge \forall x[\mathrm{man}(a)(x) \rightarrow \mathrm{love}(a)(x,y)]]$

The most interesting case is a question like (2):

(2) Which of his relatives does every man love?
   (c) His mother
   (c') *His first grade teacher

This question too formulates a restriction on the functions that can be specified as answers to it. Here the restriction can be formulated as: $\forall x$ relative-of(a)(f(x),x). The functional reading of (2) can then be represented as (25):

(25) $\lambda f[\forall x\ \mathrm{relative\text{-}of}(a)(f(x),x) \wedge \forall x[\mathrm{man}(a)(x) \rightarrow \mathrm{love}(a)(x,f(x))]]$

It is clear that thus interpreted (c) constitutes an acceptable answer to (2), but (c') does not. Notice that the variable x in relative-of(a)(f(x),x), which corresponds to the pronoun his in the wh-term which of his relatives is not bound by the universal quantifier in the translation of every man. Rather, it is bound by the universal quantifier in the restriction on the function. Still, the effect is as if it is bound by every man since for every choice of a man x, f(x) is a relative of x. This is the result of restricting f in such a way that when applied to an individual it gives a relative of that individual as its value. So, although we can say that the pronoun _his_ in the wh-term is 'bound' in a certain sense by the term _every man_, it is not connected with it in the usual direct way of being translated as a variable which is bound by the quantifier in the translation of the term. Rather, the pronoun depends on the term indirectly, _via_ the dependency of the Skolem-function and the way in which it is restricted. In constructions like these, the pronoun is neither a variable bound by a term, nor is it a pronoun of laziness or a discourse anaphor. Rather it signals a separate kind of dependency, a functional dependency. This is a rather unusual kind of semantic binding which allows us to account for a semantic relation between two terms which, in a sense, is the reverse of their syntactic relation.

As a last example, consider question (12), a question with a non-universal subject term. Such questions donot allow pair-list answers but they do have a functional reading. In (26) the functional reading of (12) is represented:

(12) Which of his relatives does no man love?

(26) $\lambda f[\forall x\ \text{relative-of}(a)(f(x),x) \wedge \forall x[\text{man}(a)(x) \rightarrow \neg\text{love}(a)(x,f(x))]]$

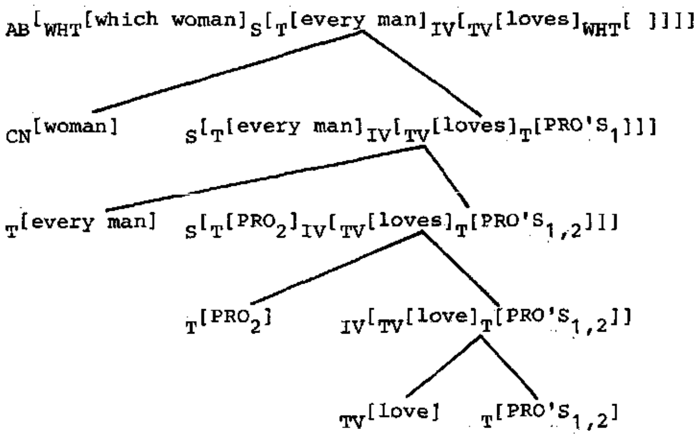
The expression in (26) denotes the set of functions f such that for every x, f(x) is a relative of x, and for no man x it holds that x loves f(x). Answering (12) on this reading by a functional answer like _His mother_ is specifying one of those functions, and expresses that no man loves his mother. For other questions with non-universal subject terms, the functional reading can be represented in a similar fashion.

