Questioning to resolve decision problems

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Abstract. Why do we ask questions? Because we want to have some information. But why this particular kind of information? Because only information of this particular kind is helpful to resolve the *decision problem* that the agent faces. In this paper I argue that questions are asked because their answers help to resolve the questioner's decision problem, and that this assumption helps us to interpret interrogative sentences. Interrogative sentences are claimed to have a semantically *underspecified* meaning and this underspecification is resolved by means of the decision problem.

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1. Introduction

According to the appealing partition-based analysis of *wh*-questions of Higginbotham & May (1981) and Groenendijk & Stokhof (1982, 1984) you only resolve, or completely answer, a *wh*-question, when you answer, roughly speaking, by giving the *exhaustive* list of individuals *by name* who satisfy the relevant predicate. Ginzburg (1995) and others have argued, however, that the notion of *resolvedness* is sensitive to the *goals* of the questioner. In this paper I will show how a similar idea can be made precise: the idea that whether an answer to a *wh*-question is resolving or not depends on the relevant *decision problem* the questioner faces. I will argue that context helps to determine the actual meaning of a question, and not just whether an answer is resolving or not. The most important part of this paper is section 5. In this section I argue that decision problems do *not* help to *disambiguate* between the various possible semantic meanings of questions, but rather help to *resolve* the *underspecified meaning* of an interrogative sentence. I propose a very simple, though still substantial, underspecied meaning of an interrogative sentence. The actual interpretation will then further depend only on a relevance relation '$>$' which, in turn, is completely determined by the contextually given decision problem.

In this paper I will first discuss some empirical shortcomings of the assumptions that (i) the meaning of a question should be given in a context independent way, and (ii) should be represented by its set of complete answers. As we will see, the problem is that it is context dependent whether an assertion intuitively completely answers a question or not. I will show that when we relate questions and answers to decision problems, we can determine the *utility* and/or *relevance* of answers and questions by making use of standard methods in statistical decision theory. This, in turn, will allow us to account for the intuition that the notion of resolvedness is context-dependent. This will help us in particular for determining the domain of quantification over which *wh*-phrases range and to determine whether a *wh*-question has to be given a mention-all or a mention-some answer. A major part of the paper will address the question of which assumption we should give up: (i) the idea that interrogative sentences have a context-independent meaning; or (ii) the intuition that a question is interpreted as its set of resolving answers? I will argue that we should maintain claim (ii), and, in the final section, I will show how we can do this by giving interrogative sentences an *underspecified* meaning. Moreover, I will show that by making use of this underspecified meaning, *scalar* questions can be appropriately analyzed as well.

2. Context dependence of resolving answer

According to the analyses of questions proposed by Hamblin (1973), Karttunen (1977), Higginbotham & May (1981) and Groenendijk & Stokhof (1982, 1984), a question should be represented by its set of 'good' answers. It is normally assumed, implicitly, that what a good answer is depends on which individuals or objects satisfy a certain predicate. Taking proper names to be rigidly referring expressions, it is commonly assumed that to answer a *wh*-question satisfactorily you have to mention the individuals that have the relevant property by *name*, and that there is a fixed relevant domain of individuals.[1] This would mean that whether an answer to a question is good, or appropriate, is independent of context. As stressed by Boër & Lycan (1975), Hintikka (1976, 1978), Grewendorf (1981) and Ginzburg (1995), however, this assumption of context independence is wrong.

The perhaps most obvious way (cf. Boër & Lycan, 1975; Grewendorf, 1981; Gerbrandy, 1997; Aloni 2001) in which the appropriateness of an answer depends on context has to do with so-called *identification questions* as the following:

(1) Q: Who is Cassius Clay?

In many situations A can answer this question appropriately by mentioning his other name:

[1] Only recently, however, Balder ten Cate made me realize that in Karttunen (1977) a *wh*-phrase ranges over individual concepts, rather than over (rigid) individuals.

(2) A: Muhammed Ali.

Notice that this is already somewhat strange. On the standard assumption that proper names are rigid designators, the names 'Cassius Clay' and 'Muhammed Ali' refer by necessity to the same individual, resulting in the prediction that the answer cannot express a contingent proposition. Because Q wants to know the identity of Cassius Clay, it seems that the latter name cannot be treated as a rigid designator, but should be interpreted attributively. But if we assume that 'Muhammed Ali' is still treated as a rigid designator, new problems arise. The reason is that although in this case most question-semantics predict that (2) completely resolves question (1), we can imagine Q to continue by asking (3):

(3) Q: Ok, but who is Muhammed Ali?

This can happen, for instance, when Q sees two men, knows that one of them is Cassius Clay but doesn't know which, and has never heard of the name 'Muhammed Ali'. In that case an answer like (4) seems to be called for:

(4) A: The man over there [pointing at one person].

Notice that in this situation, answers like (5a) or (5b) seem to be inappropriate.

(5) a. The Greatest.

b. The heavy weight champion of boxing in the seventies.

In a quiz-like situation, however, an answer like (5b) would be the most appropriate answer to question (3), even if Ali himself were present.

These above examples strongly suggest that whether an assertion appropriately answers an identification question depends on the contextually dependent required *method of identification*.

Hintikka (1976) shows that the method of identification is not only crucial for answers to identification questions, but for other kinds of *wh*-questions as well. In many circumstances, answer (6b) to question (6a) is more appropriate than answer (6c):

(6) a. Who appoints Surpreme Court Judges?

b. The President.

c. George W. Bush.

But even if we fix one particular method of identification, the requirement that the answerer must locate the individual to be identified uniquely in a certain frame of reference is too strong. Grewendorf (1981) notes that indefinite answers to who-questions can sometimes provide appropriate knowledge:

(7) a. Who was Aeschylus?

b. Aeschylus was a famous Greek tragedian.

This example illustrates that the reason why a proposition can be resolving in one context but unresolving in another does not just depend on the method of identification, but also on the required level of *specificity*. Ginzburg (1995) argues something similar, and notes that it depends on context as to which indefinite answers are appropriate:

(8) a. Q: Who has been attending these talks?

b. [Querier is a high ranking EC politician.]
The director: A number of linguists and psychologists.

c. [Querier is a researcher in the field covered by the institute.]
The director: A number of cognitive phoneticians and Wilshaw-net experts.

Moreover, Grewendorf (1981) and Ginzburg (1995) note that the information required for someone to know the answer to the question where she is, depends on context:

(9) a. Context: Jill about to step off a plane in Helsinki.
Flight attendant: Do you know where you are?
Jill: Helsinki.

b. Flight attendant: Ah ok. Jill knows where she is.

(10) a. Context: Jill about to step out of a taxi in Helsinki.
Driver: Do you know where you are?
Jill: Helsinki.

b. Driver: Oh dear. Jill doesn't (really) know where she is.

According to Groenendijk & Stokhof a question like 'Which individuals have property P?, represented as '$?xPx$', gives rise to an equivalence relation and should be analyzed by means of the following lambda term or its corresponding partition:

$$\begin{array}{lll} [\![?xPx]\!]^{GS} & = & \lambda w \lambda v[\lambda x P(w)(x) = \lambda x P(v)(x)] \\ & = & \{\{v \in W |\ \forall d \in D:\ d \in P(v) \text{ iff } d \in P(w)\} |\ w \in W\} \end{array}$$

The idea is that the meaning of a question is its set of resolving answers, and that to give the true resolving answer in a world you have to give the *exhaustive* list of individuals that have the relevant property in this world. Thus, for John to know the answer to the question *Who is sick?*, for instance, John must know of *each* (relevant) individual *whether* he or she is sick. To give a true and resolving answer to the question, he must *mention all* the individuals that are sick, and implicate that this is indeed the whole list. This partition analysis predicts that two worlds are in the same cell of the partition induced by the above question, if the property *being sick* has the same extension in both worlds. The elements of the partition $Q = \{q_1, ..., q_n\}$ are called the *complete answers*. An assertion counts as a *partial answer* to a question iff the proposition it expresses is incompatible with at least some but not all cells of the partition. Thus, complete answers are special kinds of partial answers.

Though appealing, Groenendijk & Stokhof's analysis is not completely satisfactory. It's unable to account for identification questions and it ignores the fact that the required level of specificity of the answers depends on context. As we will see later, these problems are more due to the particular way that Groenendijk & Stokhof formulate their partition semantics than to the basic idea behind the partition based analysis itself. However, also the partition based analysis itself is problematic. It predicts that each question has at most one true resolving answer in a world. However, questions like (11), (12) and (13) can intuitively be answered satisfactorily by mentioning just one individual, place, or manner, i.e. you don't have to give an exhaustive list of persons that have got a light, places where you can buy an Italian newspaper, or ways to go to the station, respectively.

(11) Who has got a light?

(12) Where can I buy an Italian newspaper?

(13) How can I get to the station?

But if this is so, it seems we have to give up the assumption behind a partition-based mention-all semantics for questions that in each world only one resolving answer could be given. Sometimes we need just to *mention some* individual, leaving a choice to the hearer of which one this is.[2]

We have seen in this section that whether an answer resolves a question or not depends on context, which seems problematic for approaches that equate the semantic meaning of a question with its set of answers.[3] In the remainder of this paper I will discuss the influence of one important contextual feature on the pragmatics of answers and the semantics of questions. As noted by many authors, whether or not an answer resolves a question or not depends on how *useful* the answer is. According to Boër & Lycan (1975), followed by Grewendorf (1981) and Ginzburg (1995), the usefulness of the answer, in turn, should be related to the *goals* of the questioner. Grewendorf (1981) has already suggested accounting for this by making use of Bayesian decision theory, but did not show how the usefulness of an answer should be calculated. In the remainder of this paper I will show how this can be done by relating questions and answers to *decision problems*. I will discuss two ways in which decision problems might be used as crucial contextual parameters. According to the first proposal, we stick to the idea that the meaning of a question is *context-independent*, and seek to account for the problems for such a proposal as discussed by Boer & Lycan, Ginzburg and others by saying that with respect to a certain decision problem an assertion can resolve a question, although it is not a complete semantic answer to it. Thus, according to this proposal only the notion of *resolvedness* depends on context, not the meaning of the question itself. The second proposal, on the other hand, assumes that the full meaning of the interrogative sentence itself already is dependent on context. It maintains the claim that the meaning of a question is its set of resolving answers, but assumes that the interpretation of a *wh*-interrogative is underspecified, or left ambiguous, by its conventional meaning, and that the *decision problem* is a crucial contextual parameter to *resolve* the ambiguity or underspecification; the interpretation of an interrogative is then the set of answers that would resolve the

[2] It should be clear that the fact that sometimes a more coarse-grained answer resolves the question than at other times doesn't mean that in these situations the question requires only a mention-some and not a mention-all answer: for examples like (7a), (9a) and (10a) the mention-some and mention-all answers coincide.

