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On the Semantics of Questions and the Pragmatics of Answers

Jeroen Groenendijk and Martin Stokhof

0. INTRODUCTION

There is a vast, and rapidly growing, literature on questions and question-answering. The subject has had the longstanding and almost continuous attention in many areas of study, including linguistics, logic, philosophy of language, computer science, and certainly others besides. Many proposals for the analysis of questions and answers at different levels and in different fields and frameworks exist. The aim of this paper is no other than to add another proposal to this long list. We will not discuss the work of others, or point at the relative merits of our own. This is an ill-practice which we hope to make good for at some time in the future.

The analysis of questions and answers we will propose, is a fairly simple and straightforward one. Our most basic assumption, which perhaps strikes the uninitiated as rather trivial, is that there is no hope for an adequate theory of question-answering that does not take absolutely seriously the fact that a correct question signalizes a gap in the information of the questioner, and that a correct answer is an attempt to fill in this gap as well as one can by providing new information. So, information should be a crucial notion in any acceptable theory of question-answering. Whether a piece of information, a proposition, provides an answer to a question of a certain questioner, depends on the information it conveys and on the information the questioner already has. This makes the notion of answerhood essentially a pragmatic one. But no pragmatics without semantics. It is not information as such, but only information together with the semantics of a question, that determines whether a proposition counts as a suitable answer.

Although it can be read quite independently of it, this paper is a follow-up of our paper on the semantic analysis of indirect questions (Groenendijk & Stokhof 1982). In the final section of that paper, we

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expressed the hope that our analysis of indirect questions would shed some light on what a proper analysis of direct questions looks like. We share the opinion that a fully adequate theory of questions should deal with direct and indirect questions in a uniform way. The semantics of direct and indirect questions should be intimately related. The aim of this paper is to argue that our semantics for indirect questions, which enabled us to explain a number of semantic facts about sentences in which questions occur embedded under such verbs as *know* and *wonder*, can also be made to work in an analysis of the question-answer relation, thus satisfying a requirement Belnap has formulated for semantical theories of (indirect) questions (see Belnap 1981).

In this paper we explore one possible account of the question-answer relation. This analysis stays within the possible worlds framework, within which we also developed our analysis of indirect questions. This framework has its inherent shortcomings and the analysis developed here is bound to inherit them. But it seems clear to us that our analysis, when suitably rephrased, can be incorporated in a different, more sophisticated, epistemic pragmatic theory.

Although this paper is clearly related to our earlier work on indirect questions it differs from it in perspective to a considerable extent. Whereas our former paper primarily dealt with the syntax and semantics of certain linguistic constructions, this paper hardly refers to language or linguistics at all. When we talk about questions or (propositions giving) answers here, we do not mean interrogative or indicative sentences, i.e. linguistic objects, but the objects that serve as their interpretation, i.e. semantic, modeltheoretic objects.

Still, in the end, it is language that matters. We would not be satisfied if the semantic objects we discuss could not be linked in a systematic way to linguistic expressions. However, we are confident that, in principle, this will constitute no major problem. We feel that our confidence is justified by the fact that there is a well-defined syntactic relationship between direct and indirect questions. Since we have already given a compositional syntax and semantics for indirect questions and since the semantics of indirect and direct questions is the same, we feel that a compositional analysis of direct questions will be possible.

We share the basic view of questions and answers expressed here with many others. One of them, whom we should mention, is Hintikka. To our knowledge, he was the first to develop a theory of questions and answers (see Hintikka 1974, 1976, 1978) in which the notion of an answer "does not depend only on the logical ana semantical status of the question and its putative answer, [...] but also on the state of knowledge of the questioner at the time he asks the question" (Hintikka 1978, p. 290).

1. QUESTIONS AS PARTITIONS

In Groenendijk & Stokhof (1982) questions were analyzed as proposition denoting expressions. At an index, a question denotes a proposition, which we will call the true semantic answer at that index. So, the sense (meaning) of a question is a propositional concept, a function from indices to propositions, which at every index yields as its value the proposition that is the true semantic answer to that question at that index.

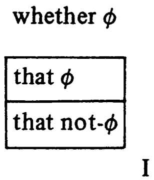
Let us immediately remark two things about this notion of semantic answerhood. Calling these answers 'semantic' indicates first of all that the resulting notion of answerhood is a limited one, indeed a limiting case of the true notion of an answer, which, in our opinion, is essentially a pragmatic notion. Secondly, it signalizes that when we are talking about questions and answers in this paper, we do not talk about linguistic entities, but refer to semantic objects. (But for reasons of readability, we italicize expressions referring to these objects.)

In this paper we will view questions as partitions of the set of indices, a perspective which is different from, though equivalent with, the propositional concepts view taken in Groenendijk & Stokhof (1982). A partition of a set A is a set of non-empty subsets of A such that the union of those subsets equals A and no two of these subsets overlap. Formally:

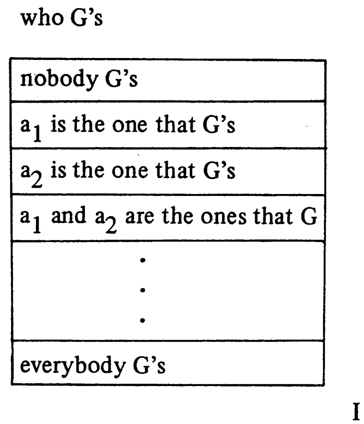
(1) $\mathcal{A}$ is a partition of A iff
$\forall X \in \mathcal{A}: X \neq \emptyset, \bigcup_{X \in \mathcal{A}} = A, \forall X, Y \in \mathcal{A} : X \cap Y = \emptyset \vee X = Y$

If we view a question as a partition of the set of indices I, each element of that partition, a set of indices, represents a proposition, a possible semantic answer to that question. Consider the question *whether* ϕ. This question has two possible semantic answers: *that* ϕ, and *that not* ϕ. The two sets of indices corresponding to these two propositions divide the total set of indices in two non-overlapping parts. So, a single whether-question (a yes/no-question) makes a bipartition on the set of indices (except for the tautological question, see section 3). Figure 1 below gives a pictorial representation.

Constituent questions can be viewed as partitions as well. The possible semantic answers to the question *who G's*, are propositions that express that the objects $a_1, \ldots, a_n$ are the ones that G. Such propositions exhaustively and rigidly specify which objects have the property G at an index.[1] The sets of indices that represent the possible semantic answers form a partition of I. They do not overlap (the various propositions each exhaustively specify a certain set of individuals), and their union equals I (the property G is a total function). Partitions made by constituent questions can also be represented pictorially (in finite cases, at least), see figure 2.



(figure 1)



(figure 2)

So, generally, a constituent question can be regarded as an n-fold partition of I, where n is the number of possible denotations of the (complex or simple) predicate involved in the question.

That the propositional concept view of questions and the partition view are equivalent is easy to see. In Groenendijk & Stokhof (1982) questions were represented by expressions of the following form:

(2) $\lambda j[\alpha/i/ = \alpha/j/]$

Here i and j are variables of type s, ranging over indices, and $\alpha/i/$ and $\alpha/j/$ are two expressions which differ only in that where the one has free occurrences of i the other has free occurrences of j. The sense of a question, $[\![\lambda i\lambda j[\alpha/i/ = \alpha/j/]]\!]_{M,g}$ is a semantic object of type $\langle s,\langle s,t\rangle\rangle$, i.e. a relation between indices. This relation holds between two indices if and only if the denotation of α is the same at both. It is easy to check that this relation is reflexive, symmetric and transitive, i.e. that it is an equivalence relation. To every equivalence relation R on a set A corresponds a partition of A, the elements being the equivalence classes of A under R. So, the semantic object expressed by a question Q can be regarded as a partition of the set of indices I:

(3) $I/Q =_{def} \{[i]_Q | i \in I\}$

where $[i]_Q$, the set $\{j \in I | Q(i)(j)\}$, is the answer to Q in i. This means that the partition I/Q is the set of possible semantic answers to Q.