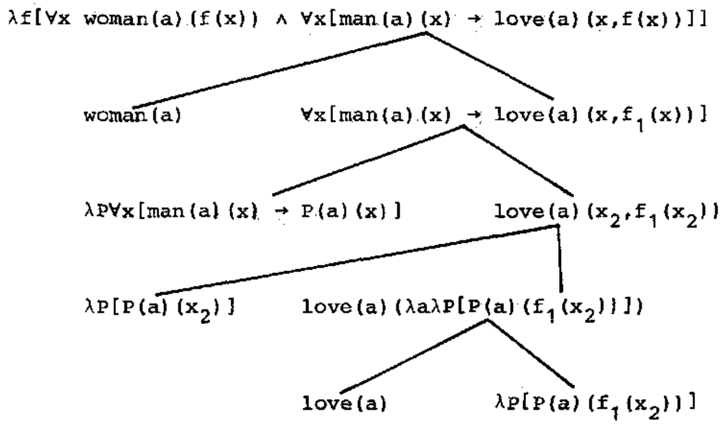
What we have ended up with now are formulas that correctly represent the interpretations of questions on their functional readings. But as we said earlier, this constitutes only half of the job. Writing down a formula that represents the meaning of a sentence is one thing, finding a compositional translation procedure which results in this formula, or in one that is equivalent to it, is quite another. (For example, it is no problem to write down formulas which represent the meaning of Bach-Peters sentences or donkey-sentences. What is difficult is to construct a compositional procedure that produces them.)

We cannot deal here with the syntax of wh-constructions in detail. For our analysis the reader is referred to G & S 1982, section 4. We will restrict ourselves to giving an informal indication of the contents of the relevant syntactic rules, by discussing some examples. What is important is that to these syntactic rules compositional translation rules correspond, thus providing a compositional semantics for the expressions produced.

Consider to begin with the derivation tree (27), which gives the functional reading of question (1), and compare it with (3), the derivation tree which resulted in the individual reading of (1):

(27)





In order to obtain the functional reading, a new kind of syntactic variable of category T is introduced.[17] It is a double-indexed variable of the form $PRO'S_{m,n}$. The two indices m and n of these syntactic variables correspond to the indices of the two free variables f_m and x_n in their translation, which is given in (28):

(28) $PRO'S_{m,n} \sim \lambda P[P(a)(f_m(x_n))]$

Here '~' is to be read as 'translates into'. P is a variable of type <s,<e,t>>, w of type s, f_m of type <e,e> and x_n of type e. The translation $\lambda P[P(a)(f_m(x_n)))]$ denotes at a the set of properties P which the individual $f_m(x_n)$, the value of f_m for x_n, has at a.

The new syntactic variables behave like all other expressions of category T. So we can form the sentence(29):

(29) $_S[_T[PRO_2]_{IV}[_{TV}[loves]_T[PRO'S_{1,2}]]]$

in the usual way. Into this sentence we can quantify <u>every man</u> for variables carrying index 2. The existing quantification rule has to be adapted slightly in view of the possible occurrences of this new kind of syntactic variable. What is important is that features for number and gender of the term that is quantified in are taken over by all those occurrences of variables with the relevant index that are not replaced by the term itself. Thus, quantifying in every man into (29) for PRO_2 results in (30):

(30) $_S[_T[\text{every man}]_{IV}[_{TV}[\text{loves}]_T[PRO'S_1]]]$

in which $PRO'S_1$ carries the features male, singular, third person, because it is bound by the male, singular, third person term every man. The translation rule corresponding to the modified quantification rule remains unaltered. Syntactically, quantifying in removes the second index on a variable $PRO'S_{m,n}$, semantically it binds the variable x_n, ranging over individuals, by the translation of the term which is quantified in.

From sentence (30) and the common noun woman an abstract is formed. If we compare this stage of the derivation of the functional reading with the corresponding stage of the derivation of the individual reading, we notice that syntactically the difference is minimal. Where the former has an occurrence of a syntactic variable $PRO'S_k$ in its input sentence, the latter has an occurrence of PRO_k. The resulting abstracts are in both derivations the same:

(31) $_{AB}[_{WHT}[\text{which woman}]_S[_T[\text{every man}]_{IV}[_{TV}[\text{loves}]_{WHT}[\ ]]]]$

They are formed by the same syntactic process. Informally, the relevant syntactic rules read as follows.