[3] This problem seems less acute for *functional* approaches towards questions that analyze (or, better, represent) *wh*-questions in terms of lambda expressions (e.g. Hausser & Zaeferer (1979), Ginzburg (1996) and Krifka (1999)): they easily allow for indefinite and non-rigid answers. Still, also such approaches have to explain under which circumstances which answers are resolving. On the assumption that the sentence *John knows where P is* is true iff John knows the resolving answer to the embedded question (cf. Krifka, 1999), this is not only important for the pragmatics of answers, but also for the semantics of questions.

question with respect to the relevant decision problem. In this paper I will argue in favor of the second proposal.

3. Answers

3.1. Utility of new information

Suppose our agent is faced with a set of actions $\mathcal{A} = \{a_1, a_2, ...a_n\}$ that she can perform. Her *decision problem* is then the dilemma of which one of those actions she should take. What is the best action in $\mathcal{A}$ depends, of course, on the desirability, or utilities, of the actions. These in turn depend on which 'state of nature', or world, prevails. It is normally assumed that each action-world pair gives rise to a consequence or outcome, and that our agent has preferences among these outcomes. Assuming that these preferences are consistent, we might represent them by means of a utility function, U. A utility function is a function from actions and worlds to real numbers. Thus, each action $a \in \mathcal{A}$ has a utility in a world w, $U(a, w)$. If our agent would know what the actual world was, it is clear which action she should choose. However, she typically is uncertain about what the actual world is, and thus how to resolve the problem. An agent has to make a decision under *risk* when the agent can quantify her uncertainty by means of a (discrete) probability function, P. A discrete probability distribution P maps worlds in W to numbers in the interval $[0, 1]$, with the constraint that $\sum_{w \in W} P(w) = 1$. We extend P to subsets C of W by taking $P(C) = \sum_{w \in C} P(w)$. A decision problem of an agent can in these circumstances be modeled as a triple, $\langle P, U, \mathcal{A} \rangle$, containing (i) the agent's probability function, P, representing the *beliefs* of the agent; (ii) her utility function, U, which helps to represent her *desires*; and (iii) the alternative *actions* she considers, $\mathcal{A}$. In order to formulate the decision criterion used in standard Bayesian decision theory as formulated by Savage (1954), we first state what the *expected utility* of action a is, $EU(a)$, with respect to probability function P. To determine this expected utility, we use '$\sum$' which denotes generalized summing.

$$EU(a) \quad = \quad \sum_w P(w) \times U(a, w)$$

In case the set of worlds and the set of actions are finite, we might represent such a decision problem as a decision table like the one below (where for simplicity the worlds are given equal probability):

		Actions		
World	Prob	a_1	a_2	a_3
u	1/3	4	-2	0
v	1/3	1	7	1
w	1/3	1	4	4

In this decision problem there are three relevant worlds, u, v, and w, and three relevant actions, a_1, a_2, and a_3. Each of the actions has a utility in these worlds; action a_1, for instance, has a utility of 4 in world u, $U(a_1, u) = 4$. However, to determine which action the agent should choose, it is not utility, but rather *expected* utility that counts. Given a decision problem, we can now determine this expected utility for each of the actions. The expected utility of action a_1, for instance, is $(P(u) \times U(u, a_1)) + (P(v) \times U(v, a_1)) + (P(w) \times U(w, a_1)) = (1/3 \times 4) + (1/3 \times 1) + (1/3 \times 1) = 4/3 + 1/3 + 1/3 = 6/3 = 2$. In a similar way we can see that the expected utility of action a_2 is 3, while action a_3 has a utility of 5/3. The optimal action to choose is obviously action a_2 because that action maximizes the expected utility. This is the general recommendation:

$$\text{choose } a_i \text{ such that } EU(a_i) \quad = \quad max_{a \in \mathcal{A}} EU(a)$$

Given this recommendation, we can also determine the utility of a whole decision problem. This value is the utility of the action with maximal expected utility of this decision problem. We will denote this value by $UV(\text{Choose now})$:

$$UV(\text{Choose now}) \quad = \quad max_{a \in \mathcal{A}} EU(a)$$

To make a better informed decision, however, our agent thinks it is better first to ask a question. Suppose that the other participant of the dialogue answers this question by giving an answer that expresses proposition C, and that, as a good Bayesian, the agent herself updates her probability state by conditionalizing on C: the probability of world w according to new probability function P_C, $P_C(w)$, will be equal to the *conditional* probability of w given C with respect to the old probability function P, $P(w/C)$. In that case we define the expected utility of action a after C is learned, $EU(a, C)$, as follows:

$$EU(a, C) \quad = \quad \sum_w P_C(w) \times U(a, w)$$

Then we can say that the utility value of making an informed decision conditional on learning C is the expected utility conditional on C of the action that has the highest expected utility:

$$UV(\text{Learn } C, \text{ choose later}) \quad = \quad max_{a \in \mathcal{A}} EU(a, C)$$

Thus, UV(Learn C, choose later) is just the value of the decision problem after C is learned, $\langle P_C, U, \mathcal{A} \rangle$. Now we can define in terms of this notion the utility value of the assertion C. Referring to a^0 as the action that has the highest expected utility according to the original decision problem, $\langle P, U, \mathcal{A} \rangle$, we can determine the *utility value* of new information C, $UV^*(C)$, as follows:

$$\begin{array}{rcl} UV^*(C) & = & UV(\text{Learn } C, \text{ choose later}) - UV(\text{Learn } C, \text{ choose } a^0) \\ & = & max_{a \in \mathcal{A}} EU(a, C) - EU(a^0, C) \quad = \quad VSI(C) \end{array}$$

This value, $UV^*(C)$, is known in statistical decision theory (cf. Raiffa & Schlaifer, 1961) as the *value of sample information* C, $VSI(C)$. It can obviously never be negative. The value of an assertion is positive according to this measure, just in case it gives new information to our agent which *changes* her mind with respect to which action she should take. And indeed, it doesn't seem unnatural to say that a cooperative participant of the dialogue makes a *relevant* assertion in case he influences the action you are going to perform.

However, according to this standard value of sample information, new information is predicted to have a positive utility *only* in case it influences the action that the agent will perform. But couldn't information also be relevant in case it would *strengthen* the choice that was already preferred? It seems that it can. To account for this fact, we can define the utility of proposition C, $UV(C)$, as the difference between the expected utility of the action which has maximal expected utility in case you are allowed to choose *after* you learn that C is true, and *before* you learn that C is true:

$$\begin{array}{rcl} UV(C) & = & UV(\text{Learn } C, \text{ choose later}) - UV(\text{Choose now}) \\ & = & max_{a \in \mathcal{A}} EU(a, C) - max_{a \in \mathcal{A}} EU(a) \\ & = & [max_{a \in \mathcal{A}} \sum_w P(w/C) \times U(a, w)] \\ & & \qquad - [max_{a \in \mathcal{A}} \sum_w P(w) \times U(a, w)] \end{array}$$

In distinction with $VSI(C)$ this notion can be negative, but it is (strictly) positive in case it strengthens a choice already made. If $UV(C) > 0$, we might say that new information C is (positively) *relevant* to the decision maker.[4] As it turns out, this notion of utility was

[4] In terms of this notion of relevance we can also account for the intuition that new information that changes the probability distribution over the worlds, but doesn't

used already within semantics/pragmatics by Prashant Parikh (1992, 2001) to account for some conversational implicatures.[5] Also Rohit Parikh (1994) applies this notion to account for successful communication with common nouns which have a vague meaning. The notion is also appealing because some standard communication-theoretical measures (cf. Shannon 1948; Bar-Hillel & Carnap 1953) like the reduction of entropy due to a proposition, and the absolute informativity of the propositions (used by Atlas & Levinson (1981) for some linguistic applications) can be shown (cf. van Rooy, 2002) to be special cases of our notion of utility of a proposition in case only truth is at stake. Moreover, we can show that the *argumentation*-based notion of relevance proposed by Merin (1999) to account for several linguistic phenomena is a special case of this utility value as well.[6]

Our quantitative measurement of utility gives rise to a *comparative scale*. We can say that one assertion, C, is 'better' than another, D, just in case the utility value of the proposition expressed by the former assertion is higher than the utility value of the latter, $UV(C) > UV(D)$. As I noted above, our notion of utility of a proposition is very general and allows for several interpretations, depending on what the preferences are of the decision maker. For our application it seems natural to assume that the decision maker prefers most of all to *resolve* her decision problem. She wants to be absolutely sure to choose the right action, and wants to get rid of her state of *indecision* as to what to do. This suggests that we should say that information C **resolves** a decision problem if after learning C, one of the actions in $\mathcal{A}$ *dominates* all other actions, i.e. if in each resulting world no action has a higher utility than this one.