2. QUESTIONS, ANSWERS AND INFORMATION

Above we have characterized the proposition denoted by a question at a certain index as the true, semantic answer to that question at that index. As we noted in Groenendijk & Stokhof (1982), this semantic notion of answerhood can hardly do as a satisfactory explication of the intuitive notion of answerhood. E.g. the proposition that is a semantic answer to the question *who G's,* gives a rigid specification of the objects that have the property G. If the objects are individuals, such a specification might be given using the individual's proper names, assuming the latter to be rigid designators. There are many problems with the consequent rigid notion of answerhood. For one thing, in an actual speech situation, it may very well be the case that, for one reason or other, no such names are available to the speech participants. Further, there are situations in which identification of objects by means of descriptions could serve just as well, and sometimes even better. However, a proposition in which an object that has a certain property is identified by means of a proper name, is not equivalent to, and in general even logically independent of, a proposition in which this identification of carried out by means of a description. Yet, in many cases, the latter provide excellent answers to questions. There is no purely semantic way to relate these answers 'by description' to the semantic answers 'by naming'. And, of course, this is not to be expected. The relationship between questions and answers cannot be isolated from the purpose of posing questions and of answering them: to fill in a gap in the information of the questioner. And consequently, whether two semantically unrelated propositions can serve equally well as an answer to a question, cannot be decided without taking this information into account. So, the question-answer relation is essentially of a pragmatic nature.

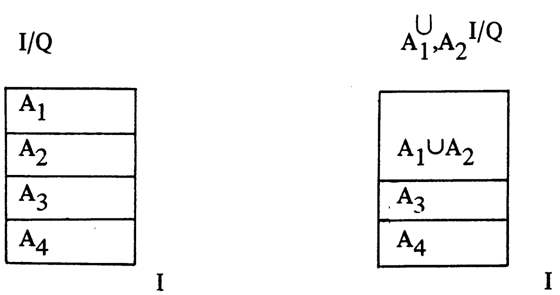
Within the limits of possible world semantics, the information of a speech participant can simple-mindedly be represented as a non-empty subset of the set of indices. Each index in such an information set represents a state of affairs that is compatible with the information in question. Evidently, the amount of information is inversely proportional to the extension of the corresponding set. Information is maximal if the information set is a singleton, and minimal if it equals I.

Considerations like those presented above, lead us to a relativization of questions and answers to information sets. Notice that although from a semantic point of view, i.e. if we take the full set of indices into account, a description will, in general, not be a rigid specification of an object, it may very well be that it is such a rigid specification if we limit ourselves to a subset of I. In fact, if a speech participant has the information to which object a description refers, such a description will function pragmatically as a rigid designation of that object. So, although descriptions and proper names in general will not be semantically equivalent, they may very well happen to be pragmatically equivalent.

3. SOME FORMAL PROPERTIES OF QUESTIONS

The cardinality of a question I/Q equals the number of possible semantic answers to it. The lowest possible cardinality of I/Q is 1 (since we do not allow $I = \emptyset$, in that case it would hold for all Q: $I/Q = \emptyset$). In this case $I/Q = \{I\}$. We call this the tautological question in I. Its only answer is the tautology. E.g. if ϕ is a tautology or contradiction, then the single whether question *whether* ϕ is the tautological question. The questions *whether* (ϕ *or not*-ϕ) and *whether* (ϕ *and not*-ϕ) have the equivalent answers *yes*, ϕ *or not*-ϕ, and *no*, *not* ϕ *and not*-ϕ, respectively. Tautological constituent questions are e.g. *who G's or does not G,* and, *which F is not an F.* One could very well say that the tautological question does never arise. A question that has only one possible answer is not a proper question at all.

Some operations on questions (partitions) result in new questions (partitions), as do the 1-place operations that take the union of two elements of a partition:



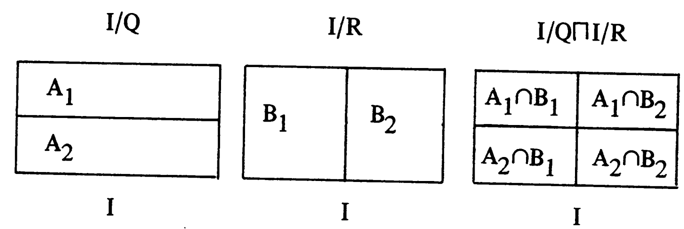
(figure 3)

This operation can be defined as follows:

(4) For $X,Y \in I/Q$: $\bigsqcup_{X,Y} I/Q = \{ Z \mid Z = X \cup Y \vee (Z \neq X \;\&\; Z \neq Y \;\&\; Z \in I/Q)\}$

(The 1-place operation that takes the complements of all the elements of a partition does not in general result in a partition again. It does so only when it operates on a bi-partition, in which case it maps it onto itself, which reflects the equivalence of the questions *whether* ϕ and *whether not*-ϕ.)

A two-place operation on partitions that results in a new partition, is the one that takes the non-empty intersections of all the elements of the two partitions on which it operates:



(figure 4)

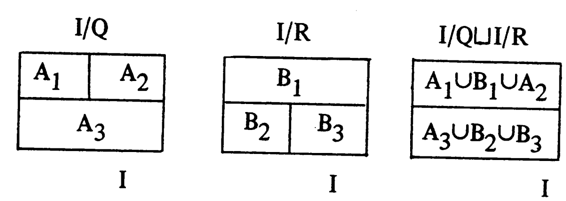
This intersection operation can be defined as follows:

(5) $I/Q \sqcap I/R = \{ X \cap Y \mid X \in I/Q \;\&\; Y \in I/R \;\&\; X \cap Y \neq \emptyset \}$

In the pictorial representation of the intersection of two partitions, the dividing lines of each of the two partitions return.

An alternative whether-question *whether* ϕ *or* ψ can be constructed as the intersection of the two bipartitions *whether* ϕ, and *whether* ψ. In general, an alternative whether-question with n terms can be constructed stepwise from n bipartitions, i.e. from n single whether-questions. In fact, any non-tautological question can be constructed by intersection from a number of bipartitions. E.g., the constituent question *who G's* can be constructed in this way from the questions *whether* a_1 *G's, whether* a_2 *G's,* etc.

The union operation on two partitions is much harder to define than the intersection. Here, the pictorial representation of the resulting partition retains only those dividing lines that the two partitions have in common.



(figure 5)

The union operation can be defined as follows:

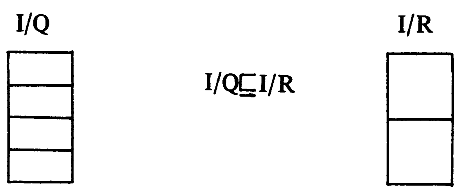
(6) $I/Q \sqcup I/R = \{Z | Z \in S \ \& \ \neg\exists Z' \in S: Z \subset Z')\}$
where $S = \{X_1 \cup \ldots \cup X_n \mid X_1, \ldots, X_n \in U \ \& \ \forall i: 1 \leqslant i < n: X_i \cap X_{i+1} \neq \emptyset\}$
and $U = \{X \cup Y \mid Z \in I/Q \ \& \ Y \in I/R \ \& \ X \cap Y \neq \emptyset\}$

We will not try to explain this definition. It plays no role in the remainder of the paper. The example given above may suffice to give the general idea.

More important in the present context is the following inclusion relation between partitions:

(7) $I/Q \sqsubseteq I/R$ iff $\forall X \in I/Q \ \exists Y \in I/R: X \subseteq Y$

The inclusion relation holds between two questions I/Q and I/R iff every semantic answer to Q implies a (unique) semantic answer to R. It is a kind of implication relation between questions. $I/Q \sqsubseteq I/R$ means that I/Q is a refinement of I/R, i.e. that every dividing line in I/R is a dividing line in I/Q as well. See the example in figure 6.



(figure 6)

The following facts can be seen to hold:

(8) For all I/Q: $I/Q \sqsubseteq \{I\}$

(9) For all I/Q: $\{\{i\} \mid i \in I\} \sqsubseteq I/Q$

(10) $I/Q \sqcap I/R \sqsubseteq I/Q$

(11) $I/Q \sqsubseteq I/R$ iff $I/Q \sqcap I/R = I/Q$

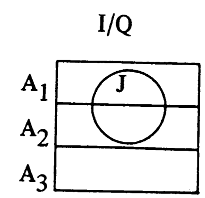
(12) $I/Q \sqsubseteq I/Q \sqcup I/R$

(13) $I/Q \sqsubseteq I/R$ iff $I/Q \sqcup I/R = I/R$

It can easily be checked that $\sqsubseteq$ is a partial order on the set of all partitions of I. $\sqsubseteq$ is a reflexive, antisymmetric and transitive relation. The operations $\sqcap$ and $\sqcup$ satisfy idempotency, commutativity, associativity and absorption.

The set of all questions on I, i.e. the set of all partitions of I, forms a complete atomic lattice under $\sqsubseteq$. The tautological question $\{I\}$ is its maximal element (8). It is the least demanding question. Its counterpart $\{\{i\} | i \in I\}$ is the most demanding one. It asks everything that can be asked. It might be phrased as: 'What is the world like?'. It is the minimal element of the lattice (9). The bipartitions (single whether-questions) are the dual atoms. $\sqcap$ and $\sqcup$ are the meet and join.

We have seen in section 2 that in order to obtain a pragmatic notion of answerhood, we are interested in relativizing questions and answers to information sets, i.e. to non-empty subsets of I. Doing so, we get pictures such as the following:



(figure 7)

In the situation depicted in figure 7, A_1 and $A_2 \in I/Q$ are the semantic answers to Q that are compatible with J. A_3 is not compatible with J, since $A_3 \cap J = \emptyset$. The set of semantic answers compatible with J, I/Q^J can be defined as follows:

(14) $I/Q^J = \{X \mid X \in I/Q \ \& \ X \cap J \neq \emptyset\}$

Of course it will always hold that $I/Q^J \subseteq I/Q$.

A second notion that suggests itself is the partition that a question Q restricted to J makes on J. We will write this as J/Q, and will simply speak of the partition that Q makes in J. This notion can be defined as follows:

(15) $J/Q = \{X \cap J \mid X \in I/Q \ \& \ X \cap J \neq \emptyset\}$

The notions I/Q^J and J/Q are related as follows:

(16) $X \in I/Q^J$ iff $\exists Y \in J/Q: Y \subseteq X$

The inclusion relation between partitions can now be generalized as follows:

(17) $J/Q \sqsubseteq K/R$ iff $\forall X \in J/Q \ \exists Y \in K/R$: $X \subseteq Y$

The following fact can be observed:

(18) $J/Q \sqsubseteq K/R$ iff $J \subseteq K$ & $J/Q \sqsubseteq J/R$

Notice that (18) implies (19):

(19) $J/Q \sqsubseteq I/Q$

This expresses that the partition that Q makes on I is preserved when Q is restricted to J, in the sense that it may be compatible with less semantic answers, but that every answer in (element of) J/Q will be a subset of a semantic answer.

The limiting case is where J/Q contains just one element (provided that J is non-empty), i.e. where $J/Q = \{J\}$. In this case, Q could be called the tautological question in J. But we will preserve the notion of the tautological question as a purely semantic one, and will not use it when talking about information sets. Instead we define:

(20) J offers an answer to Q iff $J/Q = \{J\}$

If an information set offers an answer to a question, the question can be said to be decided by that information, the information provides a (unique) answer.

Fact (18) guarantees that when one's information increases, then one remains at least as close to an answer to a question.

4. TO HAVE A (TRUE) ANSWER AND TO KNOW AN ANSWER

An information set represents information of an individual x at an index i. We will add an individual parameter and an index parameter to information sets. We can distinguish two kinds of information sets, doxastic sets and epistemic sets. We will call both kinds of sets information sets. A doxastic set $D_{x,i}$ is a non-empty set of indices, representing the consistent beliefs of x in i. An epistemic set $E_{x,i}$ represents the knowledge of x in i. Since what one knows should be true, i should be an element of $E_{x,i}$. The epistemic and the doxastic set of x in i are related, since what one knows, one also believes. So, we can formulate the following general constraints[2]:

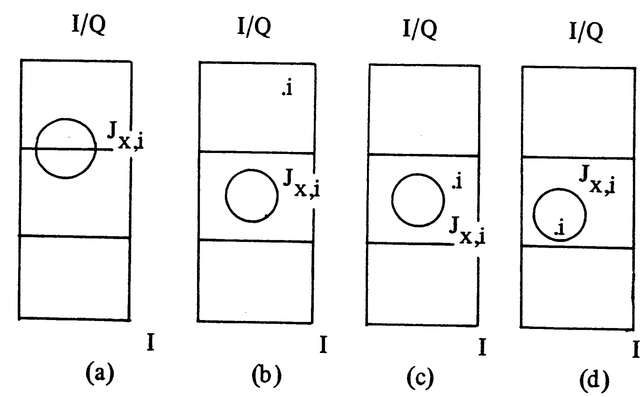
(21) $E_{x,i} \subseteq I,\ i \in E_{x,i}$
$D_{x,i} \subseteq E_{x,i},\ D_{x,i} \neq \emptyset$

Since we have $D_{x,i} \subseteq E_{x,i} \subseteq I$, we also have for any question Q:

(22) $D_{x,i}/Q \sqsubseteq E_{x,i}/Q \sqsubseteq I/Q$

The notion of an information set offering an answer, defined in (20), applies to doxastic and epistemic sets. And (22) assures us that if $E_{x,i}$ offers an answer to Q, then $D_{x,i}$ offers an answer to Q as well.

We are also interested in the notion of an information set offering a true answer to a question. If an information set $J_{x,i}$ offers an answer, this need not be a true answer. In the situation in figure 8(b), $J_{x,i}$ offers an answer, but not a true one, whereas in 8(c) and 8(d), $J_{x,i}$ offers a true answer. (In 8(a) $J_{x,i}$ does not offer an answer at all, regardless of where i is situated.) But notice that since i has to be an element of $E_{x,i}$, the situations depicted in 8(b) and 8(c) cannot occur if $J_{x,i}$ is to be an epistemic set, but only if it is a doxastic set. A doxastic set need not contain only true information about i. But still, as 8(c) illustrates, it may offer a true answer.



(figure 8)

We can define the notions of an information set offering an answer or a true answer to a question as follows:

(23) $J_{x,i}$ offers an answer to a question Q iff $J_{x,i}/Q = \{J_{x,i}\}$
$J_{x,i}$ offers a true answer to Q iff $J_{x,i} \cup \{i\}$ offers an answer to Q

Since $E_{x,i} \cup \{i\} = E_{x,i}$, $E_{x,i}$ offers a true answer to Q iff $E_{x,i}$ offers an answer to Q. This does not hold for $D_{x,i}$. What does hold is that if $D_{x,i}$ offers a true answer to Q, then it offers an answer, but not necessarily the other way around.

So, (23) gives rise to the following three possibilities:

(24) x has an answer to Q in i iff $D_{x,i}$ offers an answer to Q
x has a true answer to Q in i iff $D_{x,i}$ offers a true answer to Q
x knows an answer to Q in i iff $E_{x,i}$ offers an answer to Q

To know an answer implies to have a true answer, but not the other way around, since $D_{x,i} \cup \{i\}$ may be a proper subset of $E_{x,i}$. And to have a true answer implies to have an answer.

5. PRAGMATIC ANSWERS

We are now almost in the position to define the wider, pragmatic notion of answerhood that we are after, i.e. the notion of a proposition giving an answer with respect to an information set. A proposition gives an answer to a question in an information set, if the information set to which that proposition is added offers an answer. So, in order to calculate whether a proposition P gives an answer to a question Q in an information set $J_{x,i}$, we first update $J_{x,i}$ with P, which results in a new information set $J'_{x,i}$, and then check whether $J'_{x,i}$ offers an answer to Q.

There are several important facts to note about the update operation. The first is that it should turn an information set of a certain kind into an information set of the same kind. It should turn a doxastic set into a doxastic set, and an epistemic set into an epistemic set. Since $E_{x,i}$ and $D_{x,i}$ are related, they should be updated simultaneously. Secondly, when information sets are updated, they, in general, change. $J'_{x,i}$ need not equal $J_{x,i}$. If a model is determined by the totality of doxastic and epistemic sets of each individual at each index, updating takes us from one model into another. We will not bother to state this in detailed definitions, but it is important to bear these things in mind.

Intuitively, there are two ways to update an information set $J_{x,i}$ with a proposition P, that seem to make sense. The first is to check whether P is consistent with $J_{x,i}$, and if so, to add it to it. The second is to check whether P is true (and consistent with $J_{x,i}$), and if so, to add it to it. In fact, if we apply the first method of updating to a doxastic set $D_{x,i}$, and, at the same time, the second to the corresponding set $E_{x,i}$, with an extra proviso that keeps $D_{x,i}$ and $E_{x,i}$ related in the proper way, the resulting sets $D'_{x,i}$ and $E'_{x,i}$ will be proper information sets again.

We can define the update operation on information sets as follows:

(25) update $\langle P, \langle D_{x,i}, E_{x,i} \rangle\rangle = \langle D'_{x,i}, E'_{x,i} \rangle$
where $D'_{x,i} = D_{x,i} \cap P$, if $D_{x,i} \cap P \neq \emptyset$
$= D_{x,i}$ otherwise
$E'_{x,i} = E_{x,i} \cap P$, if $i \in P$ and $D_{x,i} \cap P \neq \emptyset$
$= E_{x,i}$ otherwise

The reader can verify that $D'_{x,i}$ and $E'_{x,i}$ satisfy the constraints layed down in (21). We will say that update $\langle P, D_{x,i} \rangle = D'_{x,i}$, and update $\langle P, E_{x,i} \rangle = E'_{x,i}$, iff update $\langle P, \langle D_{x,i}, E_{x,i} \rangle\rangle = \langle D'_{x,i}, E'_{x,i} \rangle$.

It may be illuminating to notice that if we start with no information at all, i.e. with $E_{x,i} = D_{x,i} = I$, and continuously update these sets with propositions in accordance with (25), the pair of information sets that results, is, at each step, a pair consisting of a doxastic and an epistemic set, i.e. a pair of sets satisfying (21).

In order to be able to give a definition of a notion of pragmatic answerhood, we need one more auxiliary notion that introduces nothing but a new piece of terminology:

(26) Q is a question in $J_{x,i}$ iff $J_{x,i}$ does not offer an answer to Q

Q is a question in $J_{x,i}$ iff there is more than one answer to Q that is compatible with J.

We can now give the definition of a proposition giving a (true) answer to a question in an information as follows (assuming $J_{x,i}$ to be an information set of a certain kind, and update to be the corresponding update operation):

(27) Let Q be a question in $J_{x,i}$, then (a proposition) P gives a (true) answer to Q in $J_{x,i}$ iff update $\langle P, J_{x,i} \rangle$ offers a (true) answer to Q

What this definition expresses is simply that a proposition answers a question in an information set iff when the information set is updated with the proposition, the question is no longer a question, but is (dis)solved.

Definition (23) of an information set offering a (true) answer, together with definition (25) of the update operation, guarantee that the following facts hold:

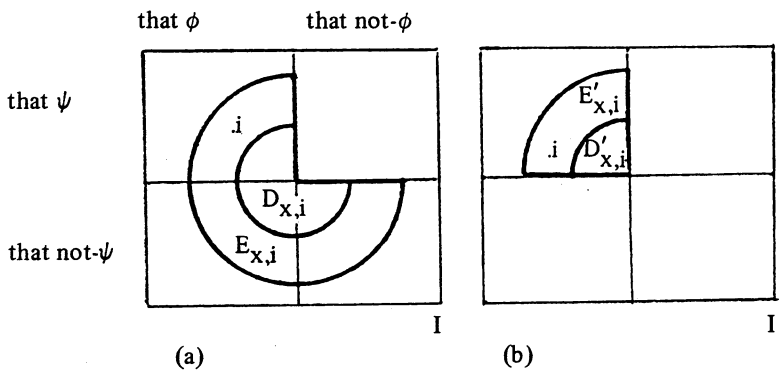
(28) P gives a true answer to Q in $E_{x,i}$ iff P gives an answer to Q in $E_{x,i}$
If P gives an answer to Q in $E_{x,i}$, then P gives a true answer to Q in $D_{x,i}$

If P gives a true answer to Q in $D_{x,i}$, then P gives an answer to Q in $D_{x,i}$

In view of (28), we can say, analogously to (24):

(29) P gives x an answer to Q in i iff P gives an answer to Q in $D_{x,i}$
P gives x a true answer to Q in i iff P gives a true answer to Q in $D_{x,i}$
P does let x know an answer to Q in i iff P gives an answer to Q in $E_{x,i}$

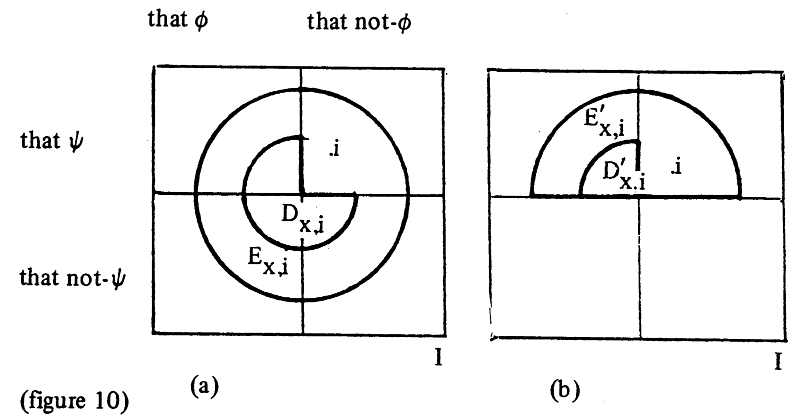
The following examples may serve to illustrate the notions of pragmatic answerhood. Consider the situation in figure 9(a):



(figure 9)

The vertical division of I is the partition I/*whether* ϕ, the horizontal one is I/*whether* ψ. Since i ϵ *that* ϕ and i ϵ *that* ψ, *that* ϕ and *that* ψ are true in i. $D_{x,i}$ and $E_{x,i}$ contain the information *that if* ψ, *then* ϕ. Neither the question *whether* ϕ nor the question *whether* ψ is answered in $D_{x,i}$ or in $E_{x,i}$. In this situation, the true proposition *that* ψ gives a true answer to the question *whether* ϕ in $D_{x,i}$, the answer *that* ϕ. And it also gives that answer to that question in $E_{x,i}$. Figure 9(b) represents the situation that results after updating $D_{x,i}$ and $E_{x,i}$ with *that* ψ. Update $\langle$*that* ψ,$D_{x,i}\rangle$ = $D'_{x,i} = D_{x,i} \cap$ *that* ψ. And update $\langle$*that* ψ,$E_{x,i}\rangle$ = $E'_{x,i} = E_{x,i} \cap$ *that* ψ. Notice that the pragmatic answer *that* ψ is logically independent of the semantic answer *that* ϕ.

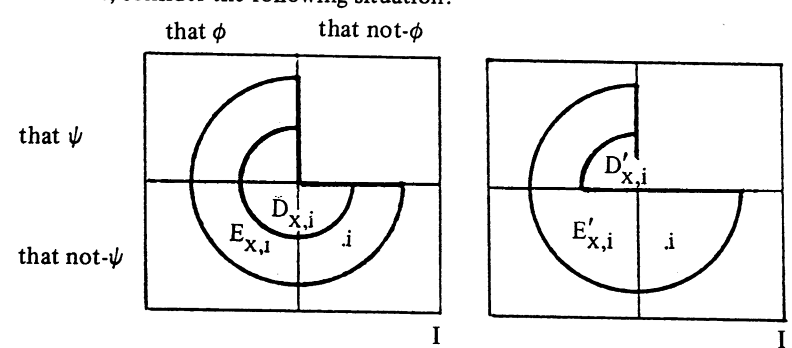
As a second example, consider the following situation:



(figure 10)

That ϕ is now false in i, but *that* ψ is still true. $D_{x,i}$ still contains the (now false) information *that if* ψ, *then* ϕ. Since it is false, $E_{x,i}$ cannot contain this piece of information anymore. In this situation, the true proposition *that* ψ still gives x an answer to the question *whether* ϕ in i, but no longer a true answer. Then, of course, it cannot let x know an answer either. A true proposition, even if it gives an answer, need not give a true answer.

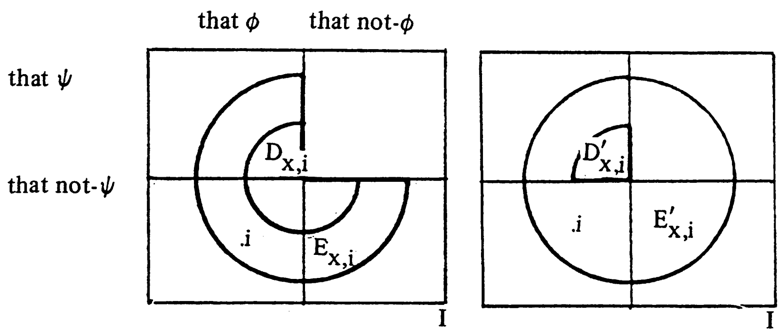
Next, consider the following situation:



(figure 11)

Both *that* ϕ and *that* ψ are now false in i. As in the first example, both $D_{x,i}$ and $E_{x,i}$ contain the information *that if* ψ, *then* ϕ. Since $D_{x,i}$ is compatible with *that* ψ, update $\langle$*that* ψ,$D_{x,i}\rangle$ = $D'_{x,i} = D_{x,i} \cap$ *that* ψ. But since i $\notin$ *that* ψ, update $\langle$*that* ψ,$E_{x,i}\rangle$ = $E'_{x,i} = E_{x,i}$. The false proposition *that* ψ gives x the false answer *that* ϕ to the question *whether* ϕ, and does not let x know an answer.

As a last one in this series of examples, consider the following situation:

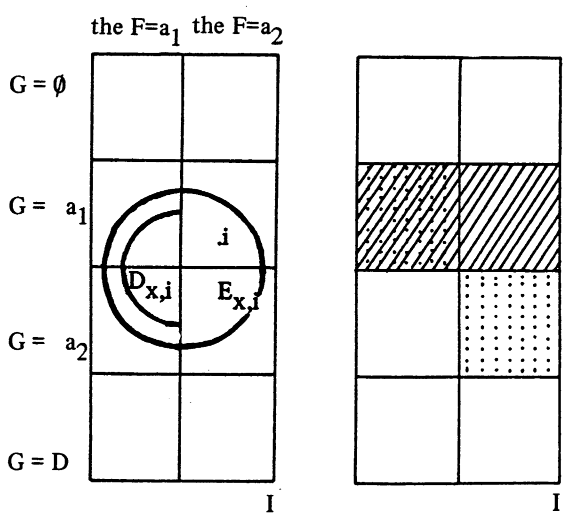


(a) (b)

(figure 12)

That ϕ is now true in i, but *that* ψ is still false. The updates of $D_{x,i}$ and $E_{x,i}$ are similar to those in the previous situation. But this time the proposition *that* ψ does not only give x an answer, it even gives x the true answer *that* ϕ. But it cannot let x know an answer, since *that* ψ is false in i. So, a false proposition can give one a true answer, but it can never let one know an answer.

Whereas in the previous series of examples we concerned ourselves with single whether-questions, in the next example we consider a constituent question.



(a) (b)

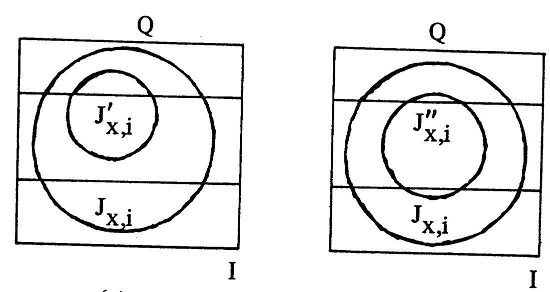
(figure 13)

In this situation, the domain of individuals D = { a_1,a_2 }. F is a property that is true of exactly one individual. The vertical division of I is the partition I/*who is the F*, the horizontal one is I/*who G's*. $D_{x,i}$ contains the (false) information *that* a_1 *is the F*, and the (true) information, also contained in $E_{x,i}$, *that exactly one individual G's*. The question *who G's* is not answered in $D_{x,i}$ and $E_{x,i}$. Both the proposition *that* a_1 *is the one who G's* (the shaded area in figure 13b) and the proposition *that the F is the one who G's* (the dotted area) give an answer to the question *who G's* in $D_{x,i}$. Notice that the former is a semantic answer, whereas the latter is a pragmatic answer, and that the two are logically independent in I, but pragmatically equivalent in $D_{x,i}$. Both propositions in fact give a true answer in $D_{x,i}$. But only the proposition *that* a_1 *is the one who G's* does let x know an answer in i. Notice that even a much weaker proposition like *that if anyone G's then the F does,* would already give x a true answer in i. And propositions like *that nobody G's* or *that everybody G's,* would not give an answer, since they are incompatible with x's information.

6. PARTIAL ANSWERS

Although the notion of a pragmatic answer is an essential step towards a satisfactory notion of answerhood, it still calls for further refinements. Pragmatic answers as defined in (27), are always complete answers. If a proposition gives an answer in an information set $J_{x,i}$, the question is always completely solved in that information set. However, in many cases the questioner will already be very happy if her question can be partially solved, i.e. if the set of answers compatible with her information is narrowed down. What we need is a notion of partial pragmatic answerhood.

If a proposition P narrows down an information set $J_{x,i}$ to a proper subset $J'_{x,i}$ such that the answers to Q compatible with $J'_{x,i}$ form a proper subset of the answers compatible with $J_{x,i}$, we will say that P gives a partial answer to Q in $J_{x,i}$. This is exemplified in figure 14(a):



(a) (b)

(figure 14)

As figure 14(b) illustrates, a proposition may be informative with respect to $J_{x,i}$, without giving a partial answer to a question Q in $J_{x,i}$.

We will say that $J'_{x,i}$ in figure 14(a) is closer to an answer to Q than $J_{x,i}$ (whereas in 14(b) $J''_{x,i}$ and $J_{x,i}$ are equally close to an answer to Q). The notion of being closer to an answer can be defined as follows:

(30) Let $J_{x,i}$ be a subset of $K_{x,i}$, then $J_{x,i}$ is closer to an answer to Q than $K_{x,i}$ iff $I/Q^{J_{x,i}} \subset I/Q^{K_{x,i}}$

If a proposition is to give a true partial answer in an information set $J_{x,i}$ to a question Q, the set of answers to Q compatible with $J_{x,i}$ updated with that proposition should be narrowed down in such a way that the true answer to Q remains accessible. The notion of an information set giving access to a true answer can be defined as follows:

(31) $J_{x,i}$ gives access to a true answer to Q iff $[i]_Q \in I/Q^{J_{x,i}}$

A doxastic set need not give access to a true answer, but an epistemic set always will. The notion of an information set being closer to a true answer can now be defined as follows:

(32) $J_{x,i}$ is closer to a true answer to Q than $K_{x,i}$ iff $J_{x,i}$ is closer to an answer to Q than $K_{x,i}$ and $J_{x,i}$ gives access to a true answer to Q

For epistemic sets, the notions of being closer to an answer and being closer to a true answer coincide, but they do not for doxastic sets. Whereas a doxastic set will always be as least as close to an answer as an epistemic set, it need not be as least as close to a true answer.

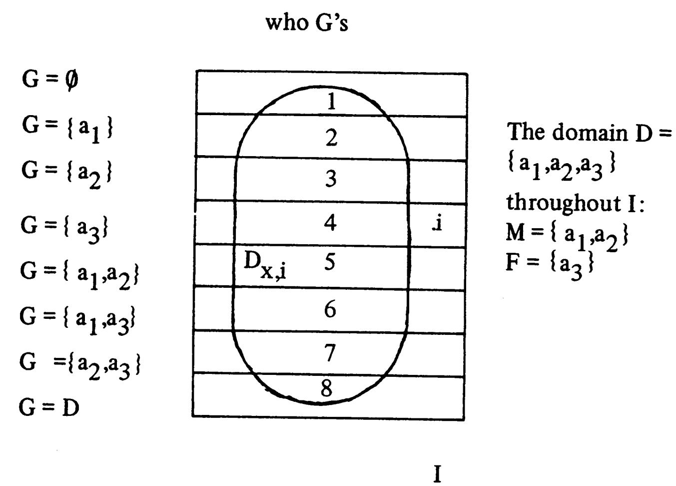
We can now define the notion of a proposition giving a (true) partial answer in an information set as follows:

(33) Let Q be a question in $J_{x,i}$, then P gives a (true) partial answer to Q in $J_{x,i}$ iff update $\langle P, J_{x,i} \rangle$ is closer to a (true) answer to Q than $J_{x,i}$

Of course, (true) pragmatic answers as defined in (27), which we might call complete pragmatic answers, form a subset of the set of (true) partial answers. The facts stated in (28) for complete pragmatic answers, hold for partial answers as well. And the three different notions of pragmatic answerhood that were distinguished in (29) apply also to partial answers.

An important fact to be noticed is that if $J_{x,i}/Q$ is a bipartition (i.e. if Q is, or comes down to, a single whether question in $J_{x,i}$), and P gives a partial answer to Q in $J_{x,i}$, then P gives a complete answer to Q in $J_{x,i}$. This fact is not very satisfactory. We will come back to it in the next section.

We will end this section by giving some examples of propositions giving partial answers in a doxastic set (the difference between a proposition giving a true answer and letting one know an answer, discussed in the previous section, applies to partial answers in much the same way, but will be left out of consideration here). Consider the situation depicted in figure 15.



(figure 15)

The proposition *that if a_1 G's then a_2 G's*, gives a true partial answer in $D_{x,i}$. Updating $D_{x,i}$ with that proposition results in an information set $D'_{x,i}$ in which the areas 2 and 6 in $D_{x,i}$ have been cut out. So, the set of semantic answers compatible with $D'_{x,i}$ is smaller than the set of semantic answers compatible with $D_{x,i}$, and the true semantic answer *that a_3 is the one who G's* is still accessible in $D'_{x,i}$.

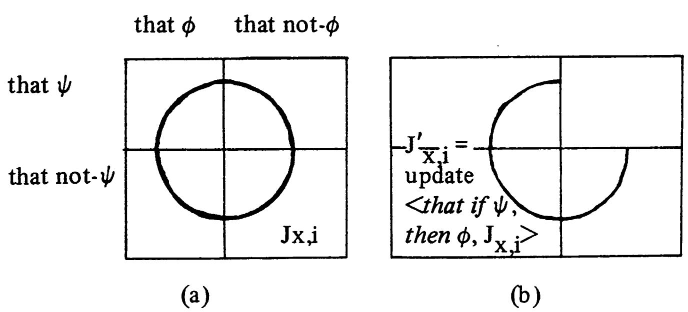
As a second example, consider the proposition *that the one who G's is an M*. This proposition gives a partial answer in $D_{x,i}$ as well, but this time not a true one. Updating $D_{x,i}$ with the proposition *that the one who G's is an M* brings $D_{x,i}$ down to the areas 2 and 3. The true answer *that a_3 is the one who G's* is no longer accessible from this information set. Notice that the proposition *that the one who G's is an M* would give a complete answer (but again not a true one) in $D'_{x,i}$, which resulted after updating $D_{x,i}$ with the proposition *that if a_1 G's then a_2 G's.*

The answer *that the one who G's is an M* might be called an exhaustive indefinite answer. It exhaustively lists the individuals that (are supposed to) walk, in this case only one, and characterizes them by means of an indefinite description. A non-exhaustive indefinite answer would then be the proposition *that (at least) an M G's.* It gives one individual that G's and specifies it in an indefinite way, but leaves open that there are other individuals that G as well. This proposition gives a partial (false) answer in $D_{x,i}$ as well. It cuts the areas 1 and 3 out of $D_{x,i}$.

Often, indefinite answers are partial ones, but they can very well be complete, the exhaustive indefinite answer *that the one who G's is an F* gives a complete true answer in $D_{x,i}$. And notice that an exhaustive definite answer like *that the one who G's is the F,* need not give a complete answer. It does so in the situation in figure 15, but it would not in an information set in which the question *who is the F* is not decided.

7. INDIRECT ANSWERS

We return now to the unsatisfactory fact noticed above, that questions which are bipartitions in an information set can be answered only completely. This implies e.g. that simple whether-questions cannot be answered partially. But it seems that in a sense, they can, Suppose that *whether* ϕ is a question in $J_{x,i}$. The proposition *that if* ψ, *then* ϕ, can be a good answer, even in case ψ is not contained in $J_{x,i}$. But it does not give a partial answer according to definition (33). Consider figure 16:



(figure 16)

What is going on here is the following. The situation in 16(b) is the one discussed above with respect to figure 9. There we saw that in this situation, *that* ψ will give an answer to the question *whether* ϕ in $J'_{x,i}$. And notice that in the situation depicted in 16(a), *that* ψ does not yet give an answer to *whether* ϕ in $J_{x,i}$. So it seems that, in a sense, x is getting closer to an

answer. What the proposition *that if* ψ, *then* ϕ does to $J_{x,i}$ is that it provides a new way of getting an answer to the question *whether* ϕ. For x can turn to someone and ask *whether* ψ, and if he is lucky, he gets the answer *that* ψ, which solves his original question *whether* ϕ at the same time. His question *whether* ϕ is related to the question *whether* ψ. This may be very important, e.g. the question *whether* ψ may be easier to get antwered. And not only informants who happen to have the information *whether* ϕ, but also informants who do not happen to have that information, but do happen to have the information *that* ψ can help him out. Notice that *whether* ϕ and *whether* ψ are not equivalent in the new information set: *that not-*ϕ does not give x an answer to *whether* ψ. In the new information set the proposition *that if* ϕ, *then* ψ also provides usefull information, without qualifying as a (partial) answer. If x updates with this proposition then his original question *whether* ϕ gets even more intimately related to *whether* ψ: it now becomes equivalent to it, for now also *that not-*ψ tells x something about *whether* ϕ, viz. *that not-*ϕ.

Similar situations can occur with constituent questions. Suppose that *who is the one who G's* is a question in $J_{x,i}$. Suppose further, that x has no idea which individual has the property G, it may be any individual in the domain. If x also has no idea as to which individual is the F, the proposition *that the F is the one who G's,* will not give a partial answer to her question in $J_{x,i}$. Still, she may be quite satisfied with this answer, because now there is the possibility to turn to another informant and ask the question *who is the F.* A (partial) answer to that question will be a (partial) answer to her original question as well. And her informant may have an answer to the new question without having one to the old one.

In view of these examples, one would like to widen the notion of answerhood, so as to include this indirect kind of answers. But doing so is a delicate matter. Informally, these indirect answers can be characterized as follows:

(34) Let Q be a question in $J_{x,i}$, then P gives an indirect answer to Q in $J_{x,i}$ iff there is some question R in update $\langle P, J_{x,i} \rangle$ such that Q depends more on R in update $\langle P, J_{x,i} \rangle$ than in $J_{x,i}$ and R is not conversationally equivalent to Q in update $\langle P, J_{x,i} \rangle$

Dependence is a relation between questions. Intuitively, a question Q depends on a question R if an answer to R tells us something about an answer to Q. Relativizing dependence to information sets, we give the following definition:

(35) Q depends on R in $J_{x,i}$ iff $\exists X \in I/R^{J_{x,i}}\ \exists Y \in I/Q^{J_{x,i}}: X \cap Y = \emptyset$

According to (35) Q depends on R iff some answer to R compatible with $J_{x,i}$ gives a partial answer to Q in $J_{x,i}$. The comparative notion is then defined as in (36):

(36) Let Q be a question in $J_{x,i} \subset K_{x,i}$, then Q depends on R in $J_{x,i}$ more than in $K_{x,i}$ iff

$$\{X \mid X \in I/R^{K_{x,i}} \ \&\ \exists Y \in I/Q^{K_{x,i}}: X \cap K_{x,i} \cap Y \neq \emptyset\} \subset$$
$$\{X \mid X \in I/R^{J_{x,i}} \ \&\ \exists Y \in I/Q^{J_{x,i}}: X \cap J_{x,i} \cap Y \neq \emptyset\}$$

According to (36) Q depends more on R in $\langle P, J_{x,i} \rangle$ than in update $J_{x,i}$ iff there are more answers to R that are partial answers to Q in update $\langle P, J_{x,i} \rangle$ than there are in $J_{x,i}$. Thus, in update $\langle P, J_{x,i} \rangle$ the chances of getting an answer to Q through an answer to R are greater than in J. As the reader can easily verify, the situations discussed above are covered by this definition.

The notion of conversational equivalence is harder to get a grip on. Elusive though it may be, it is an essential element in the definition of an indirect partial answer, since it prevents the notion from being totally void. For, without it any proposition that is informative with respect to $J_{x,i}$ would give an indirect answer to any question Q in $J_{x,i}$. This can be shown as follows. Consider a situation in which there are two fully independent (in any sense of the word) atomic propositions *that* ϕ and *that* ψ. In such a situation, it is out of the question that the proposition *that* ψ would be of any help at all for the question *whether* ϕ. So, *that* ψ should not come out as an indirect partial answer. However, if we add *that* ψ to $J_{x,i}$, the question *whether* ϕ can easily be seen to depend more on the question *whether if* ψ, *then* ϕ, than in the original $J_{x,i}$. So, all conditions of (34) are fulfilled, except for the last one.

The following informal reasoning may show how cases like these are cancelled by the requirement of conversational non-equivalence. Remember that the whole point of getting a question on which the original one depends more is that it provides the questioner with the opportunity to find an informant who is not able to answer the original question, but is able to answer the one on which it depends more, with a better chance that such an answer indirectly provides an answer to the original question. This is successfull only if the two questions are not conversationally equivalent. Two questions are conversationally equivalent if the questioner has to assume that an informant will be able to answer the one question truthfully iff she is able to answer the other truthfully as well. So, if a proposition gives rise to a new question which is conversationally equivalent to the original one, the entire point of providing an indirect answer vanishes.

This can be captured in the following, more precise definition:

(37) Q is conversationally equivalent to R for x in i iff $\forall y$(x believes to know y to know a (partial) answer to Q iff x believes to know y to know a (partial) answer to R)

What remains to be shown is that in the kind of counterexample discussed above, the new question is indeed conversationally equivalent to the original one. I.e. we have to show that under the assumption that *that* ϕ and *that* ψ are totally unrelated, the question *whether if* ψ, *then* ϕ, to which adding *that* ψ to $J_{x,i}$ gives rise, is conversationally equivalent to the question *whether* ϕ. This can be done as follows.

Suppose our questioner x asks an informant y *whether if* ψ, *then* ϕ. Suppose y replies *that, indeed, if* ψ, *then* ϕ. The propositions *that* ψ and *that* ϕ are known to be totally unrelated. Thus, x cannot interpret the conditional as expressing some kind of internal relation between ψ and ϕ, for such an interpretation would be incompatible with his information. Consequently, the only interpretation available for x is that of a straightforward material implication. This means that x has to assume that either y believes that ψ is false, or that ϕ is true. If x is to incorporate the material implication in his information, he has to make sure that the latter is the case. For, given that his information contains *that* ψ that is the only situation in which x can assume that y knows the answer to *whether if* ψ, *then* ϕ. But, obviously, this means that in the given circumstances this question is conversationally equivalent to the original question *whether* ϕ.

As will be clear from this informal discussion, a formalization of the notion of conversational equivalence involves information of speech participants about each other's information in an essential way. This requires a richer framework, and a more restricted notion of an information set, than we are using here. But, informally at least, the matter seems clear, so, assuming a formalization can be given, (34) indeed defines the notion of indirect partial answerhood.

8. ANSWERS COMPARED

Not all propositions give equally good answers to a question in an information set. In what follows, we will formulate some conditions which can be used in comparing propositions in this respect. These conditions will be seen to be related to the notion of a correct answer to a question in a Gricean, conversational, sense of the word.

First of all, there is a condition pertaining to relevance. When relevance is defined as in (38), a condition of relation can be stated as in (39):

(38) Let Q be a question in $J_{x,i}$. Then P is relevant to Q in J iff P gives a (partial) answer to Q in $J_{x,i}$

(39) If P is a good answer to Q in $J_{x,i}$, then P is relevant to Q in $J_{x,i}$

Notice that indirect answers are excluded. Of course, this is not correct, but we prefer to leave them out of consideration untill they are properly formalized.

Second, there is a condition of quality, i.e. a condition pertaining to truth:

(40) Let Q be a question in $J_{x,i}$, then P is a good answer to Q in $J_{x,i}$ iff P gives a true (partial) answer to Q in $J_{x,i}$

Two things can be noticed. First, since giving a true (partial) answer implies giving a (partial) answer, relevance is subsumed under quality. Second, the condition of quality allows for a weaker and a stronger reading. The stronger reading results if $J_{x,i}$ is required to be an epistemic set. (In that case relevance would collapse into quality.)

Besides these absolute conditions of relation and quality, there is a relative condition pertaining to the amount of information a proposition gives with respect to a question. Before giving this condition of quantity, we first define some auxiliary notions. Throughout, we assume that Q is a question in $J_{x,i}$ and that P_1, P_2 give (partial) answers to Q in $J_{x,i}$.

(41) P_1 is more informative to Q in $J_{x,i}$ than P_2 iff
$P_1 \cap J_{x,i}$ is closer to an answer to Q than $P_2 \cap J_{x,i}$

(42) P_1 is less overinformative to Q in $J_{x,i}$ than P_2 iff
(i) P_2 is not more informative to Q in $J_{x,i}$ than P_1; and
(ii) P_1 is weaker in $J_{x,i}$ than P_2, i.e. $(P_2 \cap J) \subset (P_1 \cap J)$

In terms of (41) and (42) we can define the notion of a more standard answer as follows:

(43) P_1 is a more standard answer to Q than P_2 iff either
(i) P_1 is more informative to Q in I than P_2; or
(ii) P_1 is less overinformative to Q in I than P_2

From (43) it follows that:

(44) If $P_1 \subset P_2$, then either
(i) P_1 is more informative to Q in $J_{x,i}$ than P_2; or
(ii) P_2 is less overinformative to Q in $J_{x,i}$ than P_1; or
(iii) P_1 and P_2 are equivalent in $J_{x,i}$, and P_1 is a more standard answer to Q than P_2, or P_2 is a more standard answer to Q than P_1

We are now ready to state the following condition of quantity:

(45) P_1 is a better answer to Q in $J_{x,i}$ than P_2 iff either
(i) P_1 is more informative to Q in $J_{x,i}$ than P_2; or
(ii) P_1 is less overinformative to Q in $J_{x,i}$; or
(iii) P_1 and P_2 are equivalent in $J_{x,i}$ and
P_1 is a more standard answer to Q than P_2

Clause (45) (i) correctly predicts that a proposition that gives a complete answer is a better answer than one that gives a properly partial one, if it is any good at all, i.e., if it gives a true answer. Complete answers are the most informative ones[3].

Clause (45) (ii) requires a proposition not to give more information than the question asks for. For example, suppose that $J_{x,i}$ contains no information about ϕ, or about ψ. Let the question be *whether* ϕ. Then (45) predicts that the proposition *that* ϕ is a better answer than the proposition *that* (ϕ *and* ψ). Both are complete answers, and therefore, *that* ϕ is not more informative than *that* (ϕ *and* ψ). But the former is weaker in $J_{x,i}$ than the latter, and therefore less overinformative. (Notice that *that* ϕ would be a better answer than the possible indirect answer *that* (ϕ *or* ψ), since it is more informative in this situation.)

However, if the proposition *that* ϕ is already contained in $J_{x,i}$, then *that* ϕ is no longer weaker, but equivalent with *that* (ϕ *and* ψ) in $J_{x,i}$. But clause (45) (iii) decides between the two, even in this situation. Both propositions are complete answers to *whether* ϕ in I, but *that* ϕ is weaker in I than *that* (ϕ *and* ψ), and hence a more standard answer, and therefore a better answer.

To give another example, suppose $J_{x,i}$ contains the information *that not-*ψ. Then, the proposition *that* ϕ and the proposition *that* (ϕ *or* ψ) are equivalent in $J_{x,i}$, but *that* ϕ is a more standard answer to *whether* ϕ, since it is more informative in I to *whether* ϕ, and therefore a better answer to this question. Of course, this does not mean that the proposition *that* (ϕ *or* ψ) could never be a good answer in this situation. It would be for example, if the one who answers the question is simply not able to express the proposition *that* ϕ sincerely. The proposition *that* ϕ may simply not be available as a good answer.

A natural question that arises, is whether in a given set of available good answers, there always is a best one. It can be proved that in a sense this is the case. But only if we make two assumptions. The first is that if two propositions P_1 and P_2 are available, their conjunction $P_1 \cap P_2$ and their disjunction $P_1 \cup P_2$ are available as well. The second assumption is that $J_{x,i}$ is an epistemic set. Then we can prove the following[4]:

(46) Let Q be a question in $J_{x,i}$, $J_{x,i}$ an epistemic set, and P_1, P_2 different (partial) true answers to Q in $J_{x,i}$ then either
(i) P_1 is a better answer to Q in $J_{x,i}$ than P_2; or
(ii) P_2 is a better answer to Q in $J_{x,i}$ than P_1; or
(iii) $P_1 \cap P_2$ is a good answer to Q in $J_{x,i}$, and a better answer to Q in $J_{x,i}$ than both P_1 and P_2; or
(iv) $P_1 \cup P_2$ is a good answer to Q in $J_{x,i}$, and a better answer to Q in $J_{x,i}$ than both P_1 and P_2

9. CORRECTNESS OF QUESTION-ANSWERING

We have called the conditions given above conditions of relation, quality and quantity. This should remind one of the corresponding Gricean maxims. Conditions like these may be expected to form the core of an explication of the notion of a correct answer, of an answer in accordance with the Gricean maxims. Such a notion of correctness can be formulated informally as follows:

(47) If x has a question Q, then y gives a correct answer to Q for x in expressing P iff y believes that P gives a good answer to Q for x and that there is no P′ available such that P′ gives a better answer to Q for x than P

Clearly, the notions of a good, and of a better answer, figure essentially in this definition. But it reflects the subjective, speaker-oriented, nature of the Gricean maxims. Therefore, it relates the notions of a good and of a better answer, which themselves are pragmatic in that they pertain to the information of the questioner, to the information of the one who is answering the question. Thus, a formalization of (47) essentially involves a representation of information about information. We will not attempt such an analysis of information here, the eleborations this would involve go beyond the scope of the present paper. But it may be noted that the subjective correctness notion is based upon the notion of a proposition giving a good answer to a question in an information set, and upon that of one proposition giving a better answer than another. And these notions are defined by the conditions stated above.

A closer look at (47) should reveal further that it refers to expressible and available propositions, i.e. that it refers to language. Throughout this paper we have been talking about questions and answers not as linguistic, but as semantic, modeltheoretic objects. But if we come to consider effective question-answering in speech situations, language becomes all important again. A certain proposition may be a good answer, it may even be the best one there is, but this is of little use if we are not able to express it adequately. In determining what the best answer to a question is, we are always dealing with a certain subset of the totality of all true partial pragmatic answers. Roughly, this set contains those propositions which the one who answers the question is able to express linguistically in such a way that the questioner's interpretation of this linguistic expression is a proposition that gives her a true partial pragmatic answer.

The restriction to adequately expressible propositions is highly relevant. The notion of giving a better answer strongly favours semantic answers. This is due to condition (45) (iii). In fact, if we consider all true partial answers to a question, the true semantic answer will obviously be the best one. (And if it is too strong to be given vis à vis the quality maxim, disjunctions of semantic answers will come into play.) But if semantic answers are to be expressed, we need, among other things, semantically rigid designators. And as we noted quite at the outset in section 2, such rigid designators may not be available in the language. And even when they are, they may not be available to the speech participants in the sense that they may not be, or may not be expected to be, rigid in the information of questioner or questionee[5]. A semantically rigid designator may fail to pick out a unique denotation with respect to a certain information set, whereas at the same time a semantically non-rigid expression may do so, by being pragmatically rigid with respect to that set. Obviously, in such a situation the latter kind of expression gives better means to express a pragmatic answer.

The restriction to adequately expressible propositions, which (47) makes, is very realistic in predicting that semantic answers are not always the best ones available. So, the theory of pragmatic answers developed in this paper loses none of whatever usefulness it may have, by the fact that ideally semantic answers tend to be the best ones. In fact, that under completely ideal circumstances, which include having a complete, perfect language, being a perfect language user, a perfect logician, and a walking encyclopedia, semantic answers are the best ones, may be viewed as a merit of the present theory. For it correctly links the existence and function of pragmatic answers to their proper source: the human condition.

NOTES

1. An analysis of the relation between linguistic answers and constituent questions makes use of the property or relation on which the latter are based. See Groenendijk & Stokhof (1984) for details. There the theory developed in this paper is applied to linguistic question-answer pairs.
2. These constraints are familiar from epistemic logic. More constraints would have to be added once we want to deal with information of one individual about

information of another, and with consciousness of one's own information state.
3. Notice that we will need the maxim of Manner to help decide between equivalent sentences, since in this framework they express the same proposition.
4. For a proof see Groenendijk & Stokhof (1984).
5. This presupposes that accessibility relations play a role in defining rigid designation. In a model without them, semantic rigidity would imply pragmatic rigidity.

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Individual Concepts are Useful

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1. INDIVIDUAL CONCEPTS

1.1 *Introduction*

In the model-theoretic approach to semantics of natural languages the expressions of a language are interpreted in a model. The model used by Montague (1973), henceforth PTQ, has as basic sets the set D_e of individuals, the set I of possible worlds, and the set J of time points. The elements in IxJ are called reference points. An individual concept, henceforth an IC, is by definition an element in $D_e^{I\times J}$; xo it is a technical term for a function with domain IxJ and range D_e. By convention, **u** and **v** are variables over individuals (i.e. variables of type e), whereas **x** and **y** are variables over IC's (i.e. variables of type <s,e>).

In PTQ individual concepts are used in an essential way in the treatment of the temperature paradox. Several authors reject Montague's treatment of this paradox, and for this reason they abandon individual concepts completely. The aim of the present paper is to show that there are a lot of phenomena which have nothing to do with temperatures and numbers, and for which the most natural treatment is one using individual concepts. For some of these phenomena a comparison will be made with treatments that do not use individual concepts.

When we deal with individual concepts in a technical way, they are IC's as just defined. But the ideas discussed in this paper have a more general impact and could be applied in other kinds of semantics as well. This is a consequence of the fact that in the discussion only the functional character of IC's is essential. Some possibilities for alternatives are mentioned below.

The domain of an IC is IxJ, but this specific structure of the domain plays no role. If one would base the semantic theory on *sets of data* (cf. Veltman 1981), then one could use such sets of data as domain for individual concepts. And if one would use situations and events as basic (cf. Barwise & Perry 1983), then one could use *possible situations* or *possible courses of events* (as argued for in Landman 19xx) as domain for the functions corresponding with individual concepts.

The range of IC's is defined above as consisting of individuals. Also