On the individual reading the abstract is derived by means of (S:AB2):

(S:AB2) If δ is a CN and ϕ is an S containing one or more occurrences of PRO_n which satisfy certain structural constraints, then $F_{AB2,n}(\delta,\phi)$ is an AB of the form $_{AB}[_{WHT}[\text{which } \delta]\ \phi']$, where ϕ' comes from ϕ by replacing certain of the occurrences of PRO_n by traces and all the others by anaphoric pronouns which take over the features for gender and number from the CN δ

The translation rule corresponding to (S:AB2) is (T:AB2):

(T:AB2) If $\delta \rightsquigarrow \delta'$ and $\phi \rightsquigarrow \phi'$, then
$F_{AB2,n}(\delta,\phi) \rightsquigarrow \lambda x_n[\delta'(x_n) \wedge \phi']$

On the functional reading the abstract is derived by means of a quite similar syntactic rule (S:AB2/f):

(S:AB2/f) If δ is a CN and ϕ is an S containing one or more occurrences of PRO'S_n which satisfy certain structural constraints, then $F_{AB2/f,n}(\delta,\phi)$ is an AB of the form $_{AB}[_{WHT}[\text{which } \delta]\ \phi']$, where ϕ' comes from ϕ by replacing certain of the occurrences of PRO'S_n by traces and all others by anaphoric pronouns which take over the features for gender and number from the CN δ

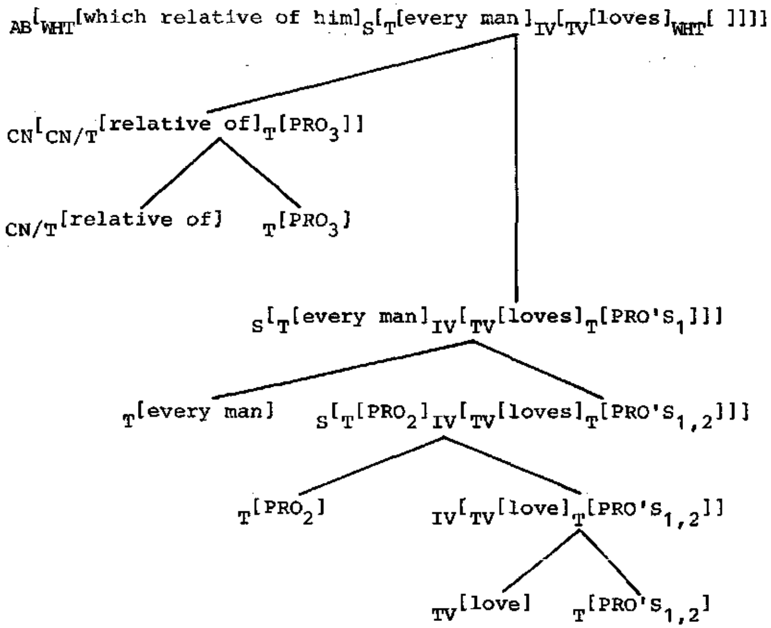
The corresponding translation rule is (T:AB2/f):

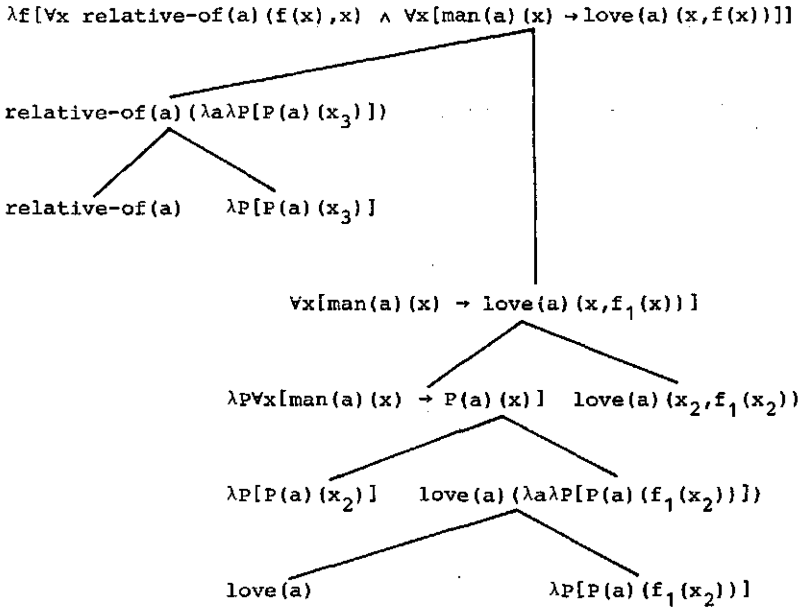
(T:AB2/f) If $\delta \rightsquigarrow \delta'$ and $\phi \rightsquigarrow \phi'$, then
$F_{AB2/f,n}(\delta,\phi) \rightsquigarrow \lambda f_n[\forall x\ \delta(f_n(x)) \wedge \phi']$

On its individual reading the abstract underlying <u>which woman every man loves</u> denotes the set of individuals y such that y is a woman and for every man x it holds that x loves y. On its functional reading the abstract denotes the set of functions f from individuals to individuals such that f is a function into the set of women and for every man x it holds that x loves f(x). So, on the individual reading the common noun <u>woman</u> in the wh-term <u>which woman</u> functions as a restriction on individuals, on the functional reading it acts as a restriction on Skolem-functions.

As a second example, consider the derivation tree plus translation of the functional reading of question (2), <u>which of his relatives does every man love?</u>:[18]

(32)





The new element in this derivation is that in forming the abstract from the sentence a common noun is used which itself contains a free syntactic variable which gets bound in the process of abstract formation. In deriving the abstract <u>which relative of him every man loves</u> from the common noun <u>relative of PRO_3</u> and the sentence <u>every man loves $PRO'S_1$</u> two variables get bound: the functional variable in $PRO'S_1$ in the S and the individual variable in PRO_3 in the CN. The syntactic rule which does this can informally be stated as follows:

(S:AB5) If δ is a CN with one or more occurrences of PRO_n and ϕ is an S with one or more occurrences of $PRO'S_m$ which satisfy certain structural constraints, then $F_{AB5,n,m}(\delta,\phi)$ is an AB of the form $_{AB}[_{WHT}[\text{which } \delta'] \ \phi']$, where δ' comes from δ by replacing the occurrences of PRO_n by anaphoric pronouns which take over the features for gender and number from $PRO'S_m$, and where ϕ' comes from ϕ as in (S:AB2/f)

The syntactic process codified in this rule is quite like that described in the previous two rules of abstract formation (S:AB2) and (S:AB2/f). The only difference lies in the fact that in addition the syntactic variable PRO_n in the CN is bound and takes over the features for number and gender from the variable $PRO'S_m$ in the S, and thereby indirectly from the term by which the latter variable in its turn is partly bound. This syntactic binding process is not parallelled by the normal semantic binding process. Although syntactically every man binds him in which relative of him, semantically the variable in the translation of him is not inside the scope of the quantifier in the translation of every man.[19] Rather it is bound in the translation of the restriction which the wh-term places on the functions. This is expressed in the translation rule corresponding to (S:AB5):

(T:AB5) If $\delta \rightsquigarrow \delta'$ and $\phi \rightsquigarrow \phi'$, then
$F_{AB5,n,m}(\delta,\phi) \rightsquigarrow \lambda f_m[\forall x_n\ \delta'(f_m(x_n)) \wedge \phi']$

Of course this description of the derivation process of functional readings of questions gives a mere indication of what a detailed syntactic analysis would look like. This is true in particular for the remarks on how morphological features function in this process. However, we are confident that such a detailed analysis can be carried out, on the basis of the syntax of wh-constructions defined in G & S 1982 and a theory of morphology as proposed in Landman & Moerdijk 1981, 1984.

More important in the context of the present paper is that our remarks have shown (and not merely indicated) that it is indeed possible to give a compositional semantics for questions which accounts for individual, pair-list and functional readings. This is shown by the compositional translation rules defined above. In fact it is the methodological principle of semantic compositionality that more or less directly leads to an analysis like the one just outlined. If one accepts compositionality as a requirement on one's grammar, one is bound to associate a derivational ambiguity with every non-lexical semantic ambiguity.

At this point it may be usefull to stress again the difference between derivation and constituent structure. Constituent structure is what we have intuitions about, intuitions which may take the form of well-formedness judgements and which can be elicited by means of various kinds of tests. Constituent structure embodies our intuitions about what the parts of an expression are, how they combine into larger parts, how they depend on one and another, etc. But as to how these constituent structures are derived, we do not have any intuitions at all. The derivational process is not directly linked with syntactic intuitions. The analysis of questions given in this paper illustrates this. The various types of derivations which we distinguished, for example the three derivations (3), (6) and (27) of question (1), are of course primarily semantically motivated. This is also evident from the fact that all of them assign the same constituent structure to the question. Quite generally, one may say that within the framework of Montague grammar the theory of syntactic structure is embodied, not in the derivations, but in the constituent structures which the grammar assigns to the expressions it produces.

One may perhaps object against the semantically motivated level of derivations in the syntax, feeling that syntax should deal with syntactic properties of expressions only. But then one has to give up the compositionality requirement. For given the fact that constituent structure as such does not determine semantic interpretation, any grammar that is set up to give a compositional semantics for the expressions it produces, will have to contain some level of analysis which is primarily semantically motivated, a level which contains in addition to the information which the constituent structure of an expression provides all other aspects which are needed to fix its semantic interpretation. One may very well argue about the precise contents of the level of analysis and its exact place in the grammar. One may prefer storage mechanisms (cf. footnote 17) or interpretation strategies over derivations, but given the common goal of logical grammar, a compositional semantics for natural language, a level of analysis like that of derivations has to be incorporated in the grammar, some way, somewhere.[20]

4. Functional readings of other constructions

In this section we will point out briefly other types of constructions than questions where functional readings seem to play a role.

Consider sentence (33):

(33) Every man loves a woman

A sentence such as (33) can be continued in a larger discourse in (at least) three different ways. These continuations are remarkably like the three ways in which the question Which woman does every man love? can be understood:

(33) (a) Mary
(b) John loves Mary, Bill loves Suzy, ...
(c) His mother

We call them the *individual continuation*, the *pair-list continuation* and the *functional continuation* accordingly. Sentence (33) is generally assumed to have two readings. The individual continuation would match the reading of (33) which is the result of constructing it indirectly, i.e. by quantifying in a woman (see (5)), which consequently gets wide scope:

(34) $\exists y[\text{woman}(a)(y) \wedge \forall x[\text{man}(a)(x) \rightarrow \text{love}(a)(x,y)]]$

So, the individual continuation (33)(a), Mary, is to be regarded as a specification of an individual that is loved by every man, that is said to exist by (33) on its reading (34). The other reading of (33) is of course the one which results from the direct construction (see(4)):

(35) $\forall x[man(a)(x) \rightarrow \exists y[woman(a)(y) \wedge love(a)(x,y)]]$

At first sight nothing speaks against taking both the pair-list continuation (33)(b) and the functional continuation (33)(c) as matching this reading of (33). In (35) it is expressed that for all men there is a woman whom he loves. This fact may well be specified either by giving a list of pairs, as in (33)(b), or by giving a function, as in (33)(c). On this view the functional continuation would be a convenient abbreviation of a pair-list continuation.

But now consider sentence (36):

(36) There is a woman whom every man loves

This sentence can be continued in two ways only, individually and functionally:

(36)(a) Mary
(b) *John loves Mary, Bill loves Suzy, ...
(c) His mother

A pair-list continuation does not result in a well-formed, interpretable discourse. Two facts call our attention. First of all, with respect to (33) the suggestion was to take the functional continuation as a mere abbreviation of a pair-list continuation. This strategy will not work, however, in case of (36), since in this case the pair-list continuation is not possible while the functional continuation is. Secondly, a sentence such as (36) is often regarded (and offered) as a disambiguation of a sentence like (33). (36) is considered to have only one reading, being the indirect reading (34) of

(33), in which a woman has wide scope over every man. This is in accordance with the fact that an individual continuation is possible for (36). But it conflicts with the previously mentioned suggestion that the functional continuation of (33) corresponds to its direct reading (35). For this leaves us at a loss as to how to account for the functional continuation of (36).

A possible solution is to assign to (36) a second, 'functional' reading of which (36)(c) is the functional continuation. This reading may be represented as follows:

(37) $\exists f[\forall x\ woman(a)(f(x)) \wedge \forall x[man(a)(x) \rightarrow love(a)(x,f(x))]]$

So, (36) can also be read as asserting that there is a function f into the set of women such that for every man x it holds that x loves f(x). The functional continuation (36)(c) specifies this function as the mother-function, much in the same way as the individual continuation (36)(a) specifies the woman that is universally loved among the men, that is asserted to exist by (36) on its reading (34), as the individual Mary.

But here a problem presents itself, for (37) is equivalent to (35). And (35) intuitively does not represent a reading of (36), an intuition which is supported by the fact that it is (35) that makes the pair-list continuation possible for (33), a type of continuation which does not exist in connection with (36). So, postulating reading (37) for (36) in order to account for the possible functional continuation (36)(c), seems to allow the impossible pair-list continuation (36)(b) as well.

A formally correct and intuitively appealing solution to this problem is to restrict the domain of the quantifier $\exists f$ in (37) to some subset of the totality of all Skolem-functions. If we do this, (37) is no longer equivalent to (35) and we have a representation of (36) which accounts for the functional continuation without allowing the pair-list one. This seems a quite reasonable move to make, for if one asks for the specification of a function (with a question on its functional reading), or asserts the existence of a function and gives a specification of it, one obviously is not satisfied with any old specification of any old weird functional relationship between individuals. If someone asserts that there is some function f such that for all x, x loves f(x), and on our demand to specify this function, starts listing all pairs <x,y> such that x loves y, this simply will not do. Somehow quantification over functions is restricted. It would seem that functions that are allowed, must be either conventional in some sense (such as the mother-function, the wife-function, etc.) and thus in some sense computable, or they must be made computable by the context. Compositions of such acceptable functions will in most cases result in acceptable functions. The exact principle, or principles, underlying this restriction are not entirely clear to us, but that something like this is going on seems quite likely.

Assuming that quantification over Skolem-functions is indeed restricted, we can not only explain that (36) has a functional reading but not a pair-list reading, it also becomes reasonable to consider (33) to be 3-ways ambiguous. The third reading of (33) will be the same as the second, functional reading of (36), reformulated as (37'):

(37') $\exists f[R(f) \wedge \forall x\ \text{woman}(a)(f(x)) \wedge \forall x[\text{man}(a)(x) \rightarrow \text{love}(a)(f(x))]]$

Here R is to be filled by some predicate over Skolem-functions which expresses the restriction to 'conventional', 'computable' functions.

Another sentence that illustrates the usefulness of distinguishing functional readings from pair-list readings is (38):

(38) There is a woman whom no man loves

Like (36) this sentence has a functional continuation, but no pair-list continuation. The functional reading of (38) is represented by (39):[21]

(39) $\exists f[R(f) \wedge \forall x\ woman(a)(f(x)) \wedge \forall x[man(a)(x) \rightarrow \neg love(a)(x,f(x))]]$

Finally, it may be noted that the special binding properties we found in questions like:

(2) Which of his relatives does every man love?

occur also in certain indicative sentences. An example is (40):

(40) Every man loves one of his relatives

This sentence does not have a reading in which the term one of his relatives is quantified in, for then the pronoun his could not be bound by every man. This appears also from the fact that (40) does not allow an individual continuation, it cannot be continued by specifying an individual. The sentence has a pair-list continuation which corresponds to the reading which results from quantifying in every man in PRO_1 loves one of PRO_1's relatives. It also allows a functional continuation which matches the reading which results from quantifying in one of PRO_1's relatives in the sentence every man loves $PRO'S_1$ by means of a process which is completely analogous to that by means of which the functional reading of a question like (2) is derived and which was described above in rule (S:AB5). In this case too, the syntactic binding of his in one of his relatives by every man is not parallelled by the usual semantic binding: the variable in the translation of his is not bound by the quantifier in the translation of every man. This is shown by the following representation of the functional reading of (40):

(41) $\exists f[R(f) \wedge \forall x\ relative\text{-}of(a)(f(x),x) \wedge$
$\forall x[man(a)(x) \rightarrow love(a)(x,f(x))]]$

The pronoun his gets bound semantically in the restriction on the range of the Skolem-function f. The effect is the same as in the case of the corresponding question: for every man x, f(x) denotes one of x's relatives. Notice that since (41) expresses restricted quantification over Skolem-functions, it is not equivalent to (42), which represents the pair-list reading of (40):

(42) $\forall x[man(a)(x) \rightarrow \exists y[relative\text{-}of(a)(y,x) \wedge love(a)(x,y)]]$

So, we assign to (40) two distinct readings, the functional one and the pair-list one.

Formula (41) also represents the only reading of sentence (43):

(43) There is one of his relatives that every man loves

This sentence allows neither an individual continuation nor a pair-list one. It can only be continued with a specification of a function. In this case the need to distinguish functional readings is quite evident, the functional reading being the only one (43) has.

The reason why (43), (38) and (36) do not have a pair-list reading is that in order to obtain this reading the term <u>every man</u>, c.q. <u>no man</u> would have to be quantified into a relative clause, which is not allowed: the scope of any term inside a relative clause is restricted to that relative clause.[22] The reason why (43), unlike (38) and (36), also does not have an individual reading is the same as why this reading does not occur with (40): it would leave the pronoun <u>his</u> in <u>one of his relatives</u> unbound.

5. Conclusion

What we have tried to show in this paper were two things: first of all, that questions have functional readings and that these readings are independent from other readings, and secondly, that an account of functional readings can be given within the framework of Montague grammar.

As for the first objective, we think that the arguments given in this paper are convincing. The phenomenon of functional readings is a real one, which even extends to other types of constructions, as we have indicated in the previous section.

Concerning the account of functional readings which we sketched above, we are less satisfied. We do believe that the rules which we have proposed give a compositional analysis of functional readings. However, we cannot reason away some doubts as to the plausibility (let alone elegance) of the syntactic part of our analysis. We would prefer one which would involve less complications in the syntax. Such an analysis would require a major modification of the framework of Montague grammar. And of the available alternatives, none strikes us as definitely superior in this respect. And it may be relevant to stress again that whatever kind of analysis one may come up with, functional readings should be represented as distinct readings of questions (and other constructions), and thus require some level of representation on which these constructions are disambiguated.

Notes

* We would like to thank Elisabet Engdahl for some stimulating discussions and Renate Bartsch and Johan van Benthem for their comments on some preparatory notes.

1. An individual answer may, of course, specify more individuals. So, if both Mary and Suzy are loved by every man, (a') is an individual answer too:

   (a') Mary and Suzy

   Something similar holds for pair-list answers and functional answers: (b') is also a pair-list answer to question (1), and (c') a functional answer:

   (b') John loves Mary, John loves Suzy, Bill loves Suzy, ...
   (c') His mother and his grandmother

   For simplicity's sake, we stick in what follows to the most simple case.

2. There are situations in which it does seem to be possible to give an individual answer to a question like (2). Suppose we quantify over the set of men in our family. These men have the same (blood-)relatives. Then the following is possible:

   (2') Which of his (blood-)relatives does every man (in our family) love?
   (a) Aunt Mary

   However, it is quite clear that in this situation the answer (2')(a) is to be regarded as a special case of a functional answer. It specifies a constant function, in this case a function which for every argument gives aunt Mary as value.
   Individual answers to (2) are also possible if the pronoun <u>his</u> is a free (deictic) pronoun:

   (3") Which of his (= John's) relatives does every man love?
   (a) (John's) aunt Mary

Unlike (2')(a), which looks like an individual answer, but is a functional one, (3")(a) is an individual answer. A last remark concerns what apparently are mixed answers:

(1) Which woman does every man love?
(d) Mary and his mother

This answer (d) seems to be a combination of an individual and a functional answer, but is, we think, better regarded as a functional answer. The answer gives (the composition of) two functions, the constant function to Mary and the mother-function.

3. 'Loosely speaking', for, as we argued in G & S 1982, section 6.3, the link between the semantic interpretation of questions and the question-answer relationship is not as direct as the formulation in the text suggests. More in particular, pragmatic factors seem to play a predominant role when it comes to characterizing what constitutes a correct answer to a question in a given situation. But for our present purposes, these aspects may be ignored.

4. Throughout we will not bother about certain details, such as mentioning rule numbers, distinguishing between verbs and their extensional counterparts by means of substars, etc. The formulas in the translation trees will be the reduced forms at each step.

5. From now on, we will leave out irrelevant syntactic and semantic information in the analysis trees and translation trees.

6. We will not give the actual rule, it can be found in G & S 1982, section 6.1, where a more extensive motivation for the existence of this rule can be found.

7. See also footnote 2.

8. See e.g. Bennett (1977), who says that a pair-list answer: "might be given in a very compressed way" in the form of a functional answer, and adds that: "Obviously, for epistemic reasons, someone is more likely to give an answer like the second one than like the first."

9. We disregard for the moment the individual reading which the indirect question, and consequently the sentence as a whole, also has.

10. This is not to deny that sometimes a list of pairs may, for the sake of convenience or for some other reason, be abbreviated by a function. The point is that this is not always the case, that functional answers do have a status of their own and that hence questions have a functional reading.

11. Notice that the following list of pairs:

    (b') John doesn't love Mary, Bill doesn't love Suzy, ...

    does not constitute an answer to a question like (11).

12. The distinction between universal and non-universal terms originates from a discussion of the specific/non-specific contrast in the use of terms, where it proved to be usefull too (see G & S 1981). Using some terminology from recent studies on generalized quantifiers (see e.g. Barwise & Cooper 1981, Zwarts 1981) we can define a universal term as one for which it holds that the set on which it lives is a subset of every set in the set of sets denoted by it. Formally:

    A term D(A) is universal iff $\forall X: X \in [\![D(A)]\!] \leftrightarrow A \subseteq X$

    The distinction between universal and non-universal terms also seems to play a role when it comes to determining when quantifying in is allowed, though there things are not as straightforward as one might wish. However, the following seems to hold at least: a non-universal term may not be quantified over another non-universal term.

13. This restriction on quantification into questions was not stated in G & S 1982.

14. We cannot discuss the relevant arguments here, since that would take us too far afield, they are given in G & S 1981c. Recently, Engdahl has come up with another proposal for the analysis of functional readings which in some respects is quite like the analysis proposed in the present paper.

15. Notice that (19) is an abstract, not a complement. From now on, we can restrict our attention to the level of abstracts since nothing changes in the way abstracts are turned into complements, i.e. proposition denoting expressions. So, the proposition denoted by a question can be 'read of' the translation of the abstract underlying it. E.g. the abstract (19) is turned into the following complement:

    (19') $\lambda i[\lambda f[\forall x[man(a)(x) \rightarrow love(a)(x,f(x))]] = \lambda f[\forall x[man(i)(x) \rightarrow love(i)(x,f(x))]]]$

16. Skolem-functions first made their appearence on the linguistic and philosophical stage in a play called 'What is a branching quantifier and why?', which ran for a short but stormy period in the seventies. For some reviews, see Hintikka (1974), Günthner & Hoepelman (1975) and Barwise (1979).

17. We extend the PTQ-mechanism of quantification rules and syntactic variables to account for scope ambiguities and binding phenomena. It is fairly easy to transpose our

entire analysis into a framework which uses Cooper-stores as an alternative (see e.g. Cooper (1975), Engdahl (1980)). However, the use of storage mechanisms is not without problems. E.g. it is not quite clear that the use that is made of Cooper-stores in the literature always obeys the compositionality requirement. See Landman & Moerdijk (1983) for a thorough analysis of Partee & Bach's (1981) extension of the storage approach.

18. Instead of analyzing (2) we take (2'):

    (2') Which relative of him does every man love?

    which is simpler in that we do not have to take into account the analysis of possessive constructions. Of course, for the problems under discussion in this paper it makes no essential difference.

19. On the pair-list reading of this abstract, syntactic and semantic binding are parallel in the usual way. There <u>every man</u> has <u>which relative of him</u> syntactically as well as semantically inside its scope. For this we need the notion of wh-reconstruction defined in G & S 1982, section 4.3.

20. From this, by the way, one may conclude that the controversy between those who require their grammar to give an explicit compositional semantics and those who restrict semantics in the grammar to those aspects determined by pure, autonomous syntax, is not an empirical dispute, but a methodological one.

21. Notice that in this case having recourse to the mechanism of functional readings is essential. Of course, the functional reading of (38) which (39) represents can also be expressed without quantification over Skolem-functions:

    (39') $\forall x[man(a)(x) \rightarrow \exists y[woman(a)(y) \wedge \neg love(a)(x,y)]]$

    But it is impossible to obtain (39') in a compositional way, using the straightforward translation of <u>no man</u> as $\lambda P \forall x[man(a)(x) \rightarrow \neg P(a)(x)]$.

22. For an extensive discussion, see Rodman (1976). The constraint in question is incorporated in the syntax of relative clauses given in G & S 1982, section 4.5.

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