Notice that not only a question, but also the set of alternative actions, $\mathcal{A}$, gives rise to a set of propositions. We can relate each action $a \in \mathcal{A}$ to the set of worlds in which there is no other action b in $\mathcal{A}$ that is strictly better. We will denote the proposition corresponding with a by a^* and the resulting set of propositions by $\mathcal{A}^*$. The set of propositions $\mathcal{A}^*$ does in general not partition the state space, but it does when for each world w there is always exactly one action $a \in \mathcal{A}$ such that $\forall b \in (\mathcal{A} - \{a\}) : \ U(a, w) > U(b, w)$.

eliminate any world, can still be useful. This allows us to say that replies like *Most probably not* can be relevant, although they are not even counted as partial answers to the yes/no question *Does John come?*. I will ignore this use of decision problems in this paper, however.

[5] Thanks to an anonymous reviewer for pointing me to Parikh's TARK paper of 1992. That paper seems to be the first one where decision problems are put into service for some semantic/pragmatic task.

[6] Merin's notion of relevance will be important in section 5.4 of this paper.

Let us now assume that our utility function depends only on the decision which action should be chosen, i.e. on the probabilities of the elements of $\mathcal{A}^*$. Assume, moreover, that when C is learned, each element of $\mathcal{A}^*$ consistent with C has equal probability.[7] Then the above induced ordering relation comes down to the claim that C is better to learn than proposition D just in case C eliminates more cells of partition $\mathcal{A}^*$ than D does. Define C_Q as the set of cells of partition Q that are compatible with answer C:

$$C_Q \quad = \quad \{q \in Q : \ q \cap C \neq \emptyset\}$$

In the special case we are considering now, proposition C resolves decision problem $\langle P, U, \mathcal{A}\rangle$ just in case the cardinality of $C_{\mathcal{A}^*}$ is 1, i.e. $|C_{\mathcal{A}^*}| = 1$. Moreover, assertion C is predicted to be more useful than D to resolve the problem which of the actions in $\mathcal{A}$ should be chosen just in case $|C_{\mathcal{A}^*}| < |D_{\mathcal{A}^*}|$. If this happens in *all* models, the ordering relation between propositions C and D can be reduced even further. In that case C is better than D iff $C_{\mathcal{A}^*} \subset D_{\mathcal{A}^*}$. It is worth remarking that in this way we have almost reduced the *quantitative* ordering of propositions in terms of utility value to the *qualitative* ordering between answers that Groenendijk & Stokhof (1984) have proposed in their dissertation. However, they go one step further: they also compare answers that are incompatible with the same cells of a partition. They propose that in case $C_Q = D_Q$, C is still a better answer than D in case D is *more informative* than C, i.e. when D entails C. The idea behind this proposal is that in those cases D is *over*informative compared to C and thus costs *more effort* to process. Groenendijk & Stokhof (1984, chapter 4) propose that C is (quantitatively) a *better*, or more relevant, semantic answer to question Q than D, $C >_Q D$, by defining the latter notion as follows:

$$C >_Q D \quad \text{iff} \quad \text{either} \begin{array}{ll} \text{(i)} & C_Q \subset D_Q, \text{ or} \\ \text{(ii)} & C_Q = D_Q \text{ and } C \supset D. \end{array}$$

As we noted above, as a special case we can take Q to be $\mathcal{A}^*$. The so induced ordering between propositions will be used in section 5. Observe that when $Q = W$, i.e., the question of how the world is, the ordering relation $>_Q$ comes down to (one-sided) entailment.

[7] Thus, for all $a^* \in \mathcal{A}^*$ it holds that $P(a^*/C) = \frac{1}{|\{a^* \in \mathcal{A}^* | \ C \cap a^* \neq \emptyset\}|}$, where $|S|$ is the cardinality of set S.

3.2. Resolving Answers

Whether an answer resolves a question or not depends on context. We have assumed that the usefulness of an answer depends on the decision problem the questioner faces. Suppose, for example, that you ask me *Where do you live?* Ginzburg rightly argues that depending on your goal, in some contexts this question might be resolved by an answer like *In Amsterdam*, while in other contexts I should give a more specific, or fine-grained, answer and say something like *In Amsterdam West.* Let us now assume that the context-independent semantic analysis of questions assumes a level of fine-grainedness related to the second kind of answer. If we now think of the first kind of answer in terms of the fine-grainedness of the second, we might think of the first answer as a disjunction of several (East or West or ...) answers of the second kind. Then we can say that the decision problem determines how *fine-grained* the answer should be to resolve the question. Thus, if $\{d, d', e, e'\}$ is the set of places at the most fine-grained level, we might say that a question like *Where do you live? semantically* always give rise to the following partition:

$$\begin{aligned} Q \quad = \quad & \{\{w \in W \mid \text{I live in } d \text{ in } w\},\ \{w' \in W \mid \text{I live in } d' \text{ in } w'\}, \\ & \{v \in W \mid \text{I live in } e \text{ in } v\},\ \ \{v' \in W \mid \text{I live in } e' \text{ in } v'\}\} \end{aligned}$$

Now suppose that d and d', and e and e' denote the east and west of Amsterdam and Utrecht, respectively. Suppose our agent's decision problem, $\mathcal{A} = \{a, u\}$, is such that she knows what to do when she knows that I am living in Amsterdam, i.e. choose a, and something similar for Utrecht, i.e. choose u. In this case the distinctions between d versus d', and e versus e' become intuitively irrelevant; although the answer *In Amsterdam* wouldn't count as a complete semantic answer, it still would resolve the relevant decision problem just like a complete answer to the question such as *In Amsterdam West.* On the assumption that the answerer knows what the agent's decision problem is, the coarser-grained, and thus *partial*, answer is by our definition given in the previous section even predicted to be preferred in these circumstances to the total answer, which seems to be in accordance with intuition.

Assume that the set of alternative actions, $\mathcal{A}$, gives rise to a set of propositions as in the previous section. Then we can determine the set of least informative resolving answers to Q, $Q_{\mathcal{A}}$. For the example discussed above this is:

$$Q_{\mathcal{A}} = \{\{w \in W \mid \text{I live in } d \text{ or } d' \text{ in } w\}, \{v \in W \mid \text{I live in } e \text{ or } e' \text{ in } v\}\}$$

In the above example the set of resolving answers still partitions the state space. This is no longer the case when there are worlds in which more than one action in $\mathcal{A}$ is optimal. This is typically the case when *wh*-questions give rise to *mention-some* readings. Suppose, for instance, that our decision maker wants to get an Italian newspaper and wonders how she should walk: to the *station* or to the *palace*, i.e. $\mathcal{A} = \{s, p\}$. Assume that there are 3 relevant worlds, u, v and w, such that in u you can buy an Italian newspaper only at the station; in v you can buy one only at the palace; but in w you can buy one at both places. Thus, the two actions are such that s is optimal in u and w, and p in v and w. In that case $\mathcal{A}$ gives rise to the following set: $\mathcal{A}^* = \{\{u, w\}, \{v, w\}\}$. Suppose that the decision maker now asks the question (12)

(12) Where can I buy an Italian newspaper?

A partition semantics predicts the partition $\{\{u\}, \{v\}, \{w\}\}$, because the predicate 'can buy an Italian newspaper' has a different denotation in the three worlds. In this case, the partial mention-some answer *At least at the station* is appropriate, because it completely resolves the decision problem: the agent learns that she should choose s and walk to the station. Taking also effort into account we predict that the assertion that expresses proposition $\{u, w\}$ is more relevant than the assertion that gives a semantically complete answer to the question and expresses $\{u\}$.[8]

In this section I have sketched how we can account for some of the problems discussed in section 2 without giving up the assumption that we can interpret interrogative sentences as partitions in a context-independent way. Context, according to this analysis, plays a role only in determining whether an answer is resolving or not. But although such an analysis might seem natural for the cases discussed above, both the partition view and the context-independence are, in fact, problematic. First, there are the examples discussed recently by Beck & Rullmann (1999) which contain expressions explicitly marking non-exhaustivity:

(14) Who, for example, came to the party?

It is clear that you can completely answer this question without giving the exhaustive list of people who came to the party. This suggests that also the meaning of a question itself consists of answers that give such

[8] In this section I have been assuming that the question is relatively 'close' to the decision problem. If this is not the case, an answer might theoretically resolve a decision problem without intuitively addressing the question at all. To account for those cases we might demand that the answer should also be *about*, or be *licensed by*, the question, as proposed by Lewis (1988) and Groenendijk (1999). I will ignore such cases, however.

a non-exhaustive list, and thus that the meaning of a question as the set of its answers does not give rise to a partition.

With respect to the context-independence assumption: there are at least two reasons to assume that context plays not only a role in the pragmatics of answers, but is also important for the semantics of questions. First, on the assumption that a sentence like *John knows who is P* is true iff John knows the resolving answer to the embedded question – an assumption defended by Ginzburg (1995) and Krifka (1999) –, the context-dependence of resolving answers is important to determine the *semantic* truth conditions of at least some sentences. If the semantic value of the whole sentence depends on the semantic values of its parts, this suggests that the context-dependence of resolvedness is crucial to determine the semantic value of the embedded clause. This holds in particular for embedded questions that typically give rise to mention-some answers like (15):

(15) John knows where he can buy an Italian newspaper.

For this sentence to be true, John needs to know only one (relevant) place where he can buy an Italian newspaper. Following Hintikka (1978), even Groenendijk & Stokhof (1984, chapter 6) propose that perhaps not all interrogative sentences should get a partition based mention-all analysis, but that some could get a mention-some interpretation (as well).

Second, the analysis suggested in this section seems to work only when *fine-grainedness* is at stake. That is, it works for answers that are intuitively resolving though semantically speaking only *partial*. But the dependence on context, i.e. the decision problem, can be of a different nature, too. This holds in particular for *identification*-questions like (2) *Who is Muhammed Ali?* It seems natural to say that depending on the decision problem this question should sometimes be answered by giving a referentially used expression (I want to shake hands with d, if d is Muhammed Ali, and with e, if e is Muhammed Ali, but I don't know who he is), and at other times by a descriptively used one (I want to listen to your story about the individual you call 'Muhammed Ali', only if he is an interesting person). But now it isn't the case that one answer is only partial but still resolving, and the other complete: as we have seen in section 2, to answer by giving a proper name, or even a deictic expression, sometimes doesn't resolve the question at all. If we want to stick to the assumption that the meaning of a question is its set of answers, identification questions force us to give up the idea that questions have a context-independent meaning.

To account for identification questions we will follow Aloni (2001) in assuming that the interpretation of the question itself is underspecified, or left ambiguous, by conventional meaning. Context determines then which of the alternative interpretations is chosen. We saw above that in order to determine the truth conditions of sentences with embedded questions we need to take the context dependence of what a resolving answer is into account as well. But if this is so, we need to determine which of the various possible interpretations of the interrogative sentence should be chosen. In the next section I propose that just as it can depend on a decision problem whether a certain proposition resolves a question or not, it can also depend on the decision problem as to what the interpretation of the interrogative sentence is. On the assumption that speakers are relevance optimizers, I will propose in the next section that the hearer chooses, and is expected to do so by the questioner, that interpretation of the interrogative sentence that has the highest utility.

4. Questions

4.1. Utility of Questions

If the aim of the question is to get some information, it seems natural to say that Q is a *better* question than Q', if it holds that whatever the world is, knowing the true answer to question Q means that you also know the true answer to Q'. In terms of Groenendijk & Stokhof's (1984) partition semantics this comes down to the natural requirement that for every element of Q there must be an element of Q' such that the former *entails* the latter, i.e. $Q \sqsubseteq Q'$:

$$Q \sqsubseteq Q' \quad \text{iff} \quad \forall q \in Q : \; \exists q' \in Q' : \; q \subseteq q'$$

According to this definition it follows, for instance, that the *wh*-question *Who of John, Mary and Sue is sick?* is better than *Who of John and Mary is sick?*, because learning the answer to the first question is *more informative* than learning the answer to the second question. Notice that by adopting this approach, the *value*, or usefulness, of a question is ultimately reduced to the pure *informativity* of the expected answer. In case we want to make a finer-grained ordering relation between questions and take also *preferences* into account, the obvious move is to extend the analysis of the previous section by determining also the utility value of questions.

In section 3.1 we defined the *utility value* of the assertion C, $UV(C)$, as follows:

$$\begin{array}{lll} UV(C) & = & UV(\text{Learn } C, \text{ choose later}) - UV(\text{Choose now}) \\ & = & max_{a \in \mathcal{A}} EU(a, C) - max_{a \in \mathcal{A}} EU(a) \end{array}$$

Now we can use these utilities to determine the usefulness of *question* Q, represented by a partition. Assuming that the questioner knows she will update her prior probability function by the proposition expressed by the answer, we determine the *expected utility of a question* as the average expected utility of the answer that will be given:[9]

$$EUV(Q) \quad = \quad \sum_{q \in Q} P(q) \times UV(q)^{10}$$

In section 3.1 we noted that in contrast to the more traditional measure, i.e. the value of sample information of C, $VSI(C)$, the value of $UV(C)$ can be negative. The standard way to determine the value of an experiment in statistical decision theory (Raiffa & Schlaifer, 1961) is as the *expected* value of sample information, $EVSI(Q)$.

$$EVSI(Q) \quad = \quad \sum_{q \in Q} P(q) \times VSI(q)$$

Because for any $q \in Q$, the value $VSI(q)$ cannot be negative, it immediately follows that the value of $EVSI(Q)$ can also not be negative. Notice that this value is minimal, i.e. 0, when there exists an action in $\mathcal{A}$ that *dominates* all other actions with respect to the answers to Q. As it turns out (cf. van Rooy, 2002), although for each answer $q \in Q$, $UV(q)$ is typically not the same as $VSI(q)$ and can even be negative, our notion of $EUV(Q)$ is provably equal to $EVSI(Q)$: $EUV(Q) = EVSI(Q)$, and

[9] Statisticians and Decision theorists interested in the philosophy of science determine in similar ways the value of doing an *experiment*. Their crucial assumption is that the possible results of the experiment are mutually disjoint. This latter assumption shows that we can use their analysis if we assume a partition based analysis of questions. In fact, a number of researchers working on the value of experiments (e.g. Rozenkranz (1970), Marschak (1974)) have thought of these experiments as questions to nature. These analyses have, as far as I know, not yet been used for natural language analysis. To account for the value of experiments, various authors have also looked at Shannon's (1948) mathematical theory of information. For a discussion of the relation between decision- and information-theoretic analyses of values of questions (and answers), see Marschak (1974) and van Rooy (2002).

[10] In van Rooy (1999) I defined the utility of question Q, $EUV(Q)$, in a somewhat different way as the difference between $UV(\text{Learn answer, choose later})$ and $UV(\text{Choose now})$, where the former is defined as follows:

$UV(\text{Learn answer, choose later}) = \sum_{q \in Q} P(q) \times UV(\text{Learn } q, \text{ choose later})$

It turns out, however, that the two ways of calculating $EUV(Q)$ are equivalent.

thus also cannot be negative. It also follows that $EUV(Q)$ is 0 when no answer to Q would change the agent's decision as to which action to perform. And that seems to be in accordance with intuition, because in that case the question asked seems to be completely *irrelevant*.

It is intuitively clear that for any question Q and decision problem DP, its EUV can never be higher than the so-called *expected value of perfect information* with respect to this decision problem, the $EVPI$. The reason behind this is clear too: this $EVPI$ is determined with respect to the question *What is the world like?* which is always at least as fine-grained as Q is. It turns out that this is only a special case of a much more general fact. Denoting by $EUV_{DP}(Q)$ the expected utility value of Q with respect to decision problem DP, the following fact is a special case of Blackwell's (1953) theorem for comparing information structures:

Fact $\quad Q \sqsubseteq Q' \quad \text{iff} \quad \forall DP: \; EUV_{DP}(Q) \geq EUV_{DP}(Q')$

The 'only if' part is natural and shows that it is never irrational (if collecting evidence is cost free) to try to get more information to solve one's decision problem. The 'if' part is more surprising, and it suggests that the *semantic* entailment relation between questions is an *abstraction* from the more *pragmatic* usefulness relation between questions. The proof is based on the idea that when two partitions are qualitatively incomparable, one can always find a pair of decision problems such that the first partition has a higher expected utility value than the second one according to one decision problem, and a lower expected utility value than the second one according to the other decision problem.

In Blackwell's theorem, questions are compared by abstracting away from the decision problem. However, we can also make a comparison with respect to a *particular* decision problem that the questioner faces. From the above discussion it seems we should simply order questions, or interpretations of interrogative sentences, by *relevance* in terms of their expected utility values. However, just as Groenendijk & Stokhof (1984) propose that answers should not be *overinformative*, we can now demand something similar for questions: we should not ask for extra *irrelevant* information to decide which action to perform. If we fix a decision problem we will say that question Q is *better* than question Q' if either Q is more useful than Q', or their utilities are equal and Q is less fine-grained than Q':

$$Q > Q' \quad \text{iff} \quad \begin{array}{l} \text{(i)}\;\; EUV(Q) > EUV(Q'), \text{ or} \\ \text{(ii)}\; EUV(Q) = EUV(Q') \text{ and } Q \sqsupset Q' \end{array}$$

As we will see in the next section, ordering (interpretations of) questions in terms of expected utility and overinformativity can be used to determine the *domain* over which a *wh*-phrase ranges.

4.2. Domain of *wh*-phrase depends on decision problem

The expected utility value and relevance of questions that we have determined in the previous section can be looked upon from two perspectives: a *first person* and a *third person* point of view. In decision theory and philosophy of science usually the first perspective is taken. Given a decision problem, the new problem is which question to ask, or which experiment to perform. The obvious answer is that it should be the question which has the highest (utility) value. However, in this paper we will take the *third person* perspective. Given that the questioner is assumed to be confronted with a certain decision problem and that she used a certain interrogative sentence whose interpretation is underspecified by its conventional meaning, the other participants of the conversation want to know what the actual interpretation of the sentence is. On the assumption that the questioner is a *relevance optimizer*, they will assume that the actual interpretation is the one that is most relevant for the questioner who is facing the assumed decision problem.

This is in particular the case when the interpretation of the question depends on its contextually given domain over which the *wh*-phrase ranges.[11] If I ask a question like (16), I don't ask for a full enumeration of everybody who will come to the concert.

(16) Who will come to the concert?

Still, this doesn't mean that the questions should thus receive a mention-some interpretation, for I do want to get the full enumeration of all people I care about. This set of people that I care about, however, depends on context.

According to a partition based analysis of questions, to know the answer to question (17) you have to know of each individual whether or not he or she dates Mary.

(17) Who dates Mary?

Such an analysis leads, according to Karttunen (1977), to the unacceptable conclusion

[11] The proposal to make the interpretation of a *wh*-question dependent on a contextually given domain is closely related, of course, with Westerståhl's (1984) generally accepted proposal to account for the context-sensitive interpretation of quantified sentences in terms of domain selection.

> [...] that, in order to know who dates Mary, John must have some knowledge about all the individuals including those he has never heard of and whose very existence is unknown to him. (Karttunen, 1977, p. 22)

For this reason Karttunen proposes that it is sufficient for John to know who dates Mary if John knows for everyone who Mary dates *that* he dates Mary, but it is not needed that he also knows for everyone else that he or she does not date Mary. However, this analysis seems both too strong and too weak. It is *too strong*, because it demands too much of the answerer for question (16) and *too weak*, because if it is commonly known that only Alfred and Bill could possibly date Mary and that in fact only Alfred does, Karttunen incorrectly predicts that John knows already who dates Mary if he knows that Alfred dates her, but has no idea about Bill. It seems that to know who dates Mary, John also has to know that Bill doesn't date her. As noted already by Grewendorf (1981), when we assume that the domain of quantification of a *wh*-phrase can be limited by context, Karttunen's above argument against a partition based analysis of questions disappears. By such a limitation we don't need to ask too much of the relevant agents. Moreover, such an analysis can account for those cases where Karttunen's analysis is too weak: to know the answer to (17) John has to know of each relevant individual whether or not he dates Mary.

In *semantic* theories this kind of context-dependence is normally accounted for by assuming that the relevant domain for each question is simply anaphorically given as a separate feature of the context. A *pragmatic* analysis, however, should do something more: give an *explanatory* analysis of how to select the relevant domain.[12]

Before we can explain how the decision problem helps to select the relevant domain, we first have to state how the interpretation of the interrogative sentence depends on this contextually given domain. To account for this context-dependence, we let the partition induced by *wh*-question $?xPx$ depend on the contextually given set of individuals D over which variable x ranges:

$$[\![?xPx]\!]^D \quad = \quad \{\{v \in W |\ \forall d \in D:\ d \in P(v) \text{ iff } d \in P(w)\}|\ w \in W\}$$

How can we determine the domain of quantification by means of a particular decision problem? This is done by making the question the most relevant: first, the expected utility value of the resulting question,

[12] See van Rooy (1999), the forerunner of this paper, for an earlier analysis in this direction, and Aloni (2001) for a related proposal concerning identification questions. Although optimal utility should not be considered to be the only relevant parameter to determine this domain: *salience* of the relevant domains plays a role too.

i.e. partition, should be as high as possible. This has the result that all individuals that could be relevant for the agent's decision should be in the domain. If $\mathbf{D}$ is the set of all individuals, the domain of quantification of a question should at least contain all individuals of the following set (where $d \in \mathbf{D}$, $P^*(d)$ is either $P(d)$ or $\neg P(d)$):

$$\begin{aligned}\{d|\ \exists \mathbf{D'} \subseteq (\mathbf{D}/\{d\}): \ & UV(\text{Learn} \textstyle\bigcap_{d' \in \mathbf{D'}} P^*(d') \ \&\ P^*(d), \text{choose later}) \\ & -UV(\text{Learn} \textstyle\bigcap_{d' \in \mathbf{D'}} P^*(d'), \text{choose later}) \neq 0\}^{13}\end{aligned}$$

But this still leaves many possibilities open. For example, if $[\![?xPx]\!]^D$ has the highest utility value, it will be the case that for any $D' \supseteq D$ it holds that $EUV([\![?xPx]\!]^{D'}) = EUV([\![?xPx]\!]^D)$. Our ordering relation on questions predicts that if Q and Q' have the same utility, Q is still better than Q' if $Q \sqsupset Q'$. Notice that when $D \subset D'$, the partition $[\![?xPx]\!]^{D'}$ will be finer-grained than the partition $[\![?xPx]\!]^D$: if more individuals are relevant, the question has more specific possible exhaustive answers. But this means that when $EUV([\![?xPx]\!]^{D'}) = EUV([\![?xPx]\!]^D)$ and $D \subset D'$, $[\![?xPx]\!]^D$ will be better, or more relevant, than $[\![?xPx]\!]^{D'}$. As a result, on the assumption that the domain is selected by optimization of relevance, we predict that the relevant set D contains *all and only all* individuals that could affect the decision. As I argued above, that seems to be in accordance with intuition: the domain over which the *wh*-phrase ranges should contain only those individuals the questioner cares about, because only those individuals could effect the questioner's decision.

In the above example the decision problem was used to select the relevant subdomain of $\mathbf{D}$ that functions as domain of 'quantification'. But as suggested by some examples discussed in section 2, these domains need not be subdomains of $\mathbf{D}$: they can also be thought of as sets of *coarser-grained* objects. Thus, to select the relevant domain, we should not only consider the *size*, but also the *fine-grainedness* of the objects. Taking only fine-grainedness into account, we will think of a domain as a partition of $\mathbf{D}$.[14] Suppose that D and D' are two partitions of $\mathbf{D}$ such that $D \sqsubseteq D'$. What is the best domain for the question represented by $?xPs$, i.e. how fine-grained should the objects be over which we quantify? Relevance demands that if $EUV([\![?xPx]\!]^D) > EUV([\![?xPx]\!]^{D'})$, D is preferred. However, if their expected utilities are equal, domain D' should be chosen, because in that case the question gives rise to a coarser-grained partition. In abstract, the selected level of precision will be the least one of those levels for which the value of the question

[13] For ease of exposition I have deliberately confused object- and meta-language.
[14] For simplicity I will just assume that it is clear how to interpret formulas in case objects are more coarse-grained.

asked would be maximal. And that seems to be in accordance with intuition: if we see each other in Germany, and you consider visiting me, but your decision depends only on which city I live in, it would be overinformative to answer your question *Where do you live?* by giving my precise address; mentioning *Amsterdam* suffices. The question is then interpreted as Q_A, as discussed in section 3.2.

In section 2 we saw that in certain situations we can answer an *identification question* like (3) *Who is Muhammed Ali?* by pointing to a certain individual while in others we can't. Examples like this suggest that whether an assertion appropriately answers an identification question depends on the contextually dependent required method of identification. On the assumption that an interrogative sentence should be interpreted as the set of answers that completely resolves the issue, we can follow Boër & Lycan (1975), Gerbrandy (1997) and Aloni (2001) in proposing that the interpretation of the interrogative depends on the method of identification. Aloni (2001) implements this by assuming that *wh*-phrases quantify over a set of individual *concepts*, but that this set is contextually restricted.[15] Such a contextually restricted set is called a *conceptual cover*, a set of concepts that identifies each individual in the domain of discourse in a determinate way such that in no world is an individual counted twice. Different conceptual covers can be thought of as different ways of conceiving one and the same domain, and only one of those ways is by their names. The crucial point is that when the conceptual cover over which a *wh*-phrase ranges is different, the induced partition might be different, too.

The method of identification depends on context. How? Our analysis suggests that the domain over which the *wh*-phrase of an interrogative ranges is the one for which the resulting question denotation would be most relevant to resolve the decision problem.

4.3. Mention-some questions

At the end of section 3.2 we noted that even Groenendijk & Stokhof suggest that some occurrences of *wh*-questions that typically give rise to mention-some answers should be given a mention-some question semantics. Asher & Lascarides (1998) have argued that *where* and *how* questions typically have just a mention-some reading. This suggests that such questions should be analyzed as Hamblin (1973) proposed.

[15] This is related with a proposal made by Hintikka (1976), but Aloni (2001) gives much more precise constraints on what appropriate sets of concepts are that can figure as domain.

Restricting ourselves for simplicity to single *wh*-questions, and ignoring free variables, Hamblin's analysis comes down to the following:[16]

$$[\![?xPx]\!]^H \quad = \quad \{\lambda v[d \in P(v)] : w \in W \ \& \ d \in P(w)\}$$

Notice that in case there are worlds in which more than one individual has property P, this question denotation does not give rise to a partition. In the previous section we have shown how we can use decision theory to determine the utility of partitional questions. But if we want to use the utility of questions to determine whether an interrogative sentence has a mention-all or a mention-some reading, we have to know how to determine the utility of non-partitional question-denotations as well.

As it turns out, we can do this by using Blackwell's (1953) theory of comparison of statistical experiments.[17] In terms of this theory, Blackwell formulated his general theorem in which he compares the utility of statistical experiments.[18] The fact mentioned in section 4.1 is just a special case of this theorem: the case where the experiments give rise to partitions. But now we can also compare interrogative sentences under their mention-some and mention-all readings with respect to utility. As it turns out – unsurprisingly perhaps – the expected utility of a *wh*-question under its mention-all reading is always at least as high as the expected utility under its corresponding mention-some reading, when we assume an existential presupposition for *wh*-phrases.[19] Sometimes, however, their expected utilities can be equal. In the latter circumstances my analysis predicts that the mention-some reading is preferred, because the answers under the mention-some reading are less informative. In van Rooy (to appear) I argue that this is exactly the case when the question intuitively gets a mention-some reading.

I have discussed above when a mention-some reading of a direct question arises in terms of the decision problem that the questioner faces. But it should be clear that the same reasoning can be used to

[16] Assuming that for every $d \in D$ there is a world such that $d \in P(w)$.

[17] In van Rooy (to appear), however, I made use of so-called *answer-rules* to determine the utility of non-partitional questions. In van Rooy (2002) I show that the two alternative analyses give rise to the same result.

[18] Only recently it has become clear that the formalization of similar ideas goes back to the philosopher Frank Ramsey. His notes on the topic has been published in Ramsey (1990).

[19] Although there has been some discussion in the literature whether *wh*-questions have an existential presupposition or not, I assume here an existential presupposition just to be able to give a *general* comparison between mention-some and mention-all readings of questions. Without making the existential presupposition, the utility of the question under its mention-all reading will normally still be higher, but there might be cases where it's the other way around.

determine when an *embedded* question receives a mention-some reading. The only difference is that this time it need not be the decision problem of the questioner, or speaker, that is relevant, but it can also, and typically will, be the decision problem that the agent denoted by the subject of the embedding clause faces.

5. Underspecified representation

5.1. From ambiguity to underspecification

In the previous section I defended the view that the interpretation of a question crucially depends on context, i.e. the decision problem. Thus, what is questioned by an interrogative sentence is not fully determined by the sentence itself. This suggests that semantic rules should assign to an interrogative sentence an *underspecified* meaning, and that the decision problem determines more fully what the actual interpretation is.

But according to the analysis proposed in the previous section, compositional semantics does not really give a single *underspecified* meaning to a question at all. We have assumed that questions either get a mention-all reading – determined in the Groenendijk & Stokhof fashion – or a mention-some reading determined via Hamblin's semantics. Thus, on this proposal, an interrogative sentence not only has a semantically underspecified meaning, but is also semantically *ambiguous*. Theoretically, however, this is an undesired feature of our analysis. The standard ambiguity tests seem to indicate that questions are not ambiguous in this way, but that their actual interpretation is only underspecified by its semantic meaning. Ginzburg & Sag (2001, p. 105) provide an extra argument for why questions should have a single underspecified meaning: although the actual interpretation of a question depends on agent-specific parameters, we still want to talk about questions in an agent-independent way; for instance to be able to explain how agents can *share* questions.

This argument of Ginzburg & Sag is closely related with the very similar arguments of Perry (1977) and others involving the attribution of shared beliefs with clauses containing essential indexicals. The standard solution to these latter puzzles is to assign a meaning to the embedded clause that is not dependent on the indexical expressions: a Kaplanian *character*. Such a character is a function from contexts to contents, in this case a function with propositions as a value. This suggests that we should try to find something similar for questions: a meaning – constructed as a function – that assigns to an interrogative sentence a full question interpretation, given a particular context. In the following section I will propose a uniform but semantically underspecified denotation of an interrogative sentence that contains just one contextual parameter – the decision problem.[20] Within a particular context it will then get its actual denotation. This denotation can be the standard mention-some or mention-all interpretation of the sentence, but it can be many other interpretations as well.[21]

5.2. Mentioning optimal groups

We have seen that according to Groenendijk & Stokhof (1984), a question of the form '$?xPx$' gives rise to an equivalence relation and should be analyzed by means of the following lambda term:

$$[\![?xPx]\!]^{GS} \quad = \quad \lambda w \lambda v[\lambda x P(w)(x) = \lambda x P(v)(x)]$$

Zeevat (1994) also assumes that a question gives rise to a partition – in fact, the same partition as Groenendijk & Stokhof predict. However, he derives this partition in a somewhat different way. Let us assume that $Op(P)(w)$ denotes the *optimal group* or *number* that satisfies predicate P in w. In terms of this notion, he proposes to analyze a *wh*-question as follows:

[20] Heim (1994), followed by Beck & Rullmann (1999), suggests another solution: start with Hamblin's question semantics and then derive Groenendijk & Stokhof's mention-all denotation from this. Although I find this derivation very appealing, I don't think it is what we are after. On Heim's construal, interrogative sentences have one particular *semantic* meaning which can be *strengthened* due to pragmatic factors. But I don't see why one meaning should be more basic than the other(s). Worse, I believe that in general the predicted mention-some reading is wrong. On Hamblin's analysis it is suggested that a question like (i) can be answered appropriately on its mention-some reading by mentioning just *any* place where I can buy Stephen King's books.

(i) Where can I buy the books of Stephen King?

But this doesn't seem to be in accordance with intuition: if I ask this question I want to know about one of the *best* (i.e. nearby) places where I can buy his books; even though I don't need to know all (the best) places, still not any place will do. This indicates that even to determine the mention-some reading we have to take the *preferences* of the questioner into account. Although I agree that an interrogative sentence sometimes can get the Hamblin denotation, I don't see any reason to assume why this interpretation – or any other full interpretation – should have a special status.

[21] Heim (1994) and Beck & Rullmann (1999) argue that Karttunen's (1977) so-called weakly exhaustive meaning of an interrogative sentence should have a special status as well, in particular to account for *wh*-questions embedded under verbs like *predict* and *surprise*. I am not fully convinced by these arguments, but I also don't see a reason why my to be presented underspecified meaning of a question cannot get a Karttunen-like interpretation in specific contexts. I won't go any further into this issue, however.

$$[\![?xPx]\!]^Z \quad = \quad \lambda w \lambda v[Op(P)(w) = Op(P)(v)]$$

The idea behind this formula is that $Op(P)(w)$ always denotes a *unique* group or number. But which group or number will this be? Before we will look at Zeevat's solution to this problem, it's instructive first to discuss Rullmann's (1995) solution to a similar problem.[22] Rullmann seeks to give a uniform meaning to constituent questions such that both (18a) and (18b) get the right meaning when embedded under epistemic verbs:

(18) a. Who is coming to the party?

b. How many meters can you jump?

On the assumption that 'Mary' and 'Mary and Bill' both denote *groups* like m and $m + b$, and that just as for numbers there is also a natural definition of a strict and total order, '>', for groups, he basically defines $Op(P)(w)$ as the *maximal* value of P in w.[23] Thus $Op(P) = Max(P)$ and the latter is defined (roughly) as follows:

$$[\![Max(P)]\!] \quad = \quad \{\langle w, g\rangle | P(w)(g) \ \& \ \neg\exists g'[P(w)(g') \ \& \ g' > g]\}$$

This gives rise to the intuitively correct predictions for (18a) and (18b): it assigns to each world the *exhaustive* set of individuals who are coming to the party, and the *maximal* number of meters that you can jump, respectively.

Still, the analysis is not completely satisfactory. Ignoring potential problems with explicitly partial answers, the analysis is certainly incorrect for cases like the following:

(19) In how many seconds can you run the 100 meters?

To account for this question, we should not look for maximal, but rather for *minimal* values.

$$[\![Min(P)]\!] \quad = \quad \{\langle w, g\rangle | P(w)(g) \ \& \ \neg\exists g'[P(w)(g') \ \& \ g' < g]\}$$

But do we really want to predict that *wh*-questions, and *how many* questions in particular, are systematically ambiguous? Of course not,

[22] Rullmann (1995), in fact, does not use a partition-based analysis of questions, and so makes no use of interpretation rule $[\![Q]\!]^Z$. However, for ease of exposition we will assume that he does.

[23] This idea goes back to Von Stechow's (1984) use of maximality in the analysis of comparatives. I will follow Rullmann in considering distributive predicates only.

say Zeevat (1994) and Beck & Rullmann (1999). The reason why we go for the maximal value in (18b), but for the minimal value in (19), is that these maximal and minimal values are in these cases the *most informative* true answers.[24] Zeevat proposes that in each world we ask for the *exhaustive* value of P, $Op(P) = Exh(P)$, and that this latter value is defined (roughly) as follows:

$$[\![Exh(P)]\!]^Z \;=\; \{\langle w, g\rangle | P(w)(g) \;\&\; \neg\exists g' \neq g[P(w)(g') \;\&\; P(g') \models P(g)]\}$$

This Gricean move is very appealing, and predicts correctly for all examples (18a), (18b), (19) and more. In fact, Zeevat predicts the same question-denotation as Groenendijk & Stokhof do.[25] From this it follows that also on Zeevat's analysis *wh*-questions have a *mention-all* reading only. But how, then, are we going to account for *mention-some* readings? Do we still have to assume that *wh*-questions are, in fact, ambiguous between those two readings of questions, and that the appropriate reading is then selected by pragmatic criteria? In this section I want to show that we don't need to assume that *wh*-questions are ambiguous between the two readings, and that, in fact, both can be derived from a single *underspecified* meaning with only one contextually given parameter. I will show that by slightly changing $[\![Q]\!]^Z$ and $[\![Exh(P)]\!]^Z$ we have what we want.

If we want to account for both mention-all and mention-some readings of *wh*-questions, it is obvious that we have to give up rules like $[\![Q]\!]^{GS}$ and $[\![Q]\!]^Z$, because the identity used in these formulas guarantees that we will end up with an equivalence relation, which we don't want in case of mention-some readings. Instead of $[\![Q]\!]^{GS}$ and $[\![Q]\!]^Z$, I will propose the following rule:

$$[\![?xPx]\!]^R \quad = \quad \{\lambda v[g \in Op(P)(v)] : w \in W \;\&\; g \in Op(P)(w)\}$$

Thus, one answer to $?xPx$ contains both of the worlds w and v iff there is a group g that is the optimal denotation of P in both w and v, i.e. iff this g is an element of both $Op(P)(w)$ and of $Op(P)(v)$. Notice that this still gives rise to an equivalence relation in case in each world w, the set $Op(P)(w)$ contains exactly one element.[26] We

[24] Beck & Rullmann (1999) note that the maximality plus minimality approach predicts wrongly for a question like *How many people can play this game?* when the true answer is any number between 4 and 6. The most informative answer, however, gives us the intuitively correct result: 'Between 4 and 6'.

[25] Zeevat's aim was not to come up with a new question semantics, but rather to give a somewhat different and more dynamic analysis of exhaustification of answers than proposed by Groenendijk & Stokhof (1984).

[26] We have to assume now that the empty group is a group as well.

can conclude that to account for mention-some readings, we should not adopt Zeevat's interpretation of $Op(P)(w)$ as the exhaustive value of P.

Rullmann (1995) and Zeevat (1994) assume for their interpretations of $Op(P)$ that the true answers in a world can be *ordered*: Rullmann makes use of a straightforward ordering between numbers and groups, while Zeevat (and Beck & Rullmann) uses a more sophisticated ordering in terms of informativity of the propositions expressed. Our discussion in section 3, however, suggests that the ordering, $>$, should be related to the decision problem and defined in terms of relevance, or utility. In that case, $Op(P)$ will no longer denote the *exhaustive* value of P in w, but rather (one of the) optimal value(s) of P in w – the values with the highest relevance/utility. I will do this in the following way:

$$[\![Op(P)]\!]^R \quad = \quad \{\langle w, g\rangle | P(w)(g) \ \& \ \neg\exists g'[P(w)(g') \ \& \ P(g') > P(g)]\}$$

Thus whereas Groenendijk & Stokhof and Zeevat ask for the most *informative* true answer, I ask for the most *relevant* one, where – as before – one answer is more relevant than another if it helps more to resolve the questioners' *decision problem*. Notice that if we would combine $[\![Q]\!]^R$ and $[\![Op(P)]\!]^R$ into one formula, the actual interpretation of the question depends only on one contextual feature: the relevance based ordering relation '$>$'. As we saw in section 3, in special cases we might assume that $P(g') > P(g)$ exactly when the proposition expressed by $P(g')$ eliminates more cells of the background question/decision problem $\mathcal{A}^*$ than the proposition expressed by $P(g)$:

$$\begin{aligned} P(g') >_{\mathcal{A}^*} P(g) \quad \text{iff} \quad & \{a^* \in \mathcal{A}^* | a^* \cap [\![P(g')]\!] \neq \emptyset\} \\ & \subset \{a^* \in \mathcal{A}^* : a^* \cap [\![P(g)]\!] \neq \emptyset\} \end{aligned}$$

In case $\mathcal{A}^*$ is a *finer-grained* question than the denotation of $?xPx$ as calculated by Groenendijk & Stokhof and Zeevat – for instance in case the decision problem is what the world is like – we predict that the question gives rise to 'their' partition, and thus has a mention-all reading. Indeed, in that case $>_{\mathcal{A}^*}$ comes down to (one sided) entailment. Things change, however, when $\mathcal{A}^*$ is not finer-grained. My decision problem might be, for example, to find out which way is best for me to go to get an Italian newspaper. It could be, for instance, that the *best* way to buy an Italian newspaper is at the station in u, at the palace in v, and that buying one at the station and at the palace is equally good in w. In that case, the following sentence (20)

(20) Where can I buy an Italian newspaper?

is not predicted to give rise to a partition. The reason is that in w, $Op(P)$ does not denote a singleton set: $Op(P)(w) = \{\text{station, palace}\}$ which has a non-empty intersection with both $Op(P)(u)$ and with $Op(P)(v)$. The question will thus give rise to the expected mention-some reading: $\{\{u,w\},\{v,w\}\}$. Notice that this result is not the same as the one predicted by Hamblin.

$$[\![?xPx]\!]^H \quad = \quad \{\lambda v[d \in P(v)] : w \in W \ \&\ d \in P(w)\}$$

If we assume that in all three worlds we can buy an Italian newspaper at both the station and the palace and at no other place, but that the *best* places to do so in the different worlds are as described above, the Hamblin denotation will be $\{\lambda w[\text{I can buy an Italian newspaper at the station in } w], \lambda w[\text{I can buy an Italian newspaper at the palace in } w]\} = \{\{u,v,w\}\}$, whereas our denotation will be $\{\{u,w\},\{v,w\}\}$. Thus, for us, but not for Hamblin, it is important what the 'best' places are.

5.3. Domain selection

But our new analysis manages not only to give a uniform analysis to mention-some and mention-all readings of questions. It also helps to determine the *domain* over which the *wh*-phrase ranges. Suppose that the domain in the model has 3 individuals, $D = \{d, d', e\}$. Assume, moreover, that predicate P denotes $\{d\}$ in u, $\{d,e\}$ in u', $\{d'\}$ in v, $\{d',e\}$ in v', $\{d,d'\}$ in w, and $\{d,d',e\}$ in w'. However, assume that with respect to our decision problem it is only relevant whether d and d' have property P. In that case Groenendijk & Stokhof and Zeevat predict that no two worlds are in the same cell of the partition, while we predict that the question denotation will be the following one: $\{\{u,u'\},\{v,v'\},\{w,w'\}\}$. The reason is that $Op(P)(u)$ and $Op(P)(u')$, for instance, have an element in common. Observe that in this case also $Op(P)(w)$ and $Op(P)(w')$ have one element in common: the *maximal group* of *relevant* individuals that have property P: $d + d'$.[27]

Ginzburg (1995) reminded us that sometimes a *coarse-grained* answer can *resolve* a question. Assuming that the meaning of a question is its set of resolving answers, we suggested in section 4.2 that the fine-grainedness of the domain over which the *wh*-phrase ranges depends on context. However, our new analysis suggests a different solution. In principle, the domain over which the *wh*-phrase ranges consists of

[27] Notice that if we ignore effort, for this analysis we need rule $[\![Q]\!]^R$ instead of rule $[\![Q]\!]^Z$, because $UV(P(d+d')) = UV(P(d+d'+e))$, and thus $Op(P)(w) = \{d+d'\} \neq Op(P)(w') = \{d+d', d+d'+e\}$. If we don't ignore effort, however, the expected utility of $[\![?xPx]\!]^R$, $EUV([\![?xPx]\!]^R)$, will be the same as the expected utility value of the interpretation of the interrogative sentence with the optimal domain.

objects of all kinds of granularity. However, the resulting partition will still depend on a certain level of granularity. Suppose I ask the following question:

(21) Where do you live?

Sometimes I hope you give your complete address. In other cases I am happy with hearing the city you live in, or even just your country. Which answer is appropriate depends on my decision problem: what I want with this information. Suppose I want to send you a letter. Then $Op(P)(w)$ consists only of your complete address. The partition induced will thus be very fine-grained, and it seems as if the domain over which the *wh*-phrase ranges consists just of complete addresses. But suppose that I just want to know whether you live in an interesting enough city to visit. In that case, $Op(P)(w)$ has at least *two* elements: your complete address *and* the city you live in. According to rule $[\![Q]\!]^R$, this means that the question does *not* give rise to a partition: not only the proposition expressed by your complete address, but also the one expressed by your city is considered to be a resolving answer, and thus an element of the question-denotation. Thus, if we want to account for fine-grainedness by means of rule $[\![Q]\!]^R$, it seems we have to give up the assumption that (21) gives rise to a partition.[28] Does this necessarily mean that once a more coarse-grained question is allowed, the resulting meaning will never be a partition because finer-grained answers are licensed as well? Yes, *except* when we can rule out *overinformative* answers by means of relevance. But we saw in section 3 that this can be done straightforwardly: C is better than D iff either C has a higher utility value than D (e.g. eliminates more elements of the underlying

[28] It seems as if the following – much simpler – rule to account for both mention-all and mention-some readings does better:

$$[\![?xPx]\!]^S \quad = \quad \lambda w \lambda v[Op(P)(w) \cap Op(P)(v) \neq \emptyset]$$

Notice that according to this new interpretation rule, two worlds are already in the same cell of the partition induced by question (21) if the city you live in in those two worlds is the same, irrespective of your exact address. Thus, the partition denoted by (21) will now be more *coarse-grained* than in the previous case, and it seems *as if* this is due to the fact that the *wh*-phrase ranges over more coarse-grained objects: cities, instead of full addresses. With interpretation rule $[\![Q]\!]^S$, however, this is not really what is going on: because of our relevance relation in the selection of the best answers, we don't have to worry about domains with 'overlapping' elements.

However, I don't want to adopt interpretation rule $[\![Q]\!]^S$, because it gives rise to wrong results for mention-some readings. It doesn't predict that the question-denotation is the set of its *resolving* answers. For question (20), for instance, it doesn't give rise to denotation $\{\{u,w\},\{v,w\}\}$, but rather to $\{\{u,w\},\{v,w\},\{u,v,w\}\}$. For this reason I will stick to rule $[\![Q]\!]^R$.

question/decision problem), or this latter value is the same, but D is more informative than C is (and thus *over*informative). Thus, if we take *effort* into account to determine the optimal answers in a world, (21) still gives rise to a partition according to rule $[\![Q]\!]^R$, and it indeed seems as if the *wh*-phrase ranges just over coarse-grained 'objects'.

Now consider *identification* questions like *Who is Muhammed Ali?* In different circumstances this question should be answered by either a referential (that man over there) or by a descriptive expression (the greatest boxer ever). Both can be modeled by concepts of different types: 'rigid' concepts versus 'descriptive' concepts, and it seems as if the *wh*-phrase ranges over a set of concepts of just one of those two types. But now we can also assume that the domain over which the *wh*-phrase ranges is just the set of all concepts, but that the partition induced does *as if* it quantifies only over a particular conceptual cover.

We can illustrate this by considering the following question also discussed by Aloni (2001):

(22) Who killed spiderman?

We know that either John did it, or Bill did it, and the killer either wears a blue mask or a green one, but we don't know who is who, i.e. we don't know whether John wears a blue or a green mask. This gives rise to 4 relevantly different worlds: u, where John did it and wears a blue mask; v where John did it wearing a green mask; w, where Bill did it and wears a blue mask; and x where Bill did it and wears a green mask. Intuitively, in this case, we have 4 concepts: {John, Bill, blue, green}. In section 4 we followed Aloni (2001) in assuming that the *wh*-phrase either quantifies only over $A = \{\text{John, Bill}\}$, or only over $B = \{\text{blue, green}\}$, and that which of those two so-called *conceptual covers* is used has to be determined by context. In the first case, this gives rise to partition $Q_A = \{\{u, v\}, \{w, x\}\}$, in the second case we get $Q_B = \{\{u, w\}, \{v, x\}\}$. However, already by assuming interpretation rule $[\![Q]\!]^Z$, together with the assumption that optimality is determined by relevance, we don't have to assume that the *wh*-phrase ranges only over the concepts of a particular conceptual cover, they just might range over *all* concepts. Assume that to resolve her *decision problem*, α, the questioner has to know the *name* of the culprit. In that case $Op(\lambda y Kill(y, s))(u) = Op(\lambda y Kill(y, s))(v) = \{\text{John}\}$, and $Op(\lambda y Kill(y, s))(w) = Op(\lambda y Kill(y, s))(x) = \{\text{Bill}\}$. Thus, the partition induced by question (22) with respect to decision problem α, Q_α, is $\{\{u, v\}, \{w, x\}\}$, which is exactly the same as Q_A. If we denote the problem/goal to know what the culprit looks like by β, we can see that Q_β is $\{\{u, w\}, \{v, x\}\}$, which is exactly the same as Q_B. Thus – at least for this example – in order to determine the meaning of the question we don't have to assume that the *wh*-phrase ranges over a particular conceptual cover.

What about the following question in the same situation?

(23) Who is who?

Aloni offers multiple questions like (23) as an extra argument for why *wh*-phrases must range over conceptual covers. She assumes that the two occurrences of 'who' quantify over different conceptual covers: e.g. the first one over $A = \{\text{John, Bill}\}$ and the second over $B = \{\text{blue, green}\}$. But we don't have to assume this to get the right result, i.e. the following partition: $\{\{u\}, \{v\}, \{w\}, \{x\}\}$. Representing the question by $?yz[y = z]$, and assuming that y and z range over all concepts, it will of course be the case that the proposition expressed by $y = z$ can only be informative, and thus useful, in case the two concepts involved are non-identical. Assuming that the concepts 'John' and 'Bill', and 'blue' and 'green' are pairwise incompatible, we predict that in the identity either y ranges over {John, Bill} and z over {blue, green}, or the other way around. In both cases we get what we were looking for: partition $\{\{u\}, \{v\}, \{w\}, \{x\}\}$. Notice, though, that if we don't take effort into account, $Op(\lambda yz[y = z])(u)$ is not simply $\{\langle\text{John, blue}\rangle + \langle\text{Bill, green}\rangle\}$, but $\{\langle\text{John, blue}\rangle + \langle\text{Bill, green}\rangle, \langle\text{John, John + blue}\rangle + \langle\text{Bill, Bill + green}\rangle, \langle\text{John + blue, blue}\rangle + \langle\text{Bill + green, green}\rangle\}$. Both sets, however, give rise to the same partition: both sets say that John is the one with the blue mask and Bill the suspect with the green one. Thus, to account for the intuition that in the above circumstances question (23) gives rise to a partition, we can still ignore effort.

Notice, finally, that if we assume interpretation rule $[\![Q]\!]^R$ instead of rule $[\![Q]\!]^Z$, we might account for the fact that sometimes we want to know *all*, and sometimes just *some*, of the relevant 'properties' of the individual in question. And indeed, there seems to be no convincing reason to assume that once we quantify over individual concepts, the mention-some versus mention-all distinction suddenly disappears. It is not at all clear, however, how we could account for mention-some reading over concepts if we assume that *wh*-phrases range over conceptual covers. On our analysis, however, things are straightforward.[29] In case utility just demands one concept, $Op(\lambda y Kill(y, x))(u) = \{\text{John, blue, John + blue}\}$ and thus contains three concepts, and it is predicted that you can truly answer the question in u by any of the three ways. The question (22) itself will have the following denotation: $\{\{u, v\}, \{u, w\},$

[29] But check how things go wrong in case we adopted interpretation rule $[\![Q]\!]^S$ instead of $[\![Q]\!]^R$.

$\{v,x\},\{w,x\},\{u\},\{v\},\{w\},\{x\}\}$. This seems to me a reasonable result, because the resolving answers are now predicted to be all individual concepts, plus their (compatible) combinations. Taking effort into account as well, we end up with the denotation that I favor: $\{\{u,v\},\{u,w\},\ \{v,x\},\{w,x\}\}$. This set is now the set of minimally resolving answers.

In general, our analysis suggests the following. The domain over which a *wh*-phrase ranges doesn't have to be selected *before* we determine the meaning of the question. Also, we don't have to determine the meaning of the question with respect to all kinds of different domains, and then select the domain whose question-meaning is the most relevant as I suggested in section 4. Instead, we don't determine the domain at all, though the relevant subset of the domain, the relevant level of granularity, and the relevant conceptual cover over which the *wh*-phrase seems to range is determined hand-in-hand with determining the meaning of the question itself.

5.4. Scalar Questions

In section 3 we saw that the utility value of a proposition is defined in a very general way, depending on what the preferences are of the questioner. In this paper I have been assuming throughout that the questioner most of all wants to *resolve* her decision problem and that she doesn't care much in which way this is done. That is, she just wants to know which element of $\mathcal{A}^*$ is true and the participants of the conversation have no additional preference for one element of $\mathcal{A}^*$ above the others. But, of course, in many circumstances agents have preferences on top of the ones made use of until now: one completely resolving answer can be preferred (by questioner or answerer) to another. In that case we can think of the utility value of a proposition as its *argumentative value* as proposed by Merin (1999). I will argue that once these additional preferences come into play, questions can have so-called *scalar* meanings whose existence has hardly been recognized so far.

Although scalar questions have hardly been discussed in the literature, some questions have always been given a scalar meaning. This is most obviously the case for *degree* questions like (18b) and (19), repeated below.

(18b) How many meters can you jump?

(19) In how many seconds can you run the 100 meters?

These questions can already be accounted for by Groenendijk & Stokhof's interpretation rule $[\![Q]\!]^{GS}$, or, equivalently, by $[\![Q]\!]^{Z}$, together with Zeevat's $[\![Exh(\cdot)]\!]^Z$. These examples seem obvious, because the scales involved can be ordered in terms of *entailment*. Still, this assumption gives rise to a problem. As noted before, Rullmann (1995) proposes to account for degree questions like (18b) in terms of his notion of *maximality*. One nice feature of this proposal is that in terms of it an appealing *semantic* explanation can be given for why a question like (24) is odd.

(24) How many meters *can't* you jump?

The reason is that there is (normally) no maximal number of meters that you can't jump, which makes the meaning of the question undefined on Rullmann's (1995) analysis. However, once we order the scales involved in questions like (18b) and (24) in terms of entailment, as proposed by Zeevat (1994), this appealing semantic explanation cannot be preserved. If we represent the question by $?x\neg P(x)$, it is predicted that in each world $Exh(\lambda x[\neg P(x)])$ simply denotes the first number of meters that you can't jump. Once we assume that the utility values of propositions depend on the preferences of the agents involved, however, our analysis is consistent with Rullmann's: if the goal is to jump as high as possible, $Op(\lambda x[\neg P(x)])$ will always be *undefined*, because then there is no best number of meters that you can't jump. This analysis predicts – correctly, I think – that the question first sounds odd: jumping high is normally considered to be better than jumping low. To make sense of the question, however, the preferences have to be changed, and will be reversed. In that case, the unique best answer is the one predicted by Groenendijk & Stokhof, Zeevat and Beck & Rullmann: the first number of meters you can't jump. Thus, these authors correctly predict the only sensible answer, but can't give a semantic/pragmatic explanation of why the question initially sounds odd.[30]

As emphasized by Beck &Rullmann (1999), degree questions can also have a mention-some reading. This is the case, for instance, for question (25) asked by an artist wanting to make a realistic life-size sculpture of a polar bear:

(25) How tall can a polar bear be?

Degree questions can also be forced to have a non-exhaustive reading when the question contains a phrase like 'at least' which explicitly

[30] This doesn't rule out a *syntactic* explanation, of course. But given that – at least according to Beck & Rullmann (1999) – it is widely assumed that negative elements in degree questions are unacceptable on the relevant narrow scope reading of the indefinite part of the *how many* phrase, it is unclear to me what such an explanation would look like.

marks the fact that the questioner is already satisfied – i.e., his decision problem is already resolved – when a mention-some answer is given.

That degree questions involve scales is not very surprising. However, I believe that also standard (embedded) *wh*-questions can give rise to scalar readings. Hirschberg (1985) notes that a sentence sometimes gives rise to a scalar implicature for which the underlying scale *cannot* be reduced to *entailment*. As a somewhat artificial example of such a scale, let's consider the *Beatle-hierarchy*. Suppose we are considering having autographs of the Beatles. Ignoring Paul McCartney, it seems clear that having an autograph of John Lennon is much more valuable than having one of George Harrison. Both are more important than an autograph of Ringo Star (you can still get one). Let us assume that having an autograph of John Lennon makes other autographs irrelevant, and let's make the same assumption for an autograph of Ringo Star when you already have one of Harrison. In this situation, it seems that the question does on its most natural reading not have the standard Groenendijk & Stokhof meaning with 7 (or 8) complete answers.

(26) Which Beatles' autograph do you have?

Instead, it seems that (26) rather denotes a partition with just *three* resolving answers: for each Beatle one. For reasons of autographic hierarchy, answer 'Ringo Star' just denotes worlds in which you *only* have an autograph of the drummer; 'George Harrison' is the name of the cell which contains worlds where you have an autograph of the solo guitarist, but not one of Lennon, and answer 'John Lennon' denotes the cell containing all worlds in which you *at least* have a Lennon-autograph. Notice that this follows from our analysis if from the *goal* with respect to which we determine the meaning of the question we can *derive* the Beatle-hierarchy. But this seems straightforward, certainly in 'game-like' situations: the goal is to win, and winning exclusively depends on having a more valuable autograph than your partner. This latter explanation is based on Merin's (1999) explanation of why we conclude from Mary's answer 'My husband does.' to question 'Do you speak French?' that Mary herself doesn't speak French. The only difference is that we have put this much already into the meaning of the question.

Notice, finally, that also a scalar question like (26) doesn't need to give rise to a partition: it can have a *mention-some* reading as well. Assuming that McCartney's autograph is equally valuable as Lennon's autograph, the resolving answers to (26) might indeed overlap. It should be clear how this follows once we assume interpretation rule $[\![Q]\!]^R$.

6. Conclusion and Outlook

In this paper I have argued that questions are asked because their expected answers can help to resolve the questioner's decision problem. In terms of this assumption I have determined the utility, or relevance, of both questions and answers, and argued that these values are of importance for linguistics because they can be used to determine (i) to what extend an answer resolves a question; and (ii) (help to) determine the actual interpretation of an interrogative sentence whose meaning is underspecified by compositional semantics. I think this is yet one more argument for the claim that what is actually *said* (and not just *meant*) by a sentence crucially depends on the attitudes of the participants of the conversation.

The broader aim of this paper is to contribute to the growing decision and game-theoretic literature on language use. In this paper the notion of decision problem and the value of information were used only to determine what is expressed by an interrogative sentence and whether an assertion resolves a question or not. In other work by especially P. Parikh (1991, 2001), R. Parikh (1994), Merin (1999), Schulz (2001) and myself (van Rooy 2001) these and other notions from general theories of rational behavior are also used to determine what is actually expressed by an assertion and what it conversationally implicates. What this suggests is that decision and game theory provides a perspective on language use that promises to shed new light on existing problems.

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