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Type-shifting Rules and the Semantics of Interrogatives

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0 Introduction

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

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

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

Entailment is a fundamental semantic notion. Other basic semantic notions, such as synonymy, antinomy and meaning overlap, can be defined in terms of it. And in descriptive semantics, one of the major goals is to account for semantic phenomena in terms of these and similar notions. This holds for interrogative constructions as much as it does for the more familiar indicative ones.

Being the fundamental semantic notion that it is, entailment, especially when it is combined with generalized notions of coordination, is also an important methodological and heuristic tool. Semantic theories can be evaluated with its help, and this holds for theories of the semantics of interrogatives, too. If a particular theory assigns a certain kind of semantic object, of a certain semantic type, to interrogative sentences, we can test it by applying these general definitions, and see whether the interpretation it gives to coordinated interrogatives and the predictions concerning entailment relations it makes on the basis of these definitions, stand to reason. Consequently, entailment and generalized coordination will help to find the right semantic types for interrogative sentences, and the right kind of semantic objects within these types to serve as their interpretation.

We will argue that the most adequate theory will assign a number of different semantic types to interrogatives, depending on the syntactic construction in which they occur. Type-shifting rules will play an important role in incorporating the results in the grammar. One of the most striking features of type-shifting is that it allows for flexibility in associating semantic interpretations with expressions. With the help of generally defined semantic operations, a basic interpretation of an expression can be lifted and shifted to derived interpretations. So, one and the same expression can have a wide variety of possible interpretations, which can be chosen from in different contexts.

Type-shifting can be put to different uses. E.g., as a descriptive tool, it plays a role in the analysis of coordination. Let us give a familiar example. For reasons of simplicity and elegance, it is attractive to assign to proper names, and possibly certain other NP's as well, a semantic object of type e as their basic interpretation. This cannot be the only type for proper names, however, since they can also be conjoined with other proper names, and with other kinds of NP's. Type e is not the right type to apply coordination to. Therefore, in the context of coordination proper names should rather be interpreted as denoting the set of properties of an object of type e. I.e. we need a second interpretation of proper names, that of objects of type $\langle\langle e, t\rangle, t\rangle$, which is also the lowest possible type for quantified NP's. We will see that, for similar reasons, such shifting in meaning is also required for coordination of interrogatives.

Apart from this rather "standard" use of type-shifting in the semantics of interrogatives, involving well-known lifting and shifting principles, there is something more. Among the proposed semantic theories for interrogatives, two approaches can be distinguished: the categorial approach and the propositional approach. One major difference between the two is that they assign different types to interrogatives. So, one may rush to conclude, "(at least) one of them must be wrong". No, not necessarily so, according to a flexible, type-shifting methodology. If the types employed by each of the two approaches can be related to each other by means of a significant uniform semantic operation, both might prove to be (at least) partially right. We want to argue that there are reasons to look upon things this way. We will show that the successes and failures of the categorial approach and those of the propositional approach are complementary, and that by providing a more flexible theory that combines the two, we can add up their successes and eliminate their failures. However, although we will see that such a unification of the two approaches is possible, the question remains whether the semantic operation that is needed to get from the categorial type of interpretation to the propositional type, can really be viewed as a general type-shifting procedure. It certainly is not an orthodox one, and one might say that rather than adducing further support for a flexible approach, it raises foundational questions. If a flexible approach is to be more than a mere technical descriptive device, i.e. if it is to be part of a substantial theory about the relationship between syntax and semantics, it has to be based on restrictive principles.

The paper is organized as follows. In section 1 we give a rough sketch of the ideas underlying the categorial and propositional approaches, outline why the two cannot be straightforwardly combined, and indicate how this problem can be solved. Section 2 deals with coordination of interrogatives and entailments between them, and discusses the various types in which interrogatives should be analyzed. In section 3, a flexible approach is developed which deals with the facts discussed in section 2 and which overcomes the difficulties indicated in section 1. Section 4, finally, sums up the results.

A final remark in this section concerns terminology. In what follows, we shall use the phrase *interrogative* to refer both to interrogative complements and to interrogative sentences. Further, we shall discriminate between *sentential* and *constituent* interrogatives meaning expressions such as "Does John love Mary?" and "whether John loves Mary" by the former, and constructions such as "Who ate the cake?", and "who bought which books where" by the former (using the phrase *n-constituent* (interrogative) to indicate the number of wh-phrases that occur in an interrogative). Finally, it should be noted that *interrogative* shall denote linguistic expressions, while *question* is reserved for the semantic objects they express.[1]

1 Caterpillars and Butterflies

1.1 Introduction

In this section we will outline two approaches to the semantics of interrogatives and the question-answer relation. Each of these two approaches, we will argue, solves some important issues, yet, on the face of it, the two are incompatible. However, we will show that if we take a flexible view, the conflict may be an apparent one, and that a type-shifting process may serve to unify the insights of both.

The situation we will sketch, bears a striking resemblance to the situation one finds in the semantics of noun phrases. Concerning the latter, Barbara Partee writes in her 1986 paper (which was a source of inspiration for the present paper):

> The goal [...] is to attempt a resolution of the apparent conflict between two approaches [...]. I believe that the most important insights of both sides are basically correct and mutually compatible. To try to show this, I will draw on and extend the idea of general type-shifting principles [...]. (Partee 1986, p. 115)

The two approaches we will discuss, can be dubbed the *categorial* and the *propositional* approach. In the former much emphasis is placed on the differences in syntactic category and semantic type between different kinds of interrogatives, whereas in the latter the postulate of a uniform, propositional, type is the starting point. Our own analysis, if it is successful, will be one that covers both, in the sense that it will allow us to treat interrogatives in a variety of types, which are systematically related to each other. Such an analysis would provide additional support for the kind of use of type-shifting that was made for the first time by Partee in her discussion of NP-interpretations, a kind of use that considers type-shifting as an explanatory device, rather than as a descriptive tool.

1.2 The categorial and the propositional approach

If we restrict ourselves to the (model theoretic) semantics proper of interrogatives, two main approaches can be distinguished: the categorial and the propositional approach. Disregarding details of concrete implementation (at least for the moment), they can be characterized as follows.

On the categorial view, the main semantic property of an interrogative is that it is in some sense an "incomplete" object. This object requires for its completion an answer. Different kinds of interrogatives, it is observed, call for different kinds of answers. Sentential interrogatives, for example, are characteristically answered by "Yes." or "No.", and constituent interrogatives are typically followed by constituents such as "John,", "In the park.", "John, by Mary.", and so on. These constituents do not form a homogeneous category. Some are terms, others adverbs, and others again, like "John, by Mary.", are of a category not ordinarily found in sentence grammar.

Still, in the context of an interrogative, all these different kinds of constituents are meant to convey information, to express a proposition. And, of course, which proposition a characteristic linguistic answer expresses depends on the interrogative it is meant to answer. On the categorial approach this is accounted for by analyzing interrogatives and answers in such a way that they fit together and make up a proposition. Hence, since constituent answers are of all kinds of different categories, different kinds of interrogatives are to be of different categories as well.

Taking the orthodox view, on which there is a fixed category-to-type correspondence, this means that the following general principle underlies categorial theories: *the syntactic category and the semantic type of interrogatives are determined by the category and type of their characteristic linguistic answers*. This general idea leaves room for many different implementations, but all theories have in common that interrogatives are treated as relational expressions, expressing n-place relations, and that constituent answers serve to fill in the argument places.

The other kind of approach, the propositional one, takes a different view on the semantic content of interrogatives. Answers to interrogatives, it is observed again, convey information, hence they are taken to express propositions. Consequently, the answerhood conditions of an interrogative are a determination of which proposition(s) count(s) as answer(s) to it. From this point of view, the semantic content of all kinds of interrogatives can and must be analyzed in a uniform way, viz. in terms of propositions.

In view of this, there is no reason not to consider interrogatives of different kinds to form a homogeneous category.

So, the gist of the propositional approach can be formulated in the following general principle: *interrogatives are of a uniform syntactic category and a uniform type, the semantic interpretation giving the answerhood conditions.* Again, this idea can be worked out in a number of different ways. In most cases, the meaning of an interrogative is taken to be a function which determines for each possible world a (set of) proposition(s) which constitute(s) the true semantic answer(s) to that interrogative in that world. The differences between the various individual theories mainly reside in what true semantic answers are taken to be.

As we said above, the situation we are confronted with in developing a semantic theory for interrogatives resembles the situation concerning the semantic interpretation of noun phrases which Partee analyzes in Partee (1986). There are two radically different approaches, each one based on an intuitively clear idea, and each one capable of explaining an interesting and important class of phenomena. Each approach makes predictions about the kind of semantic object that an interrogative represents, and these predictions are incompatible, if, that is, one takes the orthodox view on the relationship between syntactic categories and semantic types. If one assumes that to each syntactic category there corresponds a unique semantic type, the two approaches are incompatible in two ways: the propositional one postulates a uniform semantic type, whereas the categorial one assumes interrogatives to be of a large number of different types; and even taking only one kind of interrogative into consideration, the two will not meet, since on the categorial approach an interrogative expresses an n-place relation, whereas in the propositional approach it determines a (set of) proposition(s).

However, if we take a closer look at the phenomena that each of these approaches deals with successfully, it can be observed that these are largely complementary. Hence, there is good reason to suppose that the incompatibility between the two is only an apparent one which originates from the assumption that there is such a thing as *the* semantic type of an interrogative, and that once this assumption is given up, the two can fruitfully be combined. In effect, this is what we want to argue for. So, let us first turn to the alleged complementarity of the two approaches.

1.3 A puzzling situation

In order to get a clearer picture of what exactly is going on, let us start by formulating two intuitively plausible requirements that a semantic analysis of interrogatives should meet. (This is not to suggest that this is all there is to such an analysis, but it suffices for our present purposes.) The first requirement concerns the question-answer relation as a linguistic relation, i.e. as a relation between an interrogative and its characteristic linguistic answers. It is the demand that the semantic content of the interrogative, and the semantic content of the constituent that forms a linguistic answer, together determine the semantic content of that linguistic answer.

The second, equally plausible, requirement is that a semantics of interrogatives should give a proper account of systematic semantic relationships that exist between interrogatives (and between interrogatives and indicatives). Especially in the case of interrogatives, where intuitions about the kind of semantic object that is their proper interpretation are slim, meaning *relations* are the prime data to be accounted for. A central relationship between interrogatives is the one that holds if every complete and true answer to the first also gives a complete and true answer to the second. In effect, one might dub this "entailment" between interrogatives. This relation holds, e.g., between "Who will go to the party? And what will they bring along?" and "Who will go to the party?", and between the latter interrogative and "Will John go to the party?".

