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Optimal Inquisitive Discourse

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Abstract

In this paper I combine the major results of three of the main theories of interpretation which are concerned with inquisitive discourse and I overcome their obvious limitations. Grice's cooperative principles are given a rational reformulation, with the formal rigour of a Groenendijk, Stokhof and Krifka style semantics of questions and answers. The scope of these paradigms is extended with the global perspective on discourse interpretation convincingly argued for in relevance theoretic accounts like that of Sperber and Wilson.
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4.1 Introduction

The theory of discourse, and that of discourse interpretation in particular, is still far from formal implementation. The syntax and semantics of sentences is theoretically highly sophisticated, and there is a huge amount of literature on the formal pragmatics of specific indicative assertions. Nevertheless, no general, unified formal account has been offered sofar, despite numerous attempts over the last twenty years.

In this paper I want to contribute to such an account. I take my clue from a Montagovian perspective on semantics and a Gricean perspective on conversation, agreeing that rational principles of conver-

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sation motivate a cooperative matrix. Actual interpretation, however, goes much beyond that. Interlocutors cannot always be assumed to be unconditionally cooperative and perfectly rational, and there are rules about how decent conversations ought to go by. Some theories of discourse structure focus on such rules, but they either focus on structural formal relationships between sentences, or they invoke informal principles of relevance. I want to generalize this picture, and offer an intuitively motivated and formally generalized notion of an optimal inquisitive discourse, which covers the examples discussed in the literature, and many more besides.

This paper proceeds as follows. Section 2 gives an introduction to my own implementation of the standard formal view on the semantics of questions and answers. It is based upon the basic insights of Hamblin and Karttunen which are intuitively motivated and formally worked out well by Groenendijk and Stokhof and Krifka. Section 3 discusses the logical and pragmatic merits of this type of framework and it presents my own account of how questions and answers in discourse update the common ground in discourse. This will serve to set the ground for giving us a formal paradigm to actually define a notion of an optimal inquiry. This will be done in section 4, where it is also put to test and used to explain 'mention some'-interpretations of questions. Section 5 summarizes the results.

4.2 Semantic Satisfaction of Questions and Assertions

Questions (interrogative utterances) have been studied from both a semantic and a pragmatic perspective, more than indicative sentences (assertions) have been, and for good reasons. While the interpretation of questions depends on context as much as the interpretation of assertions does, their effects upon the context are more obvious. A question normally wants to be answered. Even so, indicative utterances have also been studied from a combined semantic/pragmatic perspective in recent systems of dynamic semantics and discourse representation theory. Clearly, this motivates a treatment of both types of utterances in tandem.

According to a very old and standard picture, dating back to Frege and Wittgenstein, the meaning of an indicative sentence can be spelled out in terms of its truth-conditions. The idea is that you know the meaning of such a sentence if you know what the world should be like in order for the sentence to be true. Putting it the other way around, you grasp what information an assertion of such a sentence conveys, if you understand what the world will be like if the assertion

is true, so that you can act accordingly.

According to a not so old, but equally standard picture, dating back to Hamblin and Karttunen, the meaning of an interrogative sentence can be spelled out in terms of its answerhood conditions. You know the meaning of an interrogative sentence if you know what counts as a full answer to the question. You grasp what information is queried by the use of an interrogative sentence, if you know what, given how the world is like, would count as an answer fully resolving the question. You may fail to know the answer, and you may have information only partly resolving the question, what counts is that, if you knew what the world were like, what would be the true and complete answer.

The intuitions about indicative and interrogative sentences can be spelled out in terms of a simple satisfaction relation. Such a satisfaction relation $\models$ relates sentences or formulas ϕ of a formal language representing the idealized meanings of natural language sentences, with the conditions under which they are satisfied. In case ϕ is a purely indicative sentence, this satisfaction relation boils down to a simple Tarskian truth relation; in case ϕ is interrogative, it is satisfied by the true and full answer to the question involved. In general this is formalized as $M, g, \vec{\alpha} \models \phi$, where M is a formal model representing a possible world or situation, g is an assignment of individuals as values for variables or indices, formally required to interpret (sub-)formulas quantified over, and $\vec{\alpha}$ is a possibly empty sequence $\vec{\alpha}_1, \ldots \vec{\alpha}_n$ of answers to questions posed.

The formal language I emply is a rudimentary language of predicate logic extended with a question operator ?. It is built around atomic formulas consisting of n-place relational constants R^n plus a sequence of n arguments t_i, which are either individual constants or variables. The language can be defined as follows in Backus-Naur form (BNF):

Definition 4.1 (Language of LQA)

- $\phi ::= \ R^n t_1 \ldots t_n \mid {\sim}\phi \mid \phi \wedge \phi \mid ?\vec{x}\phi$

Besides atomic formulas we have the elementary tools of negation $\sim$, conjunction $\wedge$, and questioning ?. The question operator $?\vec{x}$ queries the possible values of the variables $\vec{x}$ under which the embedded formula ϕ can be satisfied. I use $\vec{x}$ to indicate a possibly empty sequence of variables $x_1, \ldots, x_i$. In case $\vec{x}$ is empty, $?\vec{x}\phi$ is a polar question, also known as a *yes/no* question. I could have added first and second order quantifiers to the language, but they are not pertinent to the purposes of this paper.

As indicated above, the basic semantics of our language LQA is stated in terms of a satisfaction relation $M, g, \vec{\alpha} \models \phi$. The models which I use are standard first order models $M = \langle D, I \rangle$ where D is a domain of individuals under discussion, and I an interpretation function for the constants of our language. For any individual constant c, $I(c) \in D$ is the extension of c in M, the member of D denoted by c in M. A relational constant R^n denotes the set $I(R^n)$ of tuples of individuals $d_1, \ldots, d_n$ which are supposed to stand in the R^n relation in M. A variable assignment g assigns individuals from D to the variables which our syntax requires us to use. These assignments are regulated by variable binding operators, $?\vec{x}$ in our basic system, and by variable binding quantifiers in (regular) extensions of it.

The sequence $\vec{\alpha}$ is short for any Tarskian or Kaplanian sequence of parameters relevant for the satisfaction of a formula which is being evaluated. Since I focus on a semantics for a language with questions, this sequence will be understood as a sequence of answers to the questions posed in a formula ϕ to be satisfied. Our system elaborates upon the classical insight (Hamblin (1958), Karttunen (1977), Groenendijk and Stokhof (1984)) that the meaning of a question is its full and complete answer. A question $?\vec{x}\phi$ gets satisfied by the answer to the question under which valuations of the variables $\vec{x}$ the formula ϕ gets satisfied. If $\vec{x}$ consists of one variable x only, as in $?xCx$ ("Who come?"), it asks for the extension of C; if $\vec{x} = xy$ consists of two variables, as in $?xy(Bx \wedge (Gy \wedge Sxy))$ ("Which boys saw which girls?"), it asks for the set of pairs consisting of a boy and a girl the boy saw; if $\vec{x}$ is the empty sequence, as in $?p$ ("Does it rain?") it asks for the truth value of p: it denotes the set $\{\lambda\}$ consisting of the empty sequence $\lambda = \langle\ \rangle$ only, which is the truth value *true* ($\mathbf{1}$) by definition, or the empty set $\{\ \}$, the truth value *false* ($\mathbf{0}$).

Questions can also be conjoined. For instance, $?OKy \wedge ?x(Bx \wedge Ryx)$, can be used to query whether your are OK (OKy) and which x are books (B) you read (Ry). Such a conjunction has to be satisfied by a pair of answers, a specification of books, and an acknowledgement about your well-being. In case a formula does not raise any question at all, it can only be satisfied by an empty sequence of answers, which I abbreviate by means of capital Λ. Such an empty sequence satisfies the formula if and only if it is satisfied in a classical, Fregean / Tarskian sense.

A boring, but pertinent, note on notation is crucial here. Since a formula ϕ may raise a number of questions $Q_1, \ldots Q_n$, a satisfying sequence $\vec{\alpha} = \vec{\alpha}_1, \ldots, \vec{\alpha}_n$ must answer all of these, so the numbers of the two sequences must be the same. Besides, a question Q_j can be of any

type, because it may question the values of any sequence of i variables, so $\vec{\alpha}_j$ must be an i-ary relation as well. In what follows I will assume that these sequences and the arities of their members simply match, without further discussion. I will not discuss, here, the occurrence of the question operator under other operators like that of negation, or the question operator itself. I also assume the usual interpretation of (individual and relational) constants c and variables x:

- $[c]_{M,g} = I(c)$ and $[x]_{M,g} = g(x)$

The reader should by now be able to digest the following definition of my satisfaction semantics.

Definition 4.2 (Satisfaction Semantics for LQA)

- $M, g, \Lambda \models Rt_1 \ldots t_n$ iff $\langle [t_1]_{M,g}, \ldots, [t_n]_{M,g} \rangle \in [R]_{M,g}$
  $M, g, \Lambda \models \sim\phi$ iff $M, g, \Lambda \not\models \phi$
  $M, g, \vec{\alpha}\vec{\epsilon} \models \phi \wedge \psi$ iff $M, g, \vec{\epsilon} \models \phi$ and $M, g, \vec{\alpha} \models \psi$
  $M, g, \alpha \models ?\vec{x}\phi$ iff $\alpha = \{\vec{e} \mid: M, g[\vec{x}/\vec{e}], \Lambda \models \phi\}$

Let me briefly comment. It must be obvious that atomic formulas are satisfied in a completely standard way by an empty sequence of answers Λ and it is relatively easily established that the same goes for compound formulas which do not contain any occurrences of the question operator ?. I will call these indicative formulas, and they are henceforth abbreviated as $!\phi$. For any such formula $!\phi$ (and $!\psi$):

Observation 4.1 (Satisfaction of Indicatives)

- $M, g, \Lambda \models !\phi \wedge !\psi$ iff $M, g, \Lambda \models !\phi$ and $M, g, \Lambda \models !\psi$

Conjunction is relatively simple. When we conjoin two formulas we want each of them to be satisfied. If any one of them is indicative, it must be true in the classical sense, and if it is interrogative, a satisfying sequence of answers for the conjunction must supply the answer for that conjunct as well. If two interrogatives are conjoined, the satisfying (sequences of) answers are stacked, in such a way that the last question raised must be the first to be answered.

The most simple example of a question is a polar one, $?\vec{x}!\phi$ where $\vec{x}$ is an empty sequence of variables and $!\phi$ is indicative:

(1) Does it rain? ($?p$)

Given that $\vec{x}$ is the empty sequence, this queries whether the empty sequence of individuals satisfies p, which it does in case p is actually

true. Formally:

Observation 4.2 (Satisfaction of Simple Polar Questions)

- $M, g, \alpha \models ?p$ iff $\alpha = \{\lambda\} = \mathbf{1}$ if $M, g, \Lambda \models p$ and
  $\alpha = \{\ \} = \mathbf{0}$ otherwise

Questions associated with non-empty sequences of variables constitute a generalization of the polar case. Consider:

(2) Which boys come?
$?x(Bx \wedge Cx)$

(3) Which professors failed which students?
$?xy(Px \wedge Sy \wedge Fxy)$

In these examples the possible values of x (and y) are being queried, so that the embedded formula $(Bx \wedge Cx)$ (and $(Px \wedge Sy \wedge Fxy)$, respectively) are satisfied. Formally:

Observation 4.3 (Satisfaction of Simple *Wh*-Questions)

- $M, g, \alpha \models ?x(Bx \wedge Cx)$ iff
  $\alpha = \{d \mid d \in I(B)\ \&\ d \in I(C)\}$
- $M, g, \alpha \models ?xy(Px \wedge Sy \wedge Fxy)$ iff
  $\alpha = \{dd' \mid d \in I(P)\ \&\ d' \in I(S)\ \&\ \langle d, d'\rangle \in I(F)\}$

As in standard treatments of questions, *Wh*-interrogatives denote their true and complete answers. The full answer to the question which boys come consists of a specification of the whole set of boys who come; the full answer to question (3) consists of a full specification of the set of pairs consisting of a professor and a student which the professor failed. Like indicatives, simple interrogatives, thus are also treated in the standard way.

4.3 Logic and Pragmatics of Questions and Answers

Our satisfaction semantics incorporates the basic insights of standard theories of indicatives and interrogatives, and it inherits the accomplishments and results from standard formal frameworks like those presented in, e.g., (Groenendijk and Stokhof (1984), von Stechow (1991), Krifka (1991), van Rooij (2003)). The standard theory is built on the idea that contents of assertions and information states can be characterized by means of sets of possibilities, those possibilities compatible with these assertions or states, and that questions can be taken to partition these

states. The elements of such partitions indicate what are the relevant distinctions. Agents are interested in knowing which of the elements of a partition correspond to the real world, and they are supposed to be insensitive to differences between possibilities which reside in one block.

This however does require us to generalize the extensional models we used above to intensional models $\mathcal{M} = \langle W, D, I \rangle$ consisting of a set of worlds W, a domain of individuals D, and an interpretation function I for the constants of our language, and such that for any world $w \in W$: $\mathcal{M}_w = \langle D, I_w \rangle$ is an extensional model like we had above. This is a totally standard lift from extensional to intensional.

In terms of such intensional models we can account for the contents of (mixed) indicative and interrogative sentences. As indicated above, the content of any formula can be spelled out in terms of its satisfaction conditions, so it can be equated with the set of parameters in a model which satisfy it. In the definition below these are satisfaction sets S which consist of sequences of answers $\vec{\alpha}$ plus worlds w such that w is not excluded to be the actual world and $\vec{\alpha}$, in w, provides the complete answers to outstanding questions. In terms of these satisfaction sets we can derive standard notions of data, answerhood and indifference:

Definition 4.3 (Content, Answerhood, and Indifference)

- $[\![\phi]\!]_{\mathcal{M},g} = \{\vec{\alpha}w \mid \mathcal{M}_w, g, \vec{\alpha} \models \phi\}$ (content of ϕ)
  $D(S) = \{w \mid \exists\vec{\alpha}\colon \vec{\alpha}w \in S\}$ (data of S)
  $A(S) = \{\ \{w \mid \vec{\alpha}w \in S\}\ \mid \exists v\colon \vec{\alpha}v \in S\}$ (possible answers)
  $I(S) = \{\langle v, w\rangle \mid \exists\vec{\alpha}\colon \vec{\alpha}v \in S \ \&\ \vec{\alpha}w \in S\}$ (indifference)

A satisfaction set for a simple indicatives utterance p ("It rains.") consists of the worlds in $\mathcal{M}$ in which p is true, i.e. where it rains. A satisfaction set for a simple interrogative $?q$ ("Does it rain?") consists of pairs αw where α is the true answer to the question whether q in w. A satisfaction set for a mixed sentence: $p \wedge ?q$ ("It rains. Will John come?"), consists of those worlds in $\mathcal{M}$ in which it rains, after they have been paired with the answer **1** ("Yes.") or **0** ("No.") in worlds where John does come, and in those where he doesn't, respectively. The idea is that we deem the actual world to be one of those considered possible, and not like one of those excluded, and that we want to know which of the two types of worlds we inhabit, the type where John comes or the type where he doesn't.

The data (S) provided by a satisfaction set S simply consists of

the set of worlds not excluded by S. The data thus model the information which S conveys in a standard, indicative, sense, and they neglect all the issues raised by S. As in the classical theory of questions, $A(S)$ provides the set of propositional answers to the question(s) modelled by S. That is, for any possibility $\vec{\alpha}v \in S$, the worlds w which agree with v on the full answers $\vec{\alpha}$ are collected together in a separate proposition, as a matter of fact the proposition true in exactly those worlds (which are not excluded!) in which $\vec{\alpha}$ provides the (sequence of) answers to the (sequence of) questions raised by S. In simple cases these generated sets of propositions are partitions of the sets of worlds conceived possible in S, which is to say that every world consistent with S participates in exactly one proposition in $A(S)$ (thus fleshing out the intuition that in every world there can be only one true and full answer to a particular question). Thus, the question $?xCx$ ("Who come?") can be modeled by a set of propositions: the proposition that (which is the set of worlds in which) nobody comes; the proposition that (set of worlds in which) Anja comes, and nobody else; the proposition that Boris and only he comes; the proposition that both come and nobody else; etc.

Indifference is another, and insightful, way of looking at these partitions, or at propositional answerhood. Partitions of any space can be characterized by an equivalence relation (a reflexive, transitive and symmetric relation on the points in that space). If we think of the questions in a satisfaction set S as those that are relevant, then S is indifferent about distinctions not made by the possible answers to the questions raised. That is to say, if S only raises the question whether the sun shines, then it is immaterial whether my brother visits Mexico. In that case S is concerned with the issue whether the world is like one in which the sun shines or like one in which it doesn't, and not with the issue whether the world is like one in which the sun shines and my brother visits Mexico, or like one in which the sun shines and my brother doesn't visit Mexico.

As Groenendijk and Jäger have shown, indifference looks like the most logical notion. If there are no questions involved, we are totally indifferent so that $I(S) = S^2 = \{\langle v, w \rangle \mid v, w \in W\}$, which means that we are insensitive for the difference between any two worlds v and w. If we add questions, we get a more involved look at the world, and our indifference $I(S)$ decreases. If we are just concerned with the question whether the sun shines, then we are indifferent between any two possibilities in which the state of the sun is the same, but we are sensitive to being in the type of world in which the sun does, and in one in which it does not shine. If we want to know everything, that is, if we want to know exactly what the world is like, then $I(S)$ has shrunk into

the smallest indifference relation $\{\langle v, v\rangle \mid v \in W\}$. In the introduction these observation about indifference are illustrated in a more pictorial fashion, so we refer the reader here to that part of the present volume.

The semantics of questions in terms of partitions and indifference has two major benefits and one main limitation. Such a semantics combines a fully straightforward logic (Groenendijk and Stokhof (1984)) with an intuitive decision-theoretic interpretation (van Rooij (2003)). (See also the introduction to this volume.) However, it fails a straightforward account of constituent questions (Krifka (1991)). The semantics proposed in this paper, which is based on the satisfaction semantics from the previous section, retains the goodies, and overcomes the limitations of these approaches, as it has incorporated, right from the start, some (empirical) insights from the structured meaning approaches to questions (von Stechow (1991), Krifka (1991)). The remainder of this section gives a concise sketch of these three issues, but space restrictions do not allow me to go in full detail here.

The notion of indifference allows one to define a notion of entailment or support for interrogatives and indicatives in one gloss (cf. Jäger (1996), Groenendijk (1999)):

Definition 4.4 (Support)

- $\phi \models \psi$ iff $I(\llbracket\phi\rrbracket_{\mathcal{M},g}) \subseteq I(\llbracket\psi\rrbracket_{\mathcal{M},g})$ (for all $\mathcal{M}$ and g)

With the help of the notion of indifference, support boils down to simple inclusion ($\subseteq$), which is standard. For an expression ϕ to support ψ it effectively requires ϕ to provide more data and pose more questions. For two indicative expressions this boils down to classical entailment, and for two inquisitive expressions ϕ and ψ we find that the former entails the latter iff every complete answer to the first also completely answers the second. Moreover, an indicative expression $!\phi$ entails an inquisitive expression $?\vec{x}\psi$ iff it fully answers the question.

When we turn to the use of questions and answers in discourse it is expedient, if not necessary, to use a tool to keep track of what has happened in the discourse sofar. A system of update semantics provides precisely this tool when we are interested in the information which has been exchanged and the questions that have been raised, because this enables a formal account of the process of raising and resolving issues (Ginzburg (1996), Hulstijn (2000), Roberts (1996)).

Satisfaction sets are very well suited to model the required type of information obtained at a certain stage in a discourse, because they

can serve to account for the data and questions agreed upon in one set-theoretical construct. Updating satisfaction sets proceeds as follows. Let S be the satisfaction set of the discourse at some point, so that it both contains the information provided by previous indicative utterances as well as the questions raised so far. Then the update of S with (an utterance of) ϕ consists of adding to S both the information and the questions provided by ϕ. Moreover, ϕ may contain information answering questions in S, which therefore can be wