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QUESTIONS AND ANSWERS IN A CONTEXT-DEPENDENT MONTAGUE GRAMMAR

0. INTRODUCTION

A successful formal reconstruction of a fragment of a natural language like the one presented in Montague (1973)[1] calls for extensions in various directions. Two of the most challenging ones among them are the inclusion of non-declarative sentence moods and a treatment of context-dependency beyond the interpretation of tense. The present paper advances some steps in both directions since we believe that dealing with context-dependency is a prerequisite for a satisfactory treatment of interrogatives. While transformationalists tend to regard interrogatives in isolation,[2] scholars interested in the semantics of natural language, both outside the Montague school (e.g., Keenan and Hull, 1973) and inside (e.g., Hamblin, 1973), have noted the relation that links up questions with their possible answers. Montague himself suggests[3] that a syntax and semantics of interrogatives should provide a characterization of the semantic content of a correct answer. Whether a certain expression counts as a correct answer, however, depends on the context in which it is uttered. An appropriate context has to contain an utterance of a corresponding interrogative expression. Therefore we shall tackle the problem from the rear. First we ask: What are the expressions that may serve as answers when uttered in an appropriate context and how are they interpreted? And then: How are interrogatives to be analysed in order to make sure that each corresponding answer is assigned a correct interpretation? Our attempt may thus be regarded as a first step toward a formal grammar of discourse.

1. TYPES OF QUESTIONS AND ANSWERS

Grammarians usually classify interrogatives into the following three main categories:

(A) Yes–no questions
(B) Alternative questions
(C) WH-questions.

F. Guenthner and S. J. Schmidt (eds.), Formal Semantics and Pragmatics for Natural Languages, 339–358.

Category (C) may be subclassified according to what element of the sentence is asked for:

(C1) the subject
(C2) the direct object
(C3) a subject complement
(C4) an object complement
(C5) an adverbial.

Category (C5) comprises again a number of subcategories we shall not enumerate here. In the following, we shall restrict ourselves to the most important types, namely (A) (yes–no questions), (C1) and (C2) (which we shall call term questions), and those subcategories of (C5) (adverbial questions) that use the question words *how*, *where*, *when*, and *why*.

Let us examine now the expressions that may serve as answers to these types of questions. Consider for example (1), an instance of a yes–no question:

(1) Does John love Mary?

With respect to a context created by an utterance of (1), or, as we shall also say, in the context of (1), the following expressions may be used in giving an answer:

(1a) Yes.
(1b) He does.
(1c) He does so.
(1d) He loves her.
(1e) He loves Mary.
(1f) John loves her.
(1g) John loves Mary.
(1h) Yes, (1b).
... ...
(1m) Yes, (1g).

Neglecting the different degrees of acceptability of (1a)–(1m), we may state that they all have two features in common:

(i) they commit the speaker (disregarding irony, etc.) to the truth of (1g), and
(ii) they supply just the information required by the utterance of (1).

This contrasts them with answers like (1n) and (1o):

(1n) Yes, certainly.
(1o) Yes, probably.

which give more and less, respectively, information than required and which may therefore be called over- and under-answers, respectively. Since these will presumably have to be analysed on the basis of exact answers, we feel entitled not to treat them here.

Looking through our list of possible answers to (1) one can notice that there is an increase of redundancy and explicitness from (1a) to (1g) and again from (1h) to (1m). We may call therefore (1a) a minimal or non-redundant answer and (1g) a redundant answer. (1b)–(1f) are then partially redundant answers, and (1h)–(1m) combine each a non-redundant answer with a (partially) redundant one.

Regarding the semantics of (1a) through (1m), it is clear that they are equivalent only with respect to certain contexts, namely those produced by an utterance of (1). If we replace (1) by (2),

(2) Does Bill love Mary?

(1a)–(1e) and (1h)–(1k) are still equivalent to each other, but not to (1f), (1g), (1l), and (1m). The former two still express the same proposition as they did with respect to the first context, but they have now a different illocutionary force insofar as they cannot count as answers anymore.[4] The latter two become somewhat odd in the new context.

Things are very similar with respect to term questions and their answers. Consider the following examples:

(3) Who dates Mary?
(3a) Bill.
(3b) Bill does.
(3c) Bill does so.
(3d) Bill dates her.
(3e) Bill dates Mary.

Again we may distinguish between a minimal, non-redundant answer like (3a), partially redundant answers like (3b)–(3d) and a (fully) redundant answer like (3e). There are, however, no answers to term questions corresponding to the (h)–(m) cases of example (1).

Concerning adverbial questions, the kinds of expressions that may play the rôle of an appropriate answer are demonstrated by the following example:

(4) When will Mary meet John?
(4a) At seven p.m.
(4b) She will do so at seven p.m.
(4c) She will meet him at seven p.m.
(4d) She will meet John at seven p.m.
(4e) Mary will do so at seven p.m.
(4f) Mary will meet him at seven p.m.
(4g) Mary will meet John at seven p.m.

Again, there is a scale of increasing redundancy from (4a) to (4g). And again the truth value of the answer expression will depend on the question in the context of which it is uttered, except for (4g). In this respect (4g) behaves like (3e) and (1g). This shows that redundant answers are not very interesting from a semantical point of view since their semantic representation is identical to that of ordinary declarative sentences. In fact, they are ordinary declarative sentences and the question with respect to which they are interpreted determines only the illocutionary force that they carry. Their answerhood depends on the relation between their intension and that of the question expression, and both can be established independently. The situation is different, as we have seen, with the other kinds of answers, where not only the illocutionary force depends on the meaning of the question expression but also the respective meaning the answer expression has. Since both, redundant and non-redundant answers are possible, and since non-redundant answers are generally much more natural, we hold that no serious theory of questions and answers should restrict itself to a treatment of redundant answers alone, and that it should be able to handle both. As shown above, redundant answers represent no problem with respect to semantic interpretation; the problems they pose concern only the theory of speech acts. The remaining answer-types, on the other hand, do present interesting problems concerning semantic interpretation. We may distinguish between the (a)-cases, which we called minimal answers, and the remaining ones, which share the feature of containing one or more unbound or exophoric pro-forms. But the problem of exophoric pro-forms is not limited to answer-expressions alone, it may be viewed as an instance of the general problem of determining the reference for pro-forms. We shall not go deeper into this matter here (cf. Hausser, 1977), but it seems that once this problem is solved, all partially redundant answers may be reduced to redundant ones. Therefore it is the phenomenon of minimal answers that represents the basic and crucial problem to be solved by a semantic theory of questions and answers. A final look at alternative questions and their answers may demonstrate now our reason for neglecting them in this context. Consider (5)–(5f):

(5) Does Mary sleep or is John sick?
(5a) Mary sleeps.
(5b) John is sick.
(5c) The former.
(5d) The latter.
(5e) Yes.
(5f) No.

The example shows that with respect to alternative questions, only redundant answers (5a, b) or answers with exophoric proforms (5c, d) are possible, but not minimal answers of the yes–no type.

2. EXTENDING THE PTQ-LOGIC INTO A CONTEXT-DEPENDENT SYSTEM

While the fragment of English presented in 'English as a formal language' (Montague, 1974, Chapter 6) is given a direct semantic interpretation, the fragments contained in 'Universal grammar' (Montague, 1974, Chapter 7) and in PTQ are (for the sake of perspicuity) interpreted indirectly via auxiliary languages of typed intensional logic. The 'pragmatic'[5] aspect of the notion of truth defined in PTQ lies in the fact that it is made relative not only to a given model or interpretation, as usual in model theoretical semantics, but also to a so-called point of reference $\langle i, j \rangle$, consisting of a possible world and a moment of time. This will not suffice, however, for the interpretation of minimal answers, since, as we have pointed out in the preceding section, their truth value depends on the meaning of a previously uttered interrogative expression. Therefore we have to extend the PTQ-logic into a context-dependent system which specifies for each point of reference the meaning of the preceding utterance. We could do that, following a suggestion by D. Lewis (1970), by simply adding a further coordinate, a 'previous discourse coordinate', to the point of reference, but this approach would be exposed to M. J. Cresswell's objection that it leads to an inflation of coordinates: "why not a country, climate, religion, or 'previous drinks' coordinate?" (Cresswell, 1973, p. 111). We therefore prefer another way of extending the PTQ-logic[6] which comprises the following three steps.

First we replace the interpretation or intensional model by a context-model. We define a *context-model* as an ordered triple $\langle \mathscr{A}, C, ca \rangle$, where $\mathscr{A}$ is an interpretation having the form $\langle A, I, J, \leqslant, F \rangle$ and being defined as in PTQ (p. 258), C is the set of contexts, and ca is a function from $I \times J$ into C ('ca' stands for 'context-assignment function'). C in turn is defined as $\{c_0\} \cup \bigcup_{a \in \text{Type}} ME_a$, where ME_a or the set of meaningful expressions of type a is defined as in PTQ (p. 256f.) and c_0 stands for the empty context, i.e., a context without previous discourse. (We could, of course, give C a much more complex structure in order to account for other phenomena than immediate previous-discourse dependency, but the simple formulation given here will be sufficient for the restricted aims of this paper.)

The second step of our extension of the PTQ-logic introduces a new set of basic symbols, namely the union of the sets $C\text{-Var}_a$ ($a \in$ Type) or the set of *context-variables*. If n is any natural number and $a \in$ Type, then $c\text{–}v_{n,a}$ is the nth context-variable of type a. These additional basic expressions permit us to define a larger set of meaningful expressions for each type a, which we call ME'_a. The definition of ME'_a runs like that of ME_a (p. 256f.) with the following two differences:

(i) The first clause of the definition is replaced by (1′):

(1′) Every variable, constant, and context-variable of type a is in ME'_a.

(ii) In the remaining clauses, each occurrence of 'ME_a' is replaced by 'ME'_a'.
It follows that ME_a is a proper subset of ME'_a and that $ME'_a \backslash ME_a$[7] consists of those meaningful expressions which contain at least one context-variable. It may be called the set of context-dependent meaningful expressions.

In the third step of our extension, the respective definitions for extension and intension of a meaningful expression are now adjusted to ME'_a. Let $\mathscr{L}$ be a context-model having the form $\langle \mathscr{A}, C, ca \rangle$. Suppose further that g is an $\mathscr{A}$-assignment as defined in PTQ (p. 258). If $\alpha \in ME'_a$ and $\langle i, j \rangle \in I \times J$, then $\alpha^{\mathscr{L}, i, j, g}$ is to be the *extension* of α with respect to $\mathscr{L}$, i, j, and g, where $\alpha^{\mathscr{L}, i, j, g}$ is defined as follows:

(1) If α is a constant, then $\alpha^{\mathscr{L}, i, j, g}$ is $F(\alpha)(\langle i, j \rangle)$.
(2) If α is a variable, then $\alpha^{\mathscr{L}, i, j, g}$ is $g(\alpha)$.
(3) If $\alpha \in C\text{-Var}_a$, then $\alpha^{\mathscr{L}, i, j, g}$ is $[ca(\langle i, j \rangle)]^{\mathscr{L}, i, j, g}$, in case $ca(\langle i, j \rangle) \in ME_a$, and $\alpha^{\mathscr{L}, i, j, g}$ is u else (u stands for undefined).

The following clauses (4)–(11) are systematic modifications of the clauses

(3)–(10) in PTQ, p. 258f. (including Thomason's amendments in fn. 10 on p. 259). We obtain our modified clauses from the corresponding original ones by (i) replacing each occurrence of 'ME' by 'ME'', (ii) replacing each superscript ${}^{\mathscr{A},i,j,g}$ or ${}^{\mathscr{A},i,j,g'}$ by ${}^{\mathscr{L},i,j,g}$ or ${}^{\mathscr{L},i,j,g'}$, respectively, and (iii) adding 'in case $\alpha^{\mathscr{L},i,j,g}$, $\beta^{\mathscr{L},i,j,g}$ are not u, and $\gamma^{\mathscr{L},i,j,g}$ is u else', where α, β, and γ are the meaningful expressions mentioned in the antecedens and consequens, respectively. If $\phi \in ME'_t$, then ϕ is an *interpretable formula* with respect to $\mathscr{L}$, i, and j if and only if $\phi^{\mathscr{L},i,j,g}$ is not u. If ϕ is an interpretable formula with respect to $\mathscr{L}$, i, and j, then ϕ is *true* with respect to that context-model and point of reference if and only if $\phi^{\mathscr{L},i,j,g}$ is 1 for every $\mathscr{A}$-assignment g. The *intension* $\alpha^{\mathscr{L},g}$ of α relative to $\mathscr{L}$ and g is then defined as that function h with domain $I \times J$ such that whenever $\langle i,j\rangle \in I \times J$, $h(\langle i,j\rangle)=\alpha^{\mathscr{L},i,j,g}$, in case $\alpha^{\mathscr{L},i,j,g}$ is not u, and $\alpha^{\mathscr{L},g}$ is u else.

The fact that our system allows for the case that the extension of a meaningful expression is undefined has obviously somewhat tedious technical consequences and calls for a justification. We included this feature in order to account for the fact that a minimal answer is interpretable only with respect to an appropriate context, i.e., a context built up by a suitable question. In particular, all minimal answers are uninterpretable with respect to the empty context c_0.

3. TERM QUESTIONS AND THEIR MINIMAL ANSWERS

As we have demonstrated in Section 1, the minimal answer to a term question consists in an utterance of a term phrase. Consider the following example:

(6) What does Mary imagine?
(6a) A dragon.[8]

But we have stated also that an expression like (6a), when uttered in a context like (6), denotes a truth value. It is true exactly in case Mary does imagine a dragon and false if she does not. How can these observations be combined in a formally consistent way? Note that there is a small but important difference between the term 'a dragon' and the expression (6a): The latter ends with a full stop, which indicates a falling tone and makes the utterance count as a declarative one. We shall therefore assign expressions like (6a) the category t (declarative sentence), and translate them into expressions of type t (formulas). Since the intension of (6a) depends partly on the intension of the term 'a dragon' and partly on the context, we have to translate it, according to the principle of compositionality, into a context-dependent meaningful expression containing the translation of 'a dragon'. The simplest way of doing this is adding a context-variable of fitting type to the intensionalized term-translation. We translate thus the minimal answer (6a) into (6a′):

(6a′) $\Gamma(\hat{P} \vee x[\text{dragon}'(x) \wedge P\{x\}])$.

Assuming that Γ is a context-variable of type $\langle\langle s, f(T)\rangle, t\rangle$, (6a′) as a whole turns out to be an element of ME'_t, as desired. It is easy to state now the properties an appropriate translation (6′) of (6) has to show: First, it has to be of the same type as Γ, and second, if (7′) is the translation of the redundant answer (7),

(7) Mary imagines a dragon

then the extension of (6a′) with respect to a context-model and a point of reference such that $ca(\langle i, j\rangle)$ is (6′) has to be the same as the extension of (7′) with respect to that model and point of reference. In other words, minimal and redundant answers have to be equivalent with respect to the same question. We meet this requirement formally on the basis of the principle of functional application by abstracting a function from an appropriate open formula such that it may be applied to arguments like that of Γ in (6a′). Thus a translation of (6) would be (6′):

(6′) $\hat{\mathscr{P}} m^*(\hat{\ }\text{imagine}'(\mathscr{P}))$.

According to clause (3) of our definition, the extension of (6a′) with respect to a context-model and a point of reference of the kind specified above, is the same as that of (6a″):

(6a″) $\hat{\mathscr{P}} m^*(\hat{\ }\text{imagine}'(\mathscr{P}))\,(\hat{P} \vee x[\text{dragon}'(x) \wedge P\{x\}])$.

According to some valid PTQ-principles, (6a″) is equivalent with (6a‴):

(6a‴) $m^*(\hat{\ }\text{imagine}'(\hat{P} \vee x[\text{dragon}'(x) \wedge P\{x\}]))$.

This, in turn, is exactly the result of translating (7), which shows that the desired equivalence of minimal and redundant answer is met. So far we have been loosely speaking of the translation of, e.g., (7). This is not quite correct, however, since there are two semantically different translations of (7), usually referred to as its referential and non-referential reading. Above we have treated only the latter one. It is not difficult, however, to derive the referential reading of (6a) as well:

(6b) $F_{10,0}$(a dragon, he_0.)

(6b) is surface-identical with (6a), but it translates differently:

(6b′) $\hat{P} \vee x[\text{dragon}'(x) \wedge P\{x\}](\hat{x}_0 \Gamma(\hat{P}P\{x_0\}))$.

After some reformulations we get:

(6b″) $\hat{P} \vee x[\text{dragon}'(x) \wedge P\{x\}](\hat{x}_0 m^*(\hat{}\,\text{imagine}'(\hat{P}P\{x_0\})))$,

which is the result of translating the referential reading of (7).

There are, however, some phenomena our analysis doesn't account for yet. Consider for example (8) and (8a):

(8) Whom does Mary kiss?
(8a) A fish.

(8a) is not uninterpretable with respect to the context created by (8), but it does not give the information required. (8) doesn't just ask for any object of Mary's kissing but for a human one. As fishes never are human, (8a) is an implicitly contradictory and hence always false answer with respect to (8). With respect to (9), on the other hand,

(9) What does Mary kiss?

(8a) might well be a true answer (provided Mary is a little queer). The following two steps are necessary in order to handle these facts adequately: We have to assign different translations to *what* and *who(m)* on the basis of the features *human* and *not human*, respectively, and we have to add two meaning postulates ensuring that in all possible worlds and at any moment of time, e.g., John is a human and a fish is not.[9]

Next consider (10)–(11a):

(10) Whom will Bill meet?
(11) Which girl will Bill meet?
(11a) The drum-major.

While (11a) may be a true answer to (10) as well as to (11), the conditions for its being true are not the same in both cases. Suppose the drum-major is a man. Then (11a) may be true with respect to (10), but never with respect to (11), since in the latter context, but not in the former, (11a) implies that the drum-major is a girl.[10] Our analysis of which-questions will have to account for this fact.

Finally consider (12)–(13a):

(12) Who sleeps?
(13) What does John eat?
(12a) Nobody.
(13a) Nothing.

The fact that (12a) becomes nonsensical in the context of (13) and that the same holds for (13a) with respect to (12) shows again the effects of the semantic difference between *what* and *who*. Note, however, the complete naturalness of (12a) with respect to (12) and of (13a) with respect to (13), which suggests that *what* and *who* questions do not presuppose the existence of a thing or person having the specified property. Therefore we translate *who* and *what* without existential quantifier. The data seem to be a little less convincing regarding *which* questions but we believe that (14), (14a) is also a natural question–answer pair:[11]

(14) Which man will Mary kiss?
(14a) No one.

Hence we propose to regard the existence of some man whom Mary will kiss as an invited inference rather than a logically valid one[12] and we introduce no existential quantifier into the translation of *which* neither.

As a kind of summary of our investigations in this section, we shall give now translations for several of our examples according to the rules stated in the appendix. ('(n/m)' stands for '(n) in the context of (m)'.)

(9) What does Mary kiss?
(9′) $\hat{\mathscr{P}}_1 m^*({}^\frown\text{kiss}'(\hat{P}\,\mathscr{P}_1\{\hat{x}[\neg\,\text{human}'(x) \wedge P\{x\}]\}))$.
(8a) A fish.
(8a′) $\Gamma(\hat{P} \bigvee x[\text{fish}'(x) \wedge P\{x\}])$.
(8a′/9′) $\bigvee u[\text{fish}'_*(u) \wedge \text{kiss}'_*(m, u)]$.
(10) Whom will Bill meet?
(10′) $\hat{\mathscr{P}}_1 W\, b^*({}^\frown\text{meet}'(\hat{P}\,\mathscr{P}_1\{\hat{x}[\text{human}'(x) \wedge P\{x\}]\}))$.
(11) Which girl will Bill meet?
(11′) $\hat{\mathscr{P}}_1 W\, b^*({}^\frown\text{meet}'(\hat{P}\,\mathscr{P}_1\{\hat{x}[\text{girl}'(x) \wedge P\{x\}]\}))$.
(11a) The drum-major.
(11a′) $\Gamma(\hat{P} \bigvee y[\bigwedge x[\text{drum-major}'(x) \leftrightarrow x = y] \wedge P\{x\}])$.
(11a′/10′)

$$W \bigvee v[\bigwedge u[\text{drum-major}'_*(u) \leftrightarrow u = v] \wedge \text{meet}'_*(b, v)]$$

(11a′/11′)

$W \vee v[\wedge u[\text{drum-major}'_*(u) \leftrightarrow u = v] \wedge \text{girl}'_*(v)$
$\wedge \text{meet}'_*(b, v)]$.

(12) Who sleeps?

(12′) $\hat{\mathscr{P}}_1 \hat{P} \mathscr{P}_1 \{\hat{x}[\text{human}'(x) \wedge P\{x\}]\}(\hat{}\,\text{sleep}')$

(12a) Nobody.

(12a′) $\Gamma(\hat{P} \neg \vee x[\text{human}'(x) \wedge P\{x\}])$

(12a′/12′)

$\neg \vee u[\text{human}'_*(u) \wedge \text{sleep}'_*(u)]$

(13) What does John eat?

(13′) $\hat{\mathscr{P}}_1 j^*(\hat{}\,\text{eat}'(\hat{P} \mathscr{P}_1 \{\hat{x}[\neg \text{human}'(x) \wedge P\{x\}]\}))$

(13a) Nothing.

(13a′) $\Gamma(\hat{P} \neg \vee x[\neg \text{human}'(x) \wedge P\{x\}])$

(13a′/13′)

$\neg \vee u[\neg \text{human}'_*(u) \wedge \text{eat}'_*(j, u)]$

4. YES–NO QUESTIONS AND THEIR MINIMAL ANSWERS

The analysis of yes–no questions seems to be very simple. The set of minimal answer expressions contains just those two members which gave the whole category its name. The interrogative expressions themselves are derivable from ordinary declarative sentences in a rather simple way. This coincides with the fact that they do not contain characteristic question words. There are, however, some particularities to be accounted for. First compare (15), (16), and (15a):

(15) Will John leave?

(16) Won't John leave?

(15a) No.

What are the conditions for (15a) to be true? With respect to (15), (15a) is true just in case John will not leave. The same holds, however, with respect to (16). It follows that the negative form in (16) is not a truth functional component of the whole expression. It rather has the function of an attitudinal disjunct, telling us something about the expectation the speaker had: "Oh, I thought he would." would be a natural continuation.

Secondly, consider (17) and (17a):

(17) Will Mary talk or does the dragon sleep?

(17a) Yes.

It is very improbable that (17a) will serve as a natural answer to (17). This is due to the fact that (17) can hardly be anything else than an alternative question. Compare, however, (18):

(18) Does Bill drink or smoke?

Here the alternative as well as the yes–no reading are possible and therefore (17a) is a possible answer to (18).

We account for these facts by deriving yes–no interrogatives not from declarative sentences, but from terms and intransitive verb phrases, excluding thus negation and sentential conjunction and disjunction.

The further requirements an adequate analysis of yes–no questions and their minimal answers must meet are quite obvious: If ϕ? is a yes–no interrogative and ϕ is the corresponding declarative sentence, then the extension of *Yes.* with respect to ϕ? has to be truth exactly in case the extension of ϕ is truth and the extension of *No.* with respect to ϕ? has to be truth if and only if ϕ is not true. The following translations have the desired properties: $\hat{p}[\check{}p]$ (for *yes*) and $\hat{p}[\neg\check{}p]$ (for *no*) denote complementary sets of propositions. $\Gamma(\hat{p}[\check{}p])$ (representing *Yes.*) and $\Gamma(\hat{p}[\neg\check{}p])$ (representing *No.*) denote truth values, provided the context-variable Γ denotes sets of properties of propositions. The context-variable stands again for the translation of an appropriate question, e.g., (15):

(15′) $\hat{q}q\{\hat{}W\, j^*(\hat{}\text{leave}')\}$.
(15a′) $\Gamma(\hat{p}[\neg\check{}p])$.

If we interpret (15a′) with respect to (15′), we may read it roughly as follows: The set of properties of the proposition that John will leave contains the property of not being the case. The reduction shows the desired equivalence with the redundant answer (19):

(19) John won't leave.
(19′) $\neg W\ \text{leave}'_*(j)$
(15a′/15′)
$\neg W\ \text{leave}'_*(j)$

5. ADVERBIAL QUESTIONS AND THEIR MINIMAL ANSWERS

Our general approach works for adverbial questions as well as for term and yes–no questions. We shall therefore restrict our discussion to two special points. First it is obvious that an adverbial question determines not only the syntactic category of the expression which, together with the full stop, makes up a minimal answer, but also part of its semantic content. The following examples may serve as an illustration:

(20) How does Bill walk?
(20a) Rapidly.
(20b) Slowly.
(20c) At seven p.m.
(20d) At the corner.
(20e) Into the park.
(20f) Because of Mary.

Only (20a) and (20b) make sense in the context of (20), (20c)–(20f) don't. The data are similar to those which concern the difference between *what*, *who*, and *which* plus a common noun phrase, and therefore we account for them in an analogous way: We introduce a feature into the translation of the adverbial question word (e.g., MANNER in the case of *how* — we use upper case letters in order to avoid confusion with the common noun translation *manner'*) and we ensure by a meaning postulate that this feature turns out to be redundant if the answer is suitable. But there is another phenomenon to be noticed which has no counterpart among the term questions. Compare (21), (22), and the answers (21a)–(22a):

(21) Where does John walk?
(22) Where will John meet the blonde?
(21a) In the park.
(21b) Into the park.
(22a) At the party.

(21a)–(22a) do all make sense in the context of (21), but only (21a) and (22a) do so in the context of (22). The consequence is clear: (21) has to be assigned two readings, due to the lexical ambiguity of the question word *where*. The following translations, derived according to the rules stated in the Appendix, show our proposal for dealing with that phenomenon:

(21') $\lambda \alpha_1 j^*(\hat{\ }\lambda P\hat{x}[\mathrm{PLACE}(\alpha_1) \wedge \alpha_1\{x, P\}](\hat{\ }\mathrm{walk}'))$.
(21'') $\lambda \alpha_1 j^*(\hat{\ }\lambda P\hat{x}[\mathrm{DIRECTION}(\alpha_1) \wedge \alpha_1\{x, P\}](\hat{\ }\mathrm{walk}'))$.

Using MP(14) and MP(15) (cf. the appendix, 8.4) we get the following translations for (21a) and (21b) in the context of the place- and the direction-reading of (21), respectively:

(21a′/21′)

$$\text{in}'(\hat{j}, \hat{}\text{walk}', \hat{P} \bigvee v[\bigwedge u[\text{park}'_*(u) \leftrightarrow u = v] \wedge P\{v\}]).$$

(21b′/21″)

$$\text{into}'(\hat{j}, \hat{}\text{walk}', \hat{P} \bigvee v[\bigwedge u[\text{park}'_*(u) \leftrightarrow u = v] \wedge P\{v\}]).$$

Again, we have equivalence with the redundant answers (23) and (24):

(23) John walks in the park.
(24) John walks into the park.

6. MULTIPLE QUESTIONS

Thus far we have been considering only questions that ask for one and only one item. With respect to them, a minimal answer consists in the declarative utterance of one expression of the corresponding category. There are, however, interrogative sentences like (25) which ask for more than one item:

(25) Who kisses whom?

A suitable minimal answer is, e.g., (25a):

(25a) Mary Bill.

We may call questions like (25) two-term questions. A somewhat different example is the following:

(26) When will John meet Mary where?
(26a) At seven p.m. at the corner.

Questions of this kind may be called two-adverbial questions. But the items asked for in a multiple question need not be of the same category, as the following example demonstrates:

(27) Who seeks the dragon where?
(27a) Mary in the park.

Note, however, that the degree of acceptability of the question and especially of the minimal answer diminishes as the number of questioned items increases:

(28) Who kisses whom where when how?
(28a) Mary Bill at the corner in the evening rapidly.

But since, apart from acceptability, there is no principled reason against a question–answer pair like (28), (28a), our rules account also for cases like this.

The situation is different with expressions like the following:

(29) $*$Does John leave when?

(29a) $*$Yes in the evening.

The reason for rejecting (29) is not a low degree of acceptability but sheer ungrammaticality: A yes–no question cannot contain any additional questioned item. We therefore restrict the possibility of generating multiple questions to term and adverbial questions (cf. rule S19.(d) in the Appendix).

7. CONCLUDING REMARKS

In conclusion we shall point out briefly some of the most important respects in which our approach differs from other recent proposals concerning the formal semantics of questions. We differ from Keenan and Hull (1973) mainly in three points: (a) We provide explicit and separate rules for translating question and answer expressions from natural into logical language, (b) we do not restrict ourselves to which and yes–no questions, and (c) we do not exclude answers of the nobody/nothing type from the class of natural answers. We differ from Hamblin (1973) in that our approach does not make it necessary to 'lift' the whole semantics in type, letting, e.g., the intension of a formula be the unit set of a proposition instead of the proposition itself. While Hamblin proposes to let questions denote uniformly sets of propositions, we propose to let questions denote different types of sets according to the type of that expression which is the critical one in any kind of answer. Finally, in contrast to Karttunen (1976), we do not believe that an adequate analysis of direct questions can be given by supplementing a grammar of embedded questions with the remark that direct questions can be derived from a deleted performative 'I ask you to tell me' plus the corresponding embedded questions. Apart from other problems concerning the performative analysis we see no way such a proposal could be amended in order to account for the phenomenon of minimal answers which we showed to be the crucial semantic problem in connection with direct questions.

8. APPENDIX

An extension of the PTQ-fragment of English including direct questions and minimal answers

8.1. *Additional categories*

(a) *Categories for direct questions*

$t/(t//t)$ is the category of direct yes–no questions.

t/T is the category of direct one-term questions.
t/IAV is the category of direct one-adverbial questions.
If $A, B \in \{T, IAV\}$, then $(\ldots(t/A)/\ldots)/B$ are the categories of direct multiple questions, in particular
$(t/T)/T$ is the category of direct two-term questions, and
$(t/IAV)/IAV$ is the category of direct two-adverbial questions.

(b) *Primed categories*

If A is a category, then $(A)'$ is also a category (parentheses will be omitted if no ambiguity can arise). In particular, t' is the category of open sentences.

8.2. *Additional basic expressions*

$B_{IV} = B_{IV}^{\mathrm{PTQ}} \cup \{\text{sleep, leave}\}$
$B_T = B_{IV}^{\mathrm{PTQ}} \cup \{\text{seven p.m., nobody, nothing}\}$
$B_{T'} = \{\text{who, what}\}$
$B_{TV} = B_{TV}^{\mathrm{PTQ}} \cup \{\text{meet, kiss, imagine}\}$
$B_{IAV'} = \{\text{how, when, where}_1\text{, where}_2\text{, why}\}$
$B_{CN} = B_{CN}^{\mathrm{PTQ}} \cup \{$blonde, girl, drum-major, human, dragon, evening, corner. party$\}$
$B_{IAV/T} = B_{IAV/T}^{\mathrm{PTQ}} \cup \{\text{into, at, because of}\}$
$B_{t//t} = \{\text{yes, no}\}$.

8.3. *Additional S- and T-rules*

Let s be an additional distinct member of Con_e, MANNER, TIME, PLACE, DIRECTION, and REASON be particular distinct members of $\mathrm{Con}_{\langle\langle s, f(IAV)\rangle, t\rangle}$, and a be the variable $v_{0, \langle s, f(IAV)\rangle}$.

(a) *Basic rules*

T1.(d)′ *John, Mary, Bill, ninety, seven p.m.* translate into j^*, m^*, b^*, n^*, s^* respectively.

(f) *nobody* and *nothing* translate into $\hat{P}\neg \bigvee x[\text{human}'(x) \wedge P\{x\}]$ and $\hat{P}\neg \bigvee x[\neg\text{human}'(x) \wedge P\{x\}]$ respectively.

(g) *who* and *what* translate into $\hat{P}\mathscr{P}\{\hat{x}[\text{human}'(x) \wedge P\{x\}]\}$ and $\hat{P}\mathscr{P}\{\hat{x}[\neg\text{human}'(x) \wedge P\{x\}]\}$ respectively.

(h) *how, when, where*$_1$, *where*$_2$, *why* translate into $\lambda P\, \hat{x}[\text{MANNER}\ (a) \wedge a\{x, P\}]$, $\lambda P\, \hat{x}[\text{TIME}\ (a) \wedge a\{x, P\}]$, $\lambda P\, \hat{x}[\text{PLACE}\ (a) \wedge a\{x, P\}]$, $\lambda P\, \hat{x}[\text{DIRECTION}\ (a) \wedge a\{x, P\}]$, $\lambda P\, \hat{x}[\text{REASON}\ (a) \wedge a\{x, P\}]$ respectively.

(i) *yes*, *no* translate into $\hat{p}[\check{}p]$, $\hat{p}[\neg\check{}p]$ respectively.

S2a. If $\xi \in P_{CN}$, then $F_{2a}(\xi) \in P_{T'}$, where $F_{2a}(\xi) = which\ \xi$.

T2a. If $\xi \in P_{CN}$ and ξ translates into ξ', then $F_{2a}(\xi)$ translates into $\hat{P}\mathscr{P}\{\hat{x}[\xi'(x) \wedge P\{x\}]\}$.

(b) *Rules of functional application*

S4.–S10. apply to normal categories as well as to their primed variants. If one of the input expressions is of a primed category, the category of the output expression has to be replaced by its primed variant.

S5′. If $\delta \in P_{IV/T}$ and $\beta \in P_T$, then $F_5(\delta, \beta) \in P_{IV}$, where $F_5(\delta, \beta) = \delta\beta$ if β does not have the form he_n or *who* and $F_5(\delta, he_n) = \delta\ him_n$ and $F_5(\delta, who) = \delta\ whom$.

(c) *Formation rules for direct questions*

(Since our main concern here is not syntax and for the sake of brevity we give only a rough outline of rule S19, an explicit statement of which would require the definition of several auxiliary notions.)

S18. If $\alpha \in P_T$ and $\delta \in P_{IV}$, then $F_{16}(\alpha, \delta)$, $F_{17}(\alpha, \delta)$, $F_{18}(\alpha, \delta) \in P_{t'}$, $F_{16}(\alpha, \delta) = whether\ \alpha\delta'$, $F_{17}(\alpha, \delta) = whether\ \alpha\delta''$, $F_{18}(\alpha, \delta) = whether\ \alpha\delta'''$, and δ', δ'', δ''' come from δ by replacing the first verb in δ by its third person singular present, future, or present perfect, respectively.

T18. If $\alpha \in P_T$, $\delta \in P_{IV}$, and α, δ translate into α', δ' respectively, then
$F_{16}(\alpha, \delta)$ translates into $q\{\hat{}\alpha'(\hat{}\delta')\}$,
$F_{17}(\alpha, \delta)$ translates into $q\{\hat{}W\alpha'(\hat{}\delta')\}$,
$F_{18}(\alpha, \delta)$ translates into $q\{\hat{}H\alpha'(\hat{}\delta')\}$.
q is to be the variable $v_{0,\langle s, f(t//t)\rangle}$.

S19. If $\phi \in P_{t'}$ and $\alpha, \alpha', \ldots, \beta, \beta', \ldots$ are the first, second, ... members of $P_{T'}$ and $P_{IAV'}$ respectively that occur in ϕ, then either:

(a) there is no such α or β and $F_{19}(\phi) \in P_{t/(t//t)}$, $F_{19}(\phi) = \phi'\,?$, where ϕ' comes from ϕ by first replacing the first verb in ϕ by its do-supported form (the do-supported form of *is* being *is*, of course, etc.) and then substituting the auxiliary for the initial *whether*; or

(b) there is exactly one $\alpha \in P_{T'}$ as required and $F_{20}(\phi) \in P_{t/T}$, where either $\alpha = who$ and $F_{20}(\phi) = \phi\,?$, or $\alpha = whom$ and $F_{20}(\phi) = whom\ \phi'\,?$, where ϕ' comes from ϕ by deleting *whom* in ϕ, replacing the first verb in ϕ by its do-supported form, and preposing the auxiliary; or

(c) there is exactly one $\beta \in P_{IAV'}$ as required and $F_{21}(\phi) \in P_{t/IAV}$, $F_{21}(\phi) = \beta\phi'?$, where ϕ' comes from, ϕ by deleting β in ϕ, replacing the first verb in ϕ by its do-supported form, and preposing the auxiliary; or

(d) there are $n (n > 1)$ α or β as required and $F_{22,n}(\phi) \in P_{(\ldots(t/A)/\ldots)/B}(A, B \in \{T, IAV\})$, $F_{22,n}(\phi) = \phi?$.

T19. If $\phi \in P_{t'}$, ϕ translates into ϕ', and $\alpha^1, \ldots, \alpha^n$, in that order, are the free occurrences, from left to right, of variables in ϕ', then $F_{19}(\phi)$, $F_{20}(\phi)$, $F_{21}(\phi)$, and $F_{22,n}(\phi)$ translate into $\lambda v_1 \ldots \lambda v_n \phi''$, where $v_i (1 \leqslant i \leqslant n)$ is the i-th variable of the same type as α^i and ϕ'' comes from ϕ' by replacing each α^i in ϕ' by the i-th variable of the same type.

(d) *Formation rules for minimal answers*

S20a. If $A \in \{t//t, T, IAV\}$ and $\alpha \in P_A$, then $F_{23}(\alpha) \in P_t$, where $F_{23}(\alpha) = \alpha.$.

T20a. If $\alpha \in P_A$ $(A \in \{t//t, T, IAV\})$ and α translates into α', then $F_{23}(\alpha)$ translates into $\Gamma(\hat{}\alpha')$.
Γ is to be the context-variable $c\text{-}v_{0, \langle \langle s, f(A) \rangle, t \rangle}$.

S20b. If $\alpha_1 \in P_{A_1}, \ldots, \alpha_n \in P_{A_n}$ $(A_i \in \{T, IAV\}, 1 \leqslant i \leqslant n)$, then $F_{24,n}(\alpha_1, \ldots, \alpha_n) \in P_t$ and
$F_{24,n}(\alpha_1, \ldots, \alpha_n) = \alpha_1 \ldots \alpha_n.$.

T20b. If $\alpha_1 \in P_{A_1}, \ldots, \alpha_n \in P_{A_n}$ $(A_i \in \{T, IAV\}, 1 \leqslant i \leqslant n)$, and $\alpha_1, \ldots, \alpha_n$ translate into $\alpha_1', \ldots, \alpha_n'$ respectively, then $F_{24,n}(\alpha_1, \ldots, \alpha_n)$ translates into
$\Delta_{A_1, \ldots, A_n}(\hat{}\alpha_n') \ldots (\hat{}\alpha_1')$, where $\Delta_{A_1, \ldots, A_n}$ is the context-variable $c\text{-}v_{0, \langle \langle \ldots \langle s, f(A_1) \rangle, \ldots \rangle, \langle \langle s, f(A_n) \rangle, t \rangle \rangle}$.

8.4. *Additional meaning postulates*

(10) $\Box\, \alpha(\hat{}\text{human}')$, where α is j^*, m^*, b^*, or $F_n(\xi)$ $(0 \leqslant n \leqslant 2)$, and ξ translates *man*, *woman*, *blonde*, or *girl*.

(11) $\Box\, \alpha(\hat{}\neg\text{human}')$, where α is n^*, s^*, or $F_n(\xi)$ $(0 \leqslant n \leqslant 2)$, and ξ translates any member of B_{CN} except *human* and those mentioned in MP(10).

(12) $\Box\, \text{MANNER}(\hat{}\delta)$, where δ translates *rapidly* or *slowly*.

(13) $\square$ TIME($\hat{}\delta$), where δ translates *in the evening* or *at seven p.m.*.

(14) $\square$ PLACE($\hat{}\delta(\hat{}\beta)$), where δ translates *in* or *at* and β is $F_n(\xi)$ ($0 \leqslant n \leqslant 2$), where ξ translates *park*, *corner*, or *party*.

(15) $\square$ DIRECTION($\hat{}\delta(\hat{}\beta)$), where δ translates *into* and β translates any member of P_T except *ninety*, *seven p.m.*, F_n(*price*), or F_n(*temperature*) ($0 \leqslant n \leqslant 2$).

(16) $\square$ REASON($\hat{}\delta(\hat{}\beta)$), where δ translates *because of* and β translates any member of P_T except *ninety* and *seven p.m.*.

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NOTES

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[1] 'The proper treatment of quantification in ordinary English', henceforth abbreviated as PTQ. This article has been reprinted as Chapter 8 of Montague (1974), to which we refer.

[2] Cf., e.g., Bach (1970).

[3] PTQ, p. 248, fn. 3.

[4] According to one view, answers constitute an illocutionary type (a subcategory of assertions) since they may be defined in terms of the specific change in the interactional situation they produce: They fulfill the commitment established by the previous question and they commit the speaker to the truth of their propositional content.

[5] Like Hamblin (1973, p. 47) we do not accept Montague's identifying 'pragmatics' with 'indexical semantics'. The central problems of pragmatics, as we understand this notion, are those of a theory of speech acts. For an analysis of the speech acts of asking a question see Zaefferer (in preparation).

[6] The basic idea of this approach has been outlined in Chapter 5 of Hausser (1974).

[7] As usual we understand by $A \backslash B$, A and B being any sets, the complement of the intersection of A and B with respect to A.

[8] We apologize for being fed up a little with unicorns.

[9] Remember that PTQ treats proper names as rigid designators, i.e., as referring to the same individual at all points of reference. Therefore, if *Bill jn.* refers to a steamboat, *Bill jn.* is necessarily non-human.

[10] This fact has been pointed out also by Keenan and Hull (1973, p. 448f.).

[11] In this respect we subscribe to Marga Reis' critique of Keenan and Hull (1973) in Reis (1974), fn. 17.

[12] For the notion of an invited inference see Geis and Zwicky (1971).

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