It will need no argumentation that a categorial theory will be able to meet the first requirement, at least in principle, since it assigns to an interrogative a semantic type which, when it is combined with the type of its characteristic linguistic answers, "cancels out" to *t*. And it will also be clear that, again at least in principle, a propositional theory will be able to meet the second requirement, for it identifies the semantic content of an interrogative with its answerhood conditions, and stipulates a uniform semantic type, to which a generalized notion of entailment may be applied in a straightforward way. And it is exactly the feature of a categorial theory that enables it to meet the first requirement that makes it doomed to fail on the second. For in a categorial approach a multiplicity of types of interrogatives is postulated that matches the multiplicity of types of constituents that form their characteristic linguistic answers. And it is this multiplicity of types that prevents the application of any standard notion of entailment, since entailment is typically a relationship between expressions of one and the same type.

We can illustrate the rather paradoxical situation we find ourselves in as follows. Suppose there are two interrogatives that are equivalent under the notion of entailment indicated above, i.e. for which it holds that each complete and true answer to the first gives a complete and true answer to the second, and vice versa. And suppose further that there is a characteristic linguistic answer that as an answer to the first interrogative conveys different information, expresses another proposition, than it does as an answer to the second. If such a situation exists, it is clear that neither a propositional nor a categorial theory will be able to deal with it. For the first assumption implies that on the propositional theory the semantic content of the two interrogatives is the same. Hence, combining it with the semantic content of one and the same constituent cannot but give the same result in both cases. On the other hand, a categorial theory might very well cope with the second assumption, but only in virtue of failing to deal with the first. For accounting for the fact that the constituent answer expresses different propositions in each of the two cases, requires giving the two interrogatives a different interpretation, thus failing to account for their assumed equivalence.

Examples of such pairs of interrogatives are not only theoretically possible, they actually exist. A simple case, involving almost no assumptions about the details of an actual propositional or categorial theory, is the following. Take the two interrogatives: "Who of John, Bill and Mary will go to the party?" and "Who of John, Bill and Mary will not go to the party?". These two are equivalent in the sense that they have the same answerhood conditions. Each proposition which completely settles the first question, also fully answers the second one, and vice versa. However, a constituent answer like "John and Bill." expresses a different proposition according as to which interrogative it is used to answer. In the first case it expresses that John and Bill are the ones that will attend the party, whereas in the second case it conveys the information that John and Bill are the ones that won't go to the party.

As we said, this situation is rather puzzling. We have formulated two reasonable requirements on semantic theories for interrogatives, and we seem to have found out that a semantic analysis that meets the one cannot at the same time meet the other. So what are we to do?

There are many ways in which one might react to this predicament. Before briefly discussing three of them, we want to point out the following. It should be borne in mind that we are not discussing actual theories here, but overall approaches. And we take it for granted that the insights on which the two approaches are founded are basically sound. In fact, the soundness of the ideas underlying the two approaches is reflected, we feel, in the plausibility of the two requirements we have singled out and discussed. Of course, both kinds of theories are wrong in so far as they take their respective starting points to say *all* there is to say about the meaning of interrogatives. That is exactly what the paradox shows. But, we think that this should not lead one to reject the underlying ideas as basically correct insights about *aspects* of the meaning of interrogatives.

Now, we can envisage (at least) three different reactions. The first one runs along the following lines. It hooks on to the failure of the propositional approach to meet the first requirement. Logical equivalence, so it goes, is simply not a sufficient condition for sameness of semantic content (sameness of meaning). Rather, meaning is a more fine-grained notion, and what the first requirement amounts to is that in the case of interrogatives it should be at least so finely structured that within the overall meaning of an interrogative, which in the propositional approach gives the answerhood conditions, we can distinguish as a distinct "part" the n-place relation that the categorial approach considers to be the semantic interpretation. So, instead of the usual unstructured notion of a function from worlds to (sets of) propositions, one should use structured meanings, interpreted derivation trees, or what have you.

We feel that the use of structured meanings that this reaction proposes to make, is improper, or, at least, is not in line with the usual motivation for using structured meanings. In the analysis of propositional attitudes, some have proposed the use of structured meanings, because they feel that in such contexts, which, on their view, are essentially tied up with mental representations, we need not just the semantic content of an expression, but also its semantic structure, assuming that this structure and our mental representation bear enough resemblance to let the one go proxy for the other. However, such use of structured meanings differs essentially from the one proposed above. There, no use of the structure of the entire meaning is made as such, it is only used to get at a certain part of the meaning that helped to generate it. Once you've got hold of the relevant part, the rest of the structure can be discarded. To our minds, this goes against what our two requirements actually state about the meaning of an interrogative. They are both requirements on one and the same notion of meaning.

For consider what will happen if we follow this strategy in the case at hand. According to the proposed strategy, we need the meaning of a predicate (to meet the first requirement), and we need the meaning of a sentential structure (to meet the second one). In both cases, the meanings we use, are "normal" unstructured meanings, i.e. intensions. It is only by means of a trick that the two are unified. The two separate, unstructured intensions are taken together in one "structured meaning", but to our minds, this is just a cosmetic move, for no structure of the meaning as such is used in any essential way (in fact, we just use a pair of intensions as the meaning).

So, we feel, there are theoretical reasons to be dissatisfied with this appeal to the notion of structured meaning for this particular problem. On the practical side, it may be remarked that it may lead to a theory that, extensionally, so to speak, meets the two requirements. However, structured meanings are no sure cure for any propositional theory. It depends on the way in which such a theory derives its function from worlds to (sets of) propositions whether, taken as structured objects, they do contain the required relations as retrievable parts. For example, quantificational propositional theories, such as Karttunen's and Bennett and Belnap's, may structure their meanings any way they like, the required relations just ain't in there.

The second possible reaction we want to discuss, starts from the categorial point of view, i.e. it takes interrogatives basically as expressing n-place relations. The diagnosis it gives for the failure of this approach to meet the second requirement, that of accounting for entailment between interrogatives in a general, non ad hoc way, is that it lacks a uniform type to associate with different kinds of interrogatives. Now, property theory is designed to provide such a uniform type, for it allows for the possibility of analyzing expressions which are of different types in the ordinary view, as being of one and the same type, viz. that of entities. This suggests that the two semantic objects we need in our semantic analysis of interrogatives can be gotten as special instances of the general relationship that exists between abstract objects and the corresponding relational "entities".

However, a uniform type is one thing that is needed in order to be able to satisfy the second requirement, but it is not sufficient. What is needed on top of it, is an entailment structure on (the relevant part of) the domain of objects. And the main question is how to get the proper structure. One kind of structure we need to impose on the domain of objects anyway, is the structure that is inherited from the original domains of the respective relational types of entities. For example, we can view propositions as objects, and these objects will bear structurally the same relations to one another as their propositional counterparts. And the same goes for one-place properties, two-place relations, and so on. However, it must be clear that this kind of structure of the respective parts of the domain of objects will be of no use at all for accounting for meaning relations between interrogatives. First of all, the structures in question remain restricted each to their own subdomain. If we identify these subdomains with sorts, we can express this by saying that these relationships are essentially "intra-sortal". But, and this is the important point, entailment relations between interrogatives are cross-categorial relationships, and hence would have to be "cross-sortal" relationships on the entity domain in this approach. And second, the intra-sortal relationships we do get, are not the proper ones to account for entailment between interrogatives of the same kind. For example, sentential interrogatives are not related by entailment to each other (e.g., "whether ϕ" and "whether ϕ and ψ" do not entail one another), but the corresponding propositions (in the example, "that ϕ" and "that ϕ and ψ"), and hence the corresponding propositional objects, have a very rich entailment structure. It seems that the only way to get the proper cross-sortal relationships on the one domain of objects, is through an analysis (at some level) of interrogatives as objects of a propositional type.

Of course, this does not show that interrogatives can't be, or shouldn't be, analyzed as entity denoting expressions. On the contrary, it can be argued that in certain constructions and relations in which they enter, it is profitable to analyze them as denoting an object. But what it does show is that such an analysis will not solve our present problem. We still need the two kinds of semantic objects that the categorial approach and the propositional approach postulate. Property theory will enable us to analyze both (also) as abstract objects, and this may be useful, but it does not enable us to avoid postulating a propositional type of semantic object, besides a variety of relational types, as an interpretation of interrogatives.

The third reaction is the one that we think is most adequate. It analyzes the situation in terms of type shifting. The paradox occurs, so it goes, because in both requirements mention is made of "*the* meaning of", or "*the* semantic interpretation of" interrogatives. The propositional approach assigns a uniform type to all interrogatives, and, disregarding ambiguities, in that type each has a unique semantic interpretation. The categorial view postulates various semantic types, but each kind of interrogative occurs in one type only. And again, in that type it has a unique semantic interpretation. So, both approaches take it for granted that each particular interrogative belongs to a unique type and, in that type, has a unique interpretation. If we want to stick to that, the paradox is unavoidable. Or, to put it differently, the paradox shows that this is something we should not take for granted. What the paradox indicates is that interrogatives are among those natural language expressions which do not have a unique interpretation in a unique type. Rather, taking different perspectives, such expressions can be said to have different (but related) meanings, that are of different types.

So, the third strategy proposes to solve the apparent paradox by introducing a relativization to a perspective. In this case, it claims that the two requirements are equally reasonable, but are made from different perspectives, taking different constructions as their starting point, and hence are requirements on different domains. Interrogatives have to be analyzed in (at least) two different domains, as expressions of (at least) two different types. On the one hand, they have a clearly relational meaning, as is most prominently shown in the way in which they interact with their characteristic linguistic answers. On the other hand, they also behave as propositional objects, and it is as objects of the latter type that they enter into systematic relationships, such as entailment, to each other. (In section 2.3 we will see that interrogatives belong to other domains as well.)

Within a certain conception of how to incorporate such flexibility into the grammar, about which we will say some more in section 3.3, this implies that the one major syntactic category of interrogatives has to be associated with different semantic types. And each individual interrogative will have to be given an interpretation in a suitable relational type, and also an interpretation in a uniform propositional type. An additional requirement is that these two interpretations be systematically related.

Giving up the assumption of a unique interpretation in a unique type means that the two intuitive requirements on the semantics of interrogatives have to be rephrased along the following lines. The first requirement now reads that an interrogative has to be analyzed as being of (among others) such a type that its semantic content as an expression of that type and the semantic content of the constituent that forms a linguistic answer together determine the proposition expressed by that linguistic answer. And the second requirement will now state that interrogatives also have to be analyzed as expressions of one uniform type in which a proper account of their systematic semantic relationships, in particular of their entailment structure, can be given. And the concept of a flexible grammar adds to these the additional requirement that these two should be systematically related.

In order to get a clearer view on what a flexible analysis of interrogatives amounts to, we will first concentrate on an area where the use type-shifting and flexibility is more familiar, viz. coordination. We discuss various facts and their consequences in section 2, and outline a flexible framework in sections 3.1 and 3.2. In section 3.3, we will return to the possibility of implementing the third strategy to solve our puzzling situation.

2 Coordination, Entailment and Types

2.1 Coordination

One has to live with a lot of questions, and sometimes one cannot wait to have them answered only one by one. In such situations, one may use a conjunction (or sequence) of interrogatives. An example of such a conjunction, and of the way in which it can be answered is given in (1):

(1) Whom does John love? And whom does Mary love?
– John loves Suzy and Bill. And Mary loves Bill and Peter.

In this example a simple conjunctive sequence of two interrogatives is given, which, as the answer that follows it shows, in fact poses two separate questions: the speaker wants to know both whom John loves, and whom Mary loves.

Another example of an interrogative that involves conjunction is (2):

(2) Whom do John and Mary love?

Example (2) is ambiguous between what we call a *direct* reading, on which it is equivalent with (3):

(3) Who is such that both John and Mary love him/her?

and what we call its *pair-list* reading, on which it means the same as (1) above, i.e. on which it asks for a specification of the individuals that John loves, and for a specification of those that are loved by Mary.

A similar ambiguity can be observed in interrogatives such as (4):

(4) Whom does every man love?

This example, too, has a direct reading and a pair-list reading, as the following paraphrases, and the corresponding answers, illustrate:

(4) (a) Who is such that every man loves him/her?
– Peter and Mary.

(4) (b) Whom does Peter love? And whom does Bill love? And ...
– Peter loves Mary. And Bill loves Suzy and Fred. And ...

An interesting point to note is that on its pair-list reading, as paraphrased in (4) (a), (4) behaves like (5). The latter is a two-constituent interrogative, i.e. an interrogative containing two wh-phrases. Although (4) on the relevant reading contains only one wh-term, it is answered in the same way as (5):

(5) Whom does which man love?

What (5) asks for is a specification of a list of pairs of individuals x and y, where x is a man and y an individual such that x loves y. The same holds for (4) on its reading (b), which is why it is called what it is called.

An example of a disjunction of interrogatives is given in (6):

(6) Whom does John love? Or, whom does Mary love?
– John loves Suzy and Bill.
– Mary loves Bill and Peter.
– John loves Suzy and Bill, and Mary loves Bill and Peter.

Disjunctions of interrogatives, like their conjunctive counterparts, formulate two separate questions, but, unlike conjunctions, they pose only one: they leave the hearer a choice as to which one of the formulated questions she wants to answer. As the answers in (6) show, a disjunction of interrogatives may be answered by answering either disjunct or both.

Disjunctive interrogatives need not consist of two separate interrogatives, as (7) shows:

(7) Whom does John or Mary love?

Like its conjunctive counterpart (2), (7) is ambiguous between a direct reading and what we call a *choice* reading. On the latter (7) is equivalent to (6), on the former it can be paraphrased as (7) (a):

(7) (a) Who is such that John or Mary (or both) loves him/her?
– Suzy, Bill and Peter.

As we saw above, pair-list readings are not restricted to interrogatives with overt conjunctions. In the same way choice readings can occur without overt disjunctions, as a simple example like (8) shows:

(8) What did two of John's friends give him for Christmas?

This interrogative is ambiguous. It has a direct reading, on which it asks for a specification of the presents that two of his friends gave him. And it has a choice reading, on which it invites the addressee to choose any two friends of John's and specify for each one of them what he/she gave him for Christmas. Obviously, it is a matter of the internal semantic structure of a term phrase whether it will give rise to a pair-list or a choice reading or not.[2] Again, it should be noted that choice readings of interrogatives are like two-constituent interrogatives, as is evident from the way in which they are answered.

Like ordinary interrogatives, coordinated ones can be embedded under extensional and intensional verbs, such as **know** and **wonder** respectively. Also, the ambiguity between a direct reading and a pair-list reading, and between a direct reading and a choice reading is preserved in such contexts. As for the distinction between extensional and intensional embedding verbs, it should be noticed that there is a difference when disjunction is involved, as (9) and (10) show:

(9) Peter knows whom John loves or whom Mary loves
(10) Peter wonders whom John loves or whom Mary loves.

Sentence (10) is ambiguous, allowing for the disjunction in the complement to have either wide or narrow scope with respect to **wonder**. The wide scope reading occurs when the speaker knows that Peter wants to know the answer to one of the two questions, but she herself does not know which one this is. On the narrow scope reading (10) expresses that Peter will be satisfied when he gets an answer to either one of the questions involved, no matter which one.

A last observation that should be made here, is that coordination of interrogatives goes across kinds. It is not restricted to expressions of the same kind, i.e. to sentential interrogatives, single constituent interrogatives and multiple constituent interrogatives, but combines them freely, as the following examples show:

(11) Who went to pick up John? And are they back already?
(12) Peter knows who went to pick up John and whether they are back already
(13) Which woman does which man admire most? Or do they all detest each other?

This fact, too, can be used to argue for uniformity in assigning types to these different kinds of interrogatives.

So much for coordination, let us now turn to the second part of our empirical domain, that of entailment.

2.2 Entailment

Let us first of all recall a familiar fact concerning entailment relations between coordinated indicatives and their coordinates: a conjunction entails its conjuncts, a disjunction is entailed by its disjuncts, and a conjunction entails the corresponding disjunction. Analogous facts hold for coordinated structures in general, and properly generalized notions of coordination and entailment should account for them.

Considering interrogatives, we can observe that someone who asks (11) also asks (14), and that someone who answers (15) also answers (16):

(14) Who went to pick up John?

(15) Where is your father?
(16) Where is your father? Or your mother?

In section 1.3 we used a notion of entailment between interrogatives which might be described informally as follows:

An interrogative *A* entails an interrogative *B* iff
whenever a proposition gives a complete and true answer to *A*,
it gives such an answer to *B*.

It is easy to check that this description conforms with the observations just made, and that it likewise predicts that (17) entails (16):

(17) Where is your father? And your mother?

These examples of entailments between interrogatives depend on their coordination structure. There are also other types of entailments to be observed. Let us give two more examples. The single constituent interrogative (18) entails the sentential interrogative (19):

(18) Which men does Mary love?
(19) Does Mary love John?

Getting a complete answer to (18) implies getting a complete answer to (19). Notice that in this case entailment is a relation between different kinds of interrogatives, a one-constituent interrogative and a sentential interrogative. Another example is provided by (18), (20) and (21). A complete answer to both (20) and (21) gives a complete answer to (18) as well:

(20) Whom does Mary love?
(21) Who are the men?

Notice that (20) on its own does not entail (18), for knowing the answer to (20) is knowing which individuals (within the relevant domain of discourse) Mary loves, and this entails knowing which men Mary loves only in conjunction with knowledge of which individuals are men.

In line with recent work, we assume that coordination and entailment are *general* syntactic and semantic processes. Elements of all major categories can be coordinated, and a number of people have proposed general definitions to account for this.[3]

Entailment, too, is a relation that holds between elements within any major category: indicative sentences, of course, interrogatives, as we have seen above, but also termphrases (**every man** entails **John**), verbphrases (**to walk** entails **to move**), nouns (**woman** entails **human being**), and so on. In all cases it is the same relation that is at stake, viz. that of the denotation of one element being included in all models in that of the other. To put it differently, employing a semantic meta-language based on set theory brings along a definition of entailment for all categories: inclusion of denotation in all models.

The following definitions of generalized conjunction and disjunction are based on the work referred to above. First, the notion of a "conjoinable type" is defined:

CT, the set of conjoinable types, is the smallest set such that:
(a) $t \in CT$;
(b) if $b \in CT$, then $\langle a, b \rangle \in CT$.

Then generalized conjunction is defined as follows:

$X \cap Y = X \wedge Y$, for X, Y of type t
$X \cap Y = \lambda x [X(x) \cap Y(x)]$, for any other conjoinable type.

The definition of disjunction, $\cup$, is analogous.

Entailment, $\subseteq$, can be defined generally as follows:

$X \subseteq Y = X \rightarrow Y$, for X, Y of type t
$X \subseteq Y = \forall x [X(x) \subseteq Y(x)]$, for any other conjoinable type.

It should be noted that employing such general notions of coordination and entailment means that one is kept to assign semantic interpretations to expressions in such a way that the entailment relations that can be observed are accounted for by these independently defined and motivated notions. Exceptions to this should be well-argued for.[4]

It should be stressed that this is a methodological requirement. Of course, a theory that uses different and unrelated notions of entailment or coordination for different domains, may very well be empirically adequate, in the sense that it makes the right predictions. The point we want to make, is that a theory that makes the same predictions but does so on the basis of generalized and uniform notions, is to be preferred on methodological grounds. It provides a simpler account of the relevant facts, and, hence, has greater explanatory force.

In the next section, we will show how this requirement can be used to evaluate theories that propose a certain type of semantic object as the interpretation of interrogatives.

2.3 Types for interrogatives

In this section we will investigate which types are to be assigned to interrogatives. In a flexible framework, there need not be a *unique* proper semantic type for all expressions of a certain category. Interrogatives are no exception to this rule. However, for every *construction* in which interrogatives occur, there is, as we shall see, a *key type*: the type in which the intuitive entailments between interrogatives in that construction are accounted for by the general definition of entailment that our framework provides.[5]

Also, we will argue in this section that employing general notions of coordination and entailment will enable us to evaluate various proposals within the two main approaches to the semantics of interrogatives which were discussed in section 1.

As we saw above, the main characteristic of the categorial approach can be summed up as follows:[6]

The syntactic category and the semantic type of an interrogative are uniquely determined by the category and type of its characteristic linguistic answers.

The idea is that the type of an interrogative and the type of its characteristic linguistic answers should cancel out, by functional application, to that of sentences, i.e. to type t. Let us illustrate this with a few examples. First a single constituent interrogative:

(22) Whom does John love?
– Mary.

Applying the criterion just mentioned, it follows that the (simplest possible) type of a single constituent interrogative is that of a property of individuals (a one-place relation). Next, consider a multiple constituent interrogative:

(23) Which man does which woman love?
– Mary, Bill; and Suzy, Peter.

Here the resulting type is that of a two-place relation between individuals. The last example is that of a sentential interrogative:

(24) Does John love Mary?
– Yes.

If we apply the criterion in this case, the outcome is not unique, but the simplest solution is to give sentential interrogatives type t, and hence consider "Yes." and "No." as expressions of type $\langle t, t \rangle$, which is one of the solutions we find in the literature. Considering t to be the type of zero-place relations, we can view sentential interrogatives as zero constituent interrogatives. Generalizing from these examples, we conclude that in the categorial approach, n-constituent interrogatives are interpreted as n-place relations.

Although this approach has attractive features, for one thing, it leads to a simple and intuitive analysis of the interpretation of characteristic linguistic answers, it also has its shortcomings. These concern coordination and entailment, as we shall see.

First of all, the approach as such does not account for coordination and entailment across different kinds of interrogatives and it is hard to see how it could, without giving up its fundamental characteristics. For entailment and coordination require a uniform type, which the categorial approach simply does not provide.

Moreover, even if we limit ourselves to interrogatives of the same kind, in which case the general definitions are in principle applicable, we find that the wrong predictions are made. E.g. it is predicted that (25) and (26) are equivalent, which is not the case:

(25) Who walks? And who talks?
(26) Who walks and talks?

The conjunction of interrogatives (25) asks to specify both the individuals that walk and the individuals that talk, whereas (26) asks to specify the individuals that both walk and talk (so, (25) entails (26), but not the other way around).

A second example. Analyzing one-constituent interrogatives as properties, predicts that (27) entails (28), which again is not the case:

(27) Who walks?
(28) Who moves?

If one is told which individuals walk, one is not thereby told which are all the individuals that move.

A straightforward conclusion that can be drawn, is that if one wants to employ general definitions of coordination and entailment, then, first of all, one has to analyze, at some level, all interrogatives as being of one and the same type, and, secondly, within this type one has to associate them with the right kind of object.[7]

As we saw above, theories in the second main approach, the propositional one, do assign one single type to all interrogatives. We characterized the main idea of this approach as follows:

The meaning of an interrogative is given by its answerhood conditions.

Within intensional semantic theories answers are of a propositional nature, hence interrogatives are of a "propositional" type. Here, several choices are still open. The best-known analysis, that of Karttunen,[8] makes them expressions of type $\langle\langle s, t\rangle, t\rangle$. I.e., on this analysis an interrogative denotes a set of propositions. Karttunen interprets this set as consisting of those propositions which *jointly* constitute the true and complete answer.

Two things should be noted. First of all, Karttunen's theory is, what Belnap calls, a "unique answer theory", i.e. a theory that assumes that each interrogative has a unique true and complete answer. Why this is relevant will become clear shortly. Second, since Karttunen's theory employs a uniform (conjoinable) type, it makes predictions about coordination and entailment generally, also across different kinds of interrogatives. Let us consider some of these predictions.

The schema of generalized conjunction tells us that the conjunction of two interrogatives is interpreted as the intersection of the sets of propositions denoted by each of the conjuncts. Given the interpretation of these sets of propositions on Karttunen's theory, the result is that a conjunction of interrogatives (almost) never has an answer. The following example illustrates this:

(29) Does John walk? And does Mary walk?

Suppose it happens to be the case that John walks and that Mary doesn't. Then the first conjunct denotes the set consisting of the proposition that John walks, and the second denotes the set consisting of the proposition that Mary doesn't walk. The intersection of these two sets is empty, which means that (29) cannot be answered. A similar result holds for interrogatives on pair-list readings.

Disjunction corresponds to taking the union of sets of propositions. Again, the prediction that the Karttunen analysis makes is not in accordance with the facts. Consider the disjunction of interrogatives (30):

(30) Does John walk? Or does Mary walk?

Taking the union of the set denoted by each of the disjuncts results in the set of propositions which jointly constitute the complete and true answer to the conjunction (29), rather than to the disjunction (30).

For entailment, too, the results which we get when we combine the general schema with Karttunen's interpretation of interrogatives, are not correct. A simple example is the entailment relation between (31) and (32):

(31) Who walks?
(32) Does John walk?

In the intuitive sense, (31) entails (32). But the set of propositions that is the denotation of (31) in Karttunen's theory is not generally a subset of the set denoted by (32). Hence, the theory fails to account for this entailment.

Providing a semantic account of interrogatives which deals with coordination and entailment adequately, then, is not just a matter of finding a uniform and proper type, but also of associating each interrogative with the right object of that type. One might think that Karttunen found the right type, but hit the wrong objects within that type. However, as our discussion of a second proposal intends to show, there are reasons to doubt whether this is indeed the case.

Bennett and Belnap have developed an analysis of the semantics of interrogatives that is explicitly set up to deal with those constructions of interrogatives on which they allow for more than one complete and true answer, such as disjunctions and choice-readings.[9] They assign the same semantic type to interrogatives as Karttunen does, i.e. they, too, take interrogatives to denote sets of propositions, but they interpret these denotations in a different way. In their analysis, *each* of the propositions in the set denoted by an interrogative on its own constitutes a complete and true answer. For "ordinary" interrogatives, i.e. for those which have a unique answer, this means that they denote a unit set.

Here we have an analysis which differs from Karttunen's, not in the type that it assigns to interrogatives, but in the objects of that type that interrogatives are taken to denote. And we might ask whether this change overcomes the difficulties we noted earlier.

As is to be expected, the Bennett and Belnap approach does well with respect to those interrogatives for which it was designed, viz. interrogatives which have more than one unique answer. Sticking to our general definitions, disjunction still comes down to taking the union of the denotation of the disjuncts. However, given the kind of set of propositions that an interrogative denotes on their theory, the result is correct. Consider the disjunction (30) again. Each of the disjuncts now denotes a unit set, and taking the union thereof results in a set with two elements, each of which is a proposition which is a complete and true answer to the disjunction. It is also clear that on the Bennett and Belnap analysis a disjunction is entailed by each of its disjuncts.

On this score, Bennett and Belnap do better than Karttunen. But this does not mean that now we have the right objects of the right type, at least not in all cases, as the following considerations show. Take the conjunction (29). Here we still have the same kind of problems as we met in Karttunen's theory. Given the general definition of conjunction, the denotation of a conjunction is the intersection of the (unit) sets of propositions denoted by the conjuncts, and this still results in the empty set (at least in most cases). Also, we do not get the desired entailment between a conjunction and its conjuncts. So, we must conclude that the Bennett and Belnap approach is not satisfactory either.

Let us take stock: we have seen that atomic interrogatives, i.e. non-coordinated interrogatives which are not embedded and are not given a pair-list or a choice reading, conjunctions of interrogatives and disjunctions of interrogatives behave differently with respect to types and entailment. An atomic interrogative has a unique true and complete answer (in each possible world). This means that the simplest denotational type for atomic interrogatives is type $\langle s,t\rangle$ (giving it a sense of type $\langle s,\langle s,t\rangle\rangle$). As for conjunctions, if we disregard their relations with disjunctions, they could be analyzed at the same level. Since a conjunction, too, has a unique true and complete answer: the conjunction of the propositions that answer the conjuncts, also answers their conjunction. For disjunctions, however, things are different. They do not have a unique complete and true answer, hence they simply cannot be of type $\langle s,t\rangle$. If we look at entailment relations between disjunctions on the one hand and conjunctions and atomic interrogatives on the other, we see that in order to account for them we need a *uniform* type for all, since generalized entailment requires a uniform type for all elements involved. The need for such a uniform type is underscored by the observation that in order to construct disjunctions in accordance with the general procedure, atomic interrogatives should (also) be of the same type as the disjunctions which are constructed from them.

Such considerations, by the way, constitute a general argument against the type that Karttunen, and Bennett and Belnap employ. For, although the objects of type $\langle\langle s,t\rangle,t\rangle$ that the latter associate with interrogatives give a proper interpretation for disjunction, it simply cannot be the uniform type which is required, as the examples discussed above have shown. So here we do have a case against the type as such.

The question that now arises, is what this uniform type is, and whether it is sufficient to account for all entailments. The situation we find ourselves in with regard to interrogatives, resembles that of term phrases in some important respects. The lowest type for a proper name is type e. Looking at disjunctions of proper names in isolation, we find that we can analyze them as being of type $\langle e,t\rangle$. For conjunctions this will not do. There we need a more complex type, viz. the familiar $\langle\langle e,t\rangle,t\rangle$ (disregarding intensionality). Once we take entailments into account, we see that the latter is the uniform type we need, hence that all proper names should have type $\langle\langle e,t\rangle,t\rangle$ at a certain level of analysis. Traditionally, this is achieved by "generalizing to the worst case" and treating all proper names in all contexts as expressions of that type. Within a flexible approach, however, we take $\langle\langle e,t\rangle,t\rangle$ as one of the derived types that proper names can have, a type that they must have e.g. when occurring in a coordinate structure.

With respect to interrogatives we can follow the same lead. The key type of atomic interrogatives, i.e. the type in which the entailments among them can be accounted for, is type $\langle s,t\rangle$. Looking at disjunction in isolation suggests $\langle\langle s,t\rangle,t\rangle$ as the proper type (cf. Bennett and Belnap), but taking a broader view we see that the level at which coordination and entailment can be accounted for is that of type $\langle\langle\langle s,t\rangle,t,\rangle,t\rangle$. And within a flexible frame of mind, the relation between the basic type $\langle s,t\rangle$ and the latter is a familiar one: we get from the one to the other by the type-shifting rule of "lifting", the same procedure we use in analysing term phrases.

The flexible approach is not motivated by reasons of elegance and simplicity alone. As is argued e.g. in Partee and Rooth (1983), the strategy of generalizing to the worst case is not only unnecessarily complicated in many cases, sometimes it is also empirically inadequate. The "wide scope *or*-cases" they discuss, show that there is no *a priori* worst case to generalize to. A similar argumentation can be distilled from the semantics of sentences containing an intensional verb with a disjunction of interrogatives as its complement (see (10) in section 2.1. above. We return to this example later on).

But the semantics of interrogatives provides yet another argument for the necessity of flexibility. To be able to account for entailment relations between atomic interrogatives, such as hold e.g. between (31) and (32), we need to analyze them in the key type $\langle s,t\rangle$. If we lift them to type $\langle\langle\langle s,t\rangle,t,\rangle,t\rangle$, we lose entailment relations that hold at the basic level $\langle s,t\rangle$. But in order to be able to account for entailment relations between coordinated interrogatives, or between such interrogatives and atomic ones, we do need the lifted level to get the right results. So, we cannot assign all interrogatives a uniform type in all cases. What the proper type is, in terms of the predicted entailment relations, depends on the context (e.g. on the construction in which an expression occurs).[10]

Summing up, we have found that there is no uniform key type for all interrogatives. Rather, there is a key type for each of the various constructions and relations that involve interrogatives. But these types do not constitute a heterogeneous set, they are related to each other in a systematic fashion. It is our purpose in the next section to sketch a theory in which this is accounted for.

3 A Flexible Approach

3.1 Questions as partitions

Let us now sketch the outlines of a theory that satisfies the three requirements which we formulated at the end of the section 1, and which accounts for the various observations made in section 2. We start by giving the general idea on which the theory is based.

The theory stays within the possible worlds framework. Following Stalnaker, who formulated this view on possible worlds in various places,[11] we view the set of possible worlds that is given with the model as the set of all possible alternatives, as the set of all situations which, in that model, are distinguished from one another. In this view, sincerely uttering a proposition, or accepting it as true, is restricting oneself to a subset of some initial set of alternatives.

In the same vein, a question can be viewed, not as a restriction on the set of alternatives, but as a division of it, as a grouping together of alternatives from a certain perspective. Each question has a particular subject matter, and it makes a division of the set of alternatives by grouping together those which do not distinguish themselves with respect to this subject matter. Each such group is a set of alternatives, i.e. it is a proposition. In each of the worlds within such a proposition, the answer to the question is the same. Hence, the proposition they make up together can be viewed as a possible answer to a question.

Let us give some examples. Consider the simple sentential interrogative "Is Amsterdam the capital of the Netherlands?". The question expressed by this interrogative divides a given set of alternatives (which need not be the entire set of all possible worlds) into two, depending on the truth value of its subject matter in those alternatives. The one group of alternatives consists of those worlds in which it is true that Amsterdam is the capital of the Netherlands, the other of those in which this is false. Hence, the first group forms the proposition that Amsterdam is the capital of the Netherlands, and the second the proposition that it is not. If the interrogative in question has any presuppositions – say regarding the existence of Amsterdam and the Netherlands, and the existence and uniqueness of capitals – the set of alternatives that the question makes a division on, is restricted to those worlds in which these presuppositions are true.

As a second example, take the interrogative "Which city is the capital of the Netherlands?". This question, too, makes a division of the relevant set of alternatives. In this case the division need not be in two, it can have many members, as many as there are cities that could be the capital of the Netherlands. Again, the alternatives within such a group are indistinguishable as far as the subject matter of the question, i.e. the extension of the property of being the city that is the capital of the Netherlands, is concerned. Together, they form a proposition that asserts of a certain city that it is the capital of the Netherlands, i.e. they specify a possible extension of the property in question. And each such proposition is a complete answer to the question.

From these two examples, the following picture emerges. Each interrogative in natural language expresses a question the subject matter of which is the extension of an n-place relation (sentential interrogatives being the limit case where $n = 0$). Each such question is a partition of the set of alternatives, i.e. divides this set up into a certain number of mutually exclusive propositions.

This general characterization of the notion of a question, of the meaning of an interrogative, is made from the propositional perspective, i.e. from the point of view of answerhood conditions. In fact, the description of the meaning of an interrogative that we just gave, is nothing but a statement of its answerhood conditions, i.e. a statement of the conditions under which a proposition gives a complete answer to it. But notice that in our general characterization of these answerhood conditions the subject matter of a question plays an essential role. This subject matter is, generally speaking, the extension of some n-place relation, and this brings in the second perspective on the semantics of interrogatives, that of the categorial approach.

It is also possible to describe the meaning of an interrogative in terms of the relation that is its subject matter. And in fact, as we saw above, this is what we need to do in order to be able to account for the relationship between interrogatives and their characteristic linguistic answers. Of course, the two perspectives are systematically related: each possible denotation that we can distinguish from the categorial point of view corresponds to a unique proposition that we distinguish from the propositional point of view. We get the latter by collecting those alternatives where the former is the same. In this sense, we can say that a theory which gives interrogatives interpretations both of a relational and of a propositional type, but which links these two in the way just described, still gives them a unified meaning.

Let us now turn to the formal details of a theory which is based on this idea. We have concluded above that the key type for atomic interrogatives is type $\langle s, t \rangle$. But fixing a type is not enough, we must also say which objects of this type interrogatives denote. Again, observations concerning entailment relations will give us a clue. Under the assumption that we talk about a fixed domain of individuals and that proper names are rigid designators, it holds that for every name A, (33) entails (34):

(33) Who walks?
(34) Does A walk?

Given our characterization of entailment between interrogatives (see section 2 above), this means that every proposition that gives a complete and true answer to (33), also gives a complete and true answer to (34). Given that atomic interrogatives such as (33) and (34) are of type $\langle s, t \rangle$, we should take them to denote the proposition that is the complete and true answer, which means that an atomic interrogative A entails an atomic interrogative B iff in every situation the proposition denoted by A entails the proposition denoted by B. For that is in complete accordance with the general definition of entailment.

Since (33) entails (34) for every name A, this implies that the proposition denoted by (33) gives a complete specification of the extension of the walking-property. Hence, a single constituent interrogative will denote in each world the proposition that gives a complete specification of the extension of a property in that world.

This generalizes to n-constituent interrogatives. For example, the two-constituent interrogative (35) entails for every two names A and B the interrogative (36):

(35) Who loves whom?
(36) Does A love B?

The two-constituent interrogative (36) asks for, i.e. denotes, a complete specification of the extension of the relation of loving.

In general, a complete answer to an n-constituent interrogative gives a complete specification of a possible extension of an n-place relation, and the propositions that express these specifications are its possible complete and true answers.

This tells us which object of type $\langle s, t \rangle$, i.e. which proposition, an atomic interrogative denotes. At the same time, it also determines what constitutes the sense of such an interrogative: it is a function from possible worlds to such propositions.

We conclude that every interrogative is based on some underlying n-place relation (where we take sentences, which underlie sentential interrogatives, to be zero-place relations). Every such relation has a set of possible extensions. To each possible extension corresponds a possible answer, the proposition which specifies this extension. Such a proposition is the denotation of the interrogative in the world in which the underlying relation has that extension. And the sense of an interrogative is a function from possible worlds to possible answers. The latter object we call a *question*. Schematically, we end up with the following analysis of atomic interrogatives:

n-place relation *question*
$r : W \rightarrow \text{pow}(D^n)$ $q_r : W \rightarrow \{0,1\}^W$
where $q_r(w) = \text{that } p \text{ s.th.} p(w') \Leftrightarrow r(w) = r(w')$.

This means that questions can be viewed as relations between worlds of a special kind. They are equivalence relations between the elements of W, i.e. they constitute partitions of W. The blocks in these partitions, sets of possible worlds, are the propositions that are the possible answers to the questions.

In what follows we will make use of this, and sometimes represent the meaning of an interrogative, i.e. the question it expresses, as a partition of W. We will use the language of two-sorted type theory, in which quantification and abstraction over worlds is possible, as our representation language.

Let us then quickly review how sentential interrogatives and constituent interrogatives are interpreted according to this schema. First, consider the sentential interrogative (37):

(37) Does John walk?

The underlying zero-place relation (formula) is:

(38) walk (w) (j).

Here, w is a variable of type s, ranging over possible worlds. Obviously, (37) has two complete answers. In a world in which John walks, this is the proposition that he does, and in a world in which he doesn't, it is the proposition that he does not. I.e. (37) asks to identify the actual world as belonging to one of two disjunct sets: those in which John walks, and those in which he doesn't. This means that (37) partitions the set of worlds in two:

that John walks
that John doesn't walk

W

The two blocks of this partition are the two propositions which constitute the two possible complete and true answers to (37). The meaning of (37) can now be represented as follows:

(39) $\lambda w \lambda w'[\text{walk}(w)(j) = \text{walk}(w')(j)]$.

As a second example, consider the one-constituent interrogative (40):

(40) Who walks?

In principle, this interrogative has as many answers as there are subsets of the domain that it ranges over. Or, to give a different but equivalent formulation, each proposition that specifies a possible extension of the one-place relation of walking is a possible complete and true answer to (40). I.e., (40) induces the following partition of W:

no one walks
a is the one that walks
b is the one that walks
⋮
a and b is the ones that walk
⋮
everyone walks

W

The meaning of (40) can thus be represented as follows:

(41) $\lambda w \lambda w'[\lambda x[\text{walk}(w)(x)] = \lambda x[\text{walk}(w')(x)]]$.

A representation of the meaning of the two-constituent interrogative (42) is (43):

(42) Which man does which woman love?

(43) $\lambda w \lambda w'[\lambda x \lambda y[\text{woman}(w)(x) \wedge \text{man}(w)(y) \wedge \text{love}(w)(x,y)] =$
$\lambda x \lambda y[\text{woman}(w')(x) \wedge \text{man}(w')(y) \wedge \text{love}(w')(x,y)]]$.

Generally, any n-place relational expression α can be turned into a question that is the interpretation of the corresponding atomic n-constituent interrogative, by means of the following schema:

(44) $\lambda w \lambda w'[\alpha = (\lambda w \alpha)(w')]$.

This gives a satisfactory treatment of atomic interrogatives, but, as we have seen above, we also need to raise the type of atomic interrogatives $\langle s,t \rangle$, in order to be able to deal with coordinated interrogatives and pair-list and choice readings.

3.2 Types for coordination and embedding

As we saw above, for coordinated interrogatives we need the type that is the lifted version of the type of atomic ones. I.e. we follow a familiar procedure: faced with incorrect results when we apply generalized coordination to expressions of some type a, we go over to the lifted level, i.e. to type $\langle\langle a,t \rangle, t\rangle$. The general type-shifting rule of lifting gives us for every expression α of the "basic" type a a corresponding one which gives the meaning of α as an expression of the lifted type $\langle\langle a, t\rangle, t\rangle$:

(45) $a \Rightarrow \langle\langle a, t\rangle, t\rangle$
$\alpha \Rightarrow \lambda X_{\langle\alpha, t\rangle}[X(\alpha)]$.

This is familiar from the analysis of NP's. Let us consider application of this schema to a simple example of coordination of two one-constituent interrogatives:

(46) Who walks? And, who talks?

At its basic level each conjunct of (46) is represented as an expression of type $\langle s, t\rangle$. The first interrogative for example is represented as:

(47) $\lambda w'[\lambda x[\text{walk}(w)(x)] = \lambda x[\text{walk}(w')(x)]]$.

Applying the lifting procedure of (45) we get:

(48) $\lambda Q_{\langle\langle s, t\rangle, t\rangle}[Q(\lambda w'[\lambda x[\text{walk}(w)(x)] = \lambda x[\text{walk}(w')(x)]])]$.

If we apply the same procedure to the second conjunct, and then use the generalized definition of conjunction, we get (49) as the representation of the conjunction of interrogatives (46):

(49) $\lambda Q_{\langle\langle s, t\rangle, t\rangle}[Q(\lambda w'[\lambda x[\text{walk}(w)(x)] = \lambda x[\text{walk}(w')(x)]]) \wedge$
$Q(\lambda w'[\lambda x[\text{talk}(w)(x)] = \lambda x[\text{talk}(w')(x)]])]$.

The conjunction of the two interrogatives is thus taken to denote a set of sets of propositions, viz. those which contain the answer to the first interrogative and the answer to the second one. Obviously, we obtain as a result that, given the generalized definition of entailment, a conjunction of interrogatives entails each of its conjuncts, for every set of propositions that contains a complete and true answer to both conjuncts, contains a complete and true answer to each conjunct.

Next, consider disjunction. Again, we first lift the disjuncts, and then apply generalized disjunction. (50) is then represented as (51):

(50) Who walks? Or, who talks?
(51) $\lambda Q_{\langle\langle s, t\rangle, t\rangle}[Q(\lambda w'[\lambda x[\text{walk}(w)(x)] = \lambda x[\text{walk}(w')(x)]]) \vee$
$Q(\lambda w'[\lambda x[\text{talk}(w)(x)] = \lambda x[\text{talk}(w')(x)]])]$.

Applying generalized entailment, we see that a disjunction of interrogatives is entailed by each of its disjuncts, and, moreover, that a conjunction entails the corresponding disjunction. Again, bearing the intuitive content of entailment between interrogatives in mind, these results are what we want.

As a matter of fact, it can be noticed that generalized conjunction and disjunction is defined at type $\langle s, t\rangle$ (interrogative denotations) and $\langle s, \langle s, t\rangle\rangle$ (interrogative meanings) as well. A little reflection shows that conjunction could be treated at this level, but disjunction can't. The reason for this is simple. As we saw above, atomic interrogatives induce partitions of W. Pointwise intersection of two partitions (which is what conjunction would amount to) results in a partition again. That is, we get an object, not only of the right type, but also of the right *sub*-type, i.e. one which inherits the defining properties. However, taking the pointwise union of two partitions (which is what generalized disjunction does) in general does *not* result in a partition again. What we get is of the right type, but not of the right sub-type. So, as a additional requirement on dealing with coordination in general, we can state that coordination should be performed at the lowest type that can be reached from the key type, *provided that it respects (i.e. stays within) the relevant subdomains there.*[12]

Let us now turn our attention to embedded interrogatives. Given the type $\langle s,t\rangle$ of atomic interrogatives, the lowest possible type for interrogative-embedding verbs such as **know** is $\langle\langle s,t\rangle,\langle e,t\rangle\rangle$. Taking these verbs to denote basically relations between individuals and propositions has some agreeable consequences.

First of all, given the kind of object we assign to interrogatives as their meaning (and some familiar, though not always uncontroversial, assumptions about the semantics of epistemic verbs) we get an account of the validity of such schemas as (52) and (53):

(52) x knows whether ϕ
ϕ
———————
x knows that ϕ

(53) x knows whether ϕ
not-ϕ
———————
x knows that not-ϕ

Also, given this type-assignment there is no problem in allowing for coordination of sentential and interrogative complements, using standard generalized coordination rules:

(54) John knows that Peter has left for Paris, and also whether Mary has gone with him.

Notice that the following schemata are intuitively valid:

(55) x knows whether ϕ and whether $\psi \Leftrightarrow$
x knows whether ϕ and x knows whether ψ.

(56) x knows whether ϕ or whether $\psi \Leftrightarrow$
x knows whether ϕ or x knows whether ψ.

Above we observed that conjunction at the $\langle s,t\rangle$-level respects subdomains in the case of interrogatives. However, the lowest level at which disjunction respects subdomains is that of type $\langle\langle\langle s,t\rangle,t\rangle,t\rangle$. This means that the type of **know** when it takes a coordinated interrogative complement has to be $\langle\langle\langle\langle s,t\rangle,t\rangle,t\rangle,\langle e,t\rangle\rangle$. We get the required results when we apply a second general type-shifting operation, that of "argument-lifting":[13]

(57) $\langle a, c\rangle \Rightarrow \langle\langle\langle a, t\rangle, t\rangle, c\rangle$, provided c is a conjoinable type
$\alpha \Rightarrow \lambda X_{\langle\langle a, t\rangle, t\rangle}[\mathbf{Q}(X, y_a, \alpha(y))]$
where $\mathbf{Q}(X, y, \delta) = X(\lambda y \delta)$, if δ is of type t
$= \lambda x_d[\mathbf{Q}(X, y, \delta(x_d))]$,
if δ is of type $\langle d, f\rangle$.

This type-shifting rule allows us to lift the argument of a functor, and provides a semantics for the resulting functor in terms of its original interpretation. The example of lifting **know** of type $\langle\langle s, t\rangle, \langle e, t\rangle\rangle$ to $\langle\langle\langle\langle s, t\rangle, t\rangle, t\rangle, \langle e, t\rangle\rangle$ illustrates this. Application of (57) gives the following result:

(58) $\lambda Q_{\langle\langle\langle s, t\rangle, t\rangle, t\rangle}[\lambda x_e[Q(\lambda p_{\langle s, t\rangle}[\text{know}_{\langle\langle s, t\rangle, \langle e, t\rangle\rangle}(p)(x)])]]$.

If we apply this translation of **know** to a disjunction of interrogatives, such as (50) above, we get the required distributive result.

Summing up, for extensional interrogative-embedding verbs, such as **know**, we can employ a key type $\langle\langle s, t\rangle, \langle e, t\rangle\rangle$ for dealing with embedded atomic interrogatives, and for conjunctions. For dealing with embedded disjunctive interrogative complements we need the derived type $\langle\langle\langle\langle s, t\rangle, t\rangle, t\rangle\langle e, t\rangle\rangle$, which we get by applying the type-shifting procedure of "argument-lifting" defined in (57). The latter procedure allows us to deal in general with cases where a functor is to be applied to an argument that itself has been lifted.

Besides extensional embedding verbs there are intensional ones, such as **wonder**. What basic type is to be assigned to them? One might think that a simple intensionalization of the basic type of extensional verbs would do. But the semantics of coordinated interrogative complements again provides a counter-argument. Above, in section 2.1, we observed that whereas extensional verbs distribute over disjunctive complements, intensional ones don't, at least not always. Consider (59):

(59) John wonders who walks or who talks.

The point is that (59) is ambiguous between a wide scope **or** and a narrow scope **or** reading (with respect to **wonder**). These different readings can be paraphrased as (60) and (61):

(60) John wants to know who walks or to know who talks.
(61) John wants to know who walks or he wants to know who talks.

Trying to keep the analogy between extensional and intensional verbs as close as possible would suggest to give them a basic type $\langle\langle s, \langle s, t\rangle\rangle, \langle e, t\rangle\rangle$. In order to deal with (59), we have to apply argument lifting again. But then we would get a distributive reading only. In order to get the non-distributive reading we need another, higher type, and it is clear what this type should be. On the non-distributive reading of (59) **wonder** takes the intension of the entire disjunction as its argument, hence, in this case it is of type $\langle\langle s, \langle\langle\langle s, t\rangle, t\rangle, t\rangle\rangle, \langle e, t\rangle\rangle$. This, then, is the key type of intensional interrogative embedding verbs. In order to account for the wide scope **or** reading of (59), paraphrased in (61), we might proceed in two different ways. In the line of Partee and

Rooth's treatment of ordinary intensional transitive verbs, we could apply disjunction at the level: $\text{lift}_{\langle e,t\rangle}$ (intension (lift($\langle s,t\rangle$))). Or, we could first apply an operation of argument-lowering, and then argument-lift again to get back the original type of **wonder**. For several reasons, we prefer the latter option. First of all, we think there are arguments against the function-argument "flip-flop" that the former strategy involves (see also section 3.3). Secondly, we need argument-lowering anyway, in order to arrive at simple representations of sentences with atomic interrogatives embedded under intensional verbs.

On the basis of the discussion so far, we can distinguish the following interpretation domains for interrogatives in natural language:

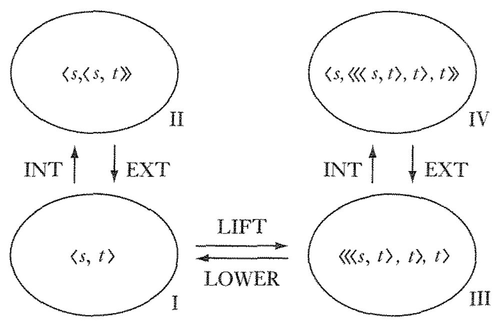

Figure 1

In Figure 1, we see the four interpretation domains for interrogatives which we discussed above, and the type shifting operations which connect them. The first domain, that of type $\langle s,t\rangle$, is the denotational key type for atomic interrogatives and contains the objects that are the interpretations of the arguments of extensional interrogative-embedding verbs. The second domain, that of type $\langle s,\langle s,t\rangle\rangle$, is the key type for meanings of atomic interrogatives, i.e. the level at which entailments between them are to be accounted for. The third domain, that of type $\langle\langle\langle s,t\rangle,t\rangle,t\rangle$, is the denotational key type for coordination of interrogatives. And the fourth domain, that of type $\langle s,\langle\langle\langle s,t\rangle,t\rangle,t\rangle\rangle$, contains the proper objects to be recognized as the meanings of such coordinated interrogatives: they are of the proper type to be associated with the arguments of intensional interrogative-embedding verbs, and they contain the right structure for an account of entailment between coordinated interrogatives. The domains I and II, and III and IV, are related by the type shifting rules of INT (intensionalization) and EXT (extensionalization). The key type for atomic interrogatives and the key type for coordinated ones are related by the operations LIFT (lifting) and LOWER (lowering). Notice that the latter is a partial function. Notice also that only a proper subset of each of these domains contains the right objects to serve as interpretations of interrogatives in their various roles. These subsets are characterized by the specific semantic interpretation rule (44) that we gave for atomic interrogatives, which defines the characteristic ("partition") properties which are "preserved" by the general type shifting principles.

Are these four all the interpretation domains for interrogatives? Probably not. One domain one might also want to use is D_e, which is to serve as the domain for nominalized interrogatives (e.g. as in "Whether ϕ is a difficult question"). And others might be distinguished as well. Prominent among them, at least in the context of this paper, are the relational types that the categorial approach uses. Do they, too, form a possible interpretation domain for interrogatives that can be fitted into a flexible framework such as outlined in this section?

That is the topic of the next section, the possible unification of the categorial and the propositional approach.

3.3 Type shifting as unification?

The discussion in the preceding sections was largely aimed at finding the proper types of semantic objects for the interpretation of interrogatives in the contexts of coordination, entailment and embedding. We found that no one unique type serves as *the* proper type in all contexts, and that we need to pursue a flexible approach in which various domains, connected to each other by general type shifting procedures, are used.

In this subsection we want to consider another (set of) type(s) for interrogatives, the relational ones, which the categorial approach uses to give an account of another construction into which interrogatives enter, viz. interrogative/answer pairs. This consideration will lead us ~~to~~ illustrate yet another aspect of the use of type shifting, viz. that of unifying equally well-motivated but different semantic approaches dealing with different parts of some empirical domain. Above we saw that there are two main approaches to the semantics of interrogatives: the categorial and the propositional one. The first assigns different relational types to different kinds of interrogatives, the latter postulates a unique, propositional type. Also, we saw that arguments in favour of each can be given, arguments which by and large are complementary. This suggests that at some level of analysis the two approaches need not be in conflict. The semantics we outlined above may well contain the elements that such a unification needs. Recall that it is based on the following rule:

n-place relation *question*
$r : W \to \text{pow}(D^n)$ $q_r : W \to \{0,1\}^W$
where $q_r(w) = \text{that } p \text{ s.th. } p(w') \Leftrightarrow r(w) = r(w')$.

On the left hand side we find the kind of semantic objects that the categorial approach typically associates with interrogatives. And on the right hand side, we have a propositional type. So the basic rule of our semantics might also be looked upon as turning a categorial analysis into a propositional one. Couldn't we, then, view this rule, too, as a type shifting rule, i.e. add to our stock of semantic domains for interrogatives that of *n*-place relations, and postulate the rule as an additional type shifting tool?

Let us first indicate what would be the advantages of such a move. As we saw above, the categorial approach is inspired by the semantics of characteristic linguistic answers to interrogatives. And it deals with them in a natural way. Consider the following example:

(62) Which man walks in the park?
(63) Who walks in the park?

(64) Hilary.
(65) Hilary walks in the park.

Given the sex-neutral status of the proper name "Hilary", this example clearly shows that the semantic interpretation of a linguistic answer depends on the semantic interpretation of the interrogative it answers. The information that (64) and (65) convey differs according to whether they answer (62) or (63).

Exactly which semantic property of an interrogative it is, that is needed for the interpretation of a linguistic answer, we illustrated above, in section 1.3, with an example like the following:

(66) Who will come to the party?
(67) Who will not come to the party?
(68) John and Mary.

Above we noticed that on a propositional approach, there tends to be no semantic difference between (66) and (67). The proposition (or propositions) that give a complete specification of the positive extension of some property or relation are the same as the one(s) that give(s) a specification of its negative extension. However, the meaning of (68) differs depending on whether it answers the positive or the negative question. From this we drew the conclusion that the semantic interpretation of characteristic linguistic answers essentially involves the *relation* that underlies the question expressed by an interrogative.

On the other hand, we have seen that there is ample reason for a propositional level as well. So, it seems that there are two complementary semantic analyses, each accounting for different aspects in the meaning of interrogatives and their answers. Unifying them could be done by postulating n-place relations as a possible interpretation domain for interrogatives and by regarding the rule specified above as a type shifting rule.

It should be remarked at the outset that we are entering largely uncharted territory here. One reaction to the afore going question, whether our basic semantic rule can be viewed as a type-shifting principle, might be one of distrust: it certainly does not look like the ones we are familiar with. But another reaction might be: "Why not, if it does the same kind of work as the others, and does that properly?" What we seem to lack is a *theory* of type shifting rules. Although investigations have been made into the formal properties of various conglomerates of type shifting rules,[14] a body of general and intuitive constraints characterizing the notion of a type shifting rule as such still remains to be formulated. Unfortunately, we do not have anything to offer on this score. We just want to point out that there may be a relation between what one wants to consider as a *bona fide* principle and the view one takes on their place in the grammar. If one considers them to be part of the syntax one's attitude might be just a little more conservative than if one takes them to play a role in the relation between syntax and semantics.

Without taking a very firm stand on the matter, we suggest that the discussion so far has provided evidence for the claim that it is possible and profitable to take the rule in question to be a type shifting principle. However, there is a potential problem that such a move meets. And this problem raises some further reaching questions regarding the place of type shifting principles in the grammar. The problem is that of potential overgeneration of meanings of expressions, and it occurs not only with this particular type shifting rule (if such it is). In order to discuss this problem, let us first give a very rough indication of our view on the place of type shifting in a grammar.

Very roughly speaking, we might distinguish two ways of incorporating flexibility in the grammar. On the first one, what we have called type shifting rules are in fact considered to be *category changing* rules, which form an integral part of the system of syntactic rules and categories.[15] This approach is orthodox in so far as it adheres to a rigid and unique category-to-type correspondence, and consequently to strict compositionality. For example, accounting for scope-ambiguities by means of category-changing rules leaves unchallenged the principle that non-lexical ambiguity in the semantics should be based on derivational ambiguity in the syntax. However, the view in question also has some unorthodox features, the most surprising and interesting, perhaps, being the willingness to give up the traditional notion of constituent structure.[16] In view of what follows, it should be noted that in a categorial syntactic framework giving up constituent structure means giving up a notion of syntactic function-argument structure.

Another view on the place of type shifting rules in the grammar is more semantic. On this approach, one of the uses of type shifting is to keep the syntax free from unnecessary complications, such as syntactically unmotivated derivational structures. The notion of constituent structure, with its associated function-argument structure, is retained. In fact, as we will argue shortly, it can be used to deal with one of the problems that the incorporation of type shifting in the grammar posits, viz. that of overgeneration. The unorthodox aspect of the semantic view on type-shifting resides in the attribution of meanings to syntactic structures. In giving up a rigid and unique category-to-type correspondence, it also gives up strict compositionality. Flexibility does not play a role in the syntax, nor in that part of the semantics that consists of the abstract theory of semantic objects that serve as meanings, but it concerns the *relationship* between syntactic structures and meanings. Of course, this does not imply that there may not be any need for flexibility in the other components of the grammar as well.[17] However, we are convinced that in many cases, e.g. coordination (including non-constituent conjunction), scope ambiguities, type/token distinctions, embedding constructions, and so forth, the semantic approach to flexibility is the more advantageous one. It keeps the syntax simple, and it links the phenomenon of flexible interpretation to syntactic constructions and contexts.

So, the basic tenet of the approach to type shifting that we favour, can be summarized in the following three statements:

No fixed category-to-type assignment is assumed, but a family of types, generated by type shifting rules from a key type, is postulated for each syntactic category.

Basic expressions go to a key type in the family associated with their category, and have potential meanings in the other types of the family predicted by the type shifting rules.

Interpretation of syntactic structures is liberalized to a relation: "anything goes that fits". I.e., a syntactic structure has as many meanings as can be generated from the potential meanings of its constituents.

A simple, and familiar, example is provided by the analysis of (extensional) transitive verbs and their arguments. We postulate one syntactic category for these transitive verbs, TV, and one for noun phrases, NP. The key type corresponding to the category TV that the grammar specifies, is $\langle e, \langle e, t\rangle\rangle$, and that corresponding to NP is e. On these types, type shifting rules may operate generating new types. Lexical expressions are given a basic translation (are assigned a basic meaning) of one of these types, and they obtain derived meanings in various (though not necessarily all) of the other types which are associated with their category by the type shifting rules. If a TV occurs with two proper names all expressions involved will fit on the basis of their basic type and meaning. Hence, no type-shifting is called for. If one NP, say the object, is a properly quantified expression, which is given $\langle\langle e, t\rangle, t\rangle$ as its basic type, the basic type of the TV is inadequate. However, one of its derived types is $\langle\langle\langle e, t\rangle, t\rangle, \langle e, t\rangle\rangle$, the result of the application of argument-lifting to its basic type, with which is associated a derived meaning for the TV within that type. Combining these gives a fitting result. Scope ambiguities of NP-arguments of TV's can be accounted for as follows. It can be argued quite generally that type shifting principles which operate on arguments of functions, must be able to operate at arbitrary depth.[18] Different relative scopes of NP-arguments then result from lifting argument places in different orders. No derivational ambiguity is needed in the syntax, the readings we want, simply arise because generating the relevant type for TV's in two different ways, generates two different meanings for a TV in that type. Clearly, this approach does not eliminate the complexity of the syntactic view, but it places it in a different part of the grammar. This can be motivated not only by an appeal to a certain kind of intuition or to elegance, but also by pointing out empirical differences.

To see why this can be so, it is important to note that adding flexibility in the form of type shifting principles to the grammar, whether in the syntax or in the semantics, faces a potential problem. These mechanisms may enlarge the power of the grammar. On the syntactic approach, this means that expressions may be recognized which do not belong to the language. And if we follow the semantic view, we run the risk of giving an expression a potential meaning it does not have, i.e for which no context can be found in which that expression must be assigned that meaning. To what extent this actually happens, depends, of course, on the actual set of type shifting rules one adopts.

For example, in Partee and Rooth (1983) type-shifting principles are used to give an account of so-called "wide scope **or**" readings of sentences such as "The department is looking for a phonologist or a phonetician". The way they proceed differs from the strategy we have followed in the previous section. They use a type shifting rule which allows them to interpret the disjunctive object NP as a function which takes the TV as an argument, thus giving it the required scope. However, the same mechanism will also predict impossible readings in certain cases. For example, the mechanism employed by Partee and Rooth also predicts that the sentence "Every student failed or got a D" has as one of its readings "Every student failed or every student got a D", which it does not. Partee and Rooth do not offer a solution for this problem.

In the present case, i.e. if we add the question formation rule to our stock of type shifting principles, overgeneration occurs as well. Adding the rule in question has the rather unpleasant consequence that our grammar predicts that any expression that expresses a relation, also, potentially, has the meaning of the corresponding question.

For example, any simple indicative sentence also gets assigned the interpretation of the corresponding sentential interrogative, which is clearly something we do not wish.

A possible solution can be found along the following lines. We restrict the *use* of type shifting in generating meanings by combination. Suppose that, as usual, functional application of meanings serves as the interpretation of the syntactic operation of concatenation, i.e. that we have rule pairs like the following:

syntactic rule: $\underset{\beta}{B/A} + \underset{\alpha}{A} \rightarrow \underset{\gamma}{B}$

semantic rule: $\gamma' = \text{FA}(\beta', \alpha')$

In an unrestricted flexible framework, such a semantic rule is a rule schema, allowing α' and β' to be *any* possible translation that can be obtained by means of the type shifting rules, as long as ordinary functional application applies to such a pair of translations. So, a whole set of translations γ' will be the result of applying the semantic rule. We propose to put the following constraints on the possible translations of α and β:

β' should be a possible translation of β which is obtained from its basic translation by only applying argument shift rules.

α' should be a possible translation of α which is obtained from its basic translation by only applying global shift rules.

The syntactic function-argument structure should be respected.

(Of course, for other syntactic rules, we might want to formulate other restrictions on the corresponding translation part.) Thus restricted, functional application allows us to obtain only certain semantic objects as meanings of complex expressions. (E.g. Partee and Rooth's treatment of wide scope or would be prohibited, since it implies a reversion of the function-argument structure of the VP in question.) Let PM (α) be the set of possible meanings of α. For basic expressions, this is a unit set (disregarding lexical ambiguity). For derived expressions, it may contain more than one element. The possible meanings of a complex expression γ built by concatenation from α and β can then also be defined as follows:

$\text{PM}(\gamma) = \{f(b)(g(a)) \mid b \in \text{PM}(\beta), a \in \text{PM}(\alpha)\} = \text{FA}(\beta', \alpha')$ where f is any composition of argument shifts, and g is any composition of global shifts.

(The difference between "global" and "argument" shifts is the difference between e.g. lifting and argument-lifting, intensionalization and argument-intensionalization, etc.) Notice that this way of implementing type shifting in the grammar has a remarkable consequence: it makes the notion of the meaning of an expression relative to its syntactic context. The meaning of α as a part of β with meaning b is that possible meaning a of α that is used to derive β with meaning b. We think that this consequence is intuitively appealing. Consider the example of a proper name. Basically it has just one meaning, that of being the name of an individual. It is only in certain (syntactic) contexts, such as in coordination with a quantified term, that we consider giving it a derived meaning as well. Or, consider the case of an atomic interrogative. In isolation, they must be given a meaning of the proper relational type. It is only e.g. in the context of an embedding verb, that we assign them their meaning in the type of questions. As for entailment, we saw that that requires this propositional type of meaning, too. But then, entailment is a *relation* of which the interrogatives are arguments.

We want to end this admittedly rough sketch with the following remark. In view of the fact that overgeneration is a potential problem both for the syntactic and for the semantic approach to flexibility, the latter, we think, has this going for it that it can employ independently motivated and restricted notions, such as the function-argument structure that is inherent in a suitably restricted account of constituent structure,[19] in dealing with this problem. This seems to square with the semantic relevance that constituent structure can be assumed to have. But we do not want to suggest that the syntactic view on type-shifting couldn't be sufficiently restricted too. The entire enterprise of incorporating flexibility in the grammar is only just beginning, and it seems wise therefore to explore various options.

4 Conclusion

In this paper we have tried to show that generalized notions of coordination and entailment can be fruitful means to obtain more insight into the nature of the semantics of interrogatives. Their usefulness, both on a descriptive, and on a methodological plane, has been demonstrated in the foregoing, we feel. In the course of doing so, we have made some critical remarks about existing theories within the propositional and the categorial approach. We want to emphasize that the observations and remarks that we have made, in no way pretend to show that these approaches as such are wrong. On the contrary, we feel that both are right. Our discussion does show, however, that they cover only part of what an adequate semantic theory of interrogatives should account for. We also have tried to sketch a theory that incorporates the insights of both approaches. And in a more speculative manner, we have indicated that a flexible way of relating syntactic structure and semantic interpretation may be of great help in achieving this. The exact format of a grammar that encompasses these principles, is still in need of further investigation. For one thing, one would like to have some intuitive and independently motivated constraints on what are adequate and natural type-shifting mechanisms. Despite the many interesting contributions one can find in the literature, we feel that this is still largely an open question.

The last remark we want to make, concerns the necessity of incorporating a semantic analysis like the one presented above, into the framework of a theory of intensional objects. The reason for being interested in this, is that one would like to regard questions, the meanings of interrogatives, as constituting a separate category of intensional objects, in much the same way as properties and propositions do, and for similar reasons. Notice that, since the analysis is carried out in a standard possible worlds framework, questions are treated extensionally, in the sense that two questions which everywhere have the extension (i.e. the same complete and true answers), are identified. In other words, what the framework provides is only an *extensional* identity criterion for questions, just as it only gives extensional identity criteria for properties and propositions. I.e., we are able to give an account of the *kind* of intensional objects that questions are (viz. equivalence relations between possible worlds), but we do not have the means to represent all of the intensionality that they comprise. Just as being true of the same individuals in every world is a necessary, but not a sufficient condition for identification of two properties, having the same true and complete answers in all situations is not all there is to two questions being identical. There is, of course, a relation between these two facts. Take any two different properties which, in some suitably chosen set of alternatives, apply to the same objects in all situations. Consequently, the question that is based on the first one, will be extensionally equivalent to the question which is formed from the second. But the questions are not the same, just as the properties are not. For someone might wonder what the extension of the first property is without also wondering which objects the second one applies to.

How would one incorporate this fact in something like Chierchia and Turner's theory of properties?[20] One might think that once one has an intensional theory of properties and/or propositions one automatically also has an intensional theory of questions, since questions are defined in terms of properties and propositions. What one would do, then, is define possible worlds using the notion of a proposition and, given that, define questions are equivalence relations on them. But this is in fact still an *extensional* approach to the semantics of interrogatives: it still identifies any two extensionally equivalent interrogatives, i.e. interrogatives which have the same true answers everywhere.

The proper way to go about, then, is to extend property theory to a general theory of intensional objects, which recognizes besides properties and propositions, also relations, individuals and questions. Another argument to the effect that questions constitute an intensional category in their own right, can perhaps be taken from the mutual dependence of questions and propositions, interrogatives and indicatives. It is, at least so since Frege, a commonplace to regard the sentence (statement) as a fundamental building block of language. But this is only part of the truth. One of the main functions of language no doubt is to discriminate the actual world (state of affairs) among the possible ones. But this function is triggered only when the question of where the actual world is located, is raised in the first place. To be sure, the dependence is mutual, for raising a question clearly presupposes the possibility of making the discriminations which the question calls for. So functionally, at least, questions and propositions are mutually dependent, a fact which we might see reflected in the fact that an extensional derivation of either category to the other is doomed to fail. Within the context of a general theory of intensional objects these considerations call for the introduction of a new basic type in our ontology, that of questions, and for the concomitant formalization of a new extensionalization relation, between questions and propositions. This relation is, of course, the relation of answerhood, i.e. the relation of being a complete and true semantic answer. But an account of that is another topic.

Notes

1 This paper is a further development of some ideas in Groenendijk and Stokhof (1984), especially chapter VI. Also, various other aspects of the approach described here are explained and defended there in more detail. We have refrained from bothering the reader with detailed references.

2 This terminology may be slightly confusing. Certainly to the Montogovian, the use of two different names suggests that there are two different underlying derivational processes at work. However, this is not the case. Both readings are the result of one and the same derivational process. It is the internal semantic structure of the term phrase that is used that determines which reading is the result. Moreover, notice that the two readings, in a sense, are not complementary. The result we get if we use a term such as *two of his friends* gives a choice reading, but once a certain choice has been made what is required is a list of pairs. Likewise, a simple proper name can be viewed as a trivial one-item list. In what follows, we will not go into the details of the derivation of pair-list and choice readings, since in this paper we are only interested in the relevant types.

3 Cf. Gazdar (1980), Keenan and Faltz (1985), Partee and Rooth (1983).

4 An example is conjunction which functions as "addition". See Partee and Rooth (1983), Partee (1986).

5 Notice that the key type is not necessarily the minimal type, in the sense of the least complex type, of an expression. For example, the least complex type of proper names is e but their key type is $\langle\langle e,t\rangle,t\rangle$.

6 See e.g. Hausser (1983).

7 It should be noted that for interrogatives of the same kind, a categorial theory might obtain correct results by appealing to the same mechanism that we will propose to use, viz. lifting (see below). Two remarks are in order. First, in a sense such a move goes against the nature of the approach. Second, this observation does suggest an adjustment of the use of coordination and entailment we are making here. As an evaluation measure it works if we constrain the use of such type-shifting procedures as lifting in order to account for coordination. The following seems intuitively justified, and prevents the move just mentioned: coordination should be accounted for in the lowest common type in which it respects "subdomains" (see section 3.2).

8 See Karttunen (1977).

9 See Bennett (1979) and Belnap (1982). What is said here about their approach is a kind of rational reconstruction of just one aspect of it. The reader is urged to consult their papers for more information.

10 Notice that something similar would hold for expressions of type e if the domain D_e would have an entailment structure defined on it.

11 See e.g. Stalnaker (1984).

12 Again, it should be noted that this is not characteristic for coordination of interrogatives. The same applies to other domains that are structured by entailment. Cf. also note 10.

13 See Partee and Rooth for another application of this rule. There is a difference in the way they account for wide scope **or** readings and the way in which we proceed. On their analysis, there is what they call "function-argument flip-flop". We keep the function-argument structure intact. For a motivation, see section 3.3.

14 See e.g. van Benthem (1986).

15 See e.g. Ades and Steedman (1982), van Benthem (1986), Dowty (1988).

16 A clear and well-argued case is presented by Zwarts (1986).

17 For example, Moortgat (1988) argues that we need flexibility in the morphology, and the "right node raising" constructions discussed in Dowty (1988) may be presented as arguments for some kind of flexibility in the syntax.

18 In fact, the distinction is rather particular to a functional formulation of type-theory. If we were to use a relational version (see Muskens (1986) for an exposition and some arguments in favour of using such a theory), we would simply say that argument-lifting may operate on any argument of a relation.

19 The restricted framework developed in Landman and Moerdijk (1983) seems to offer a good starting point.

20 See Chierchia and Turner (1987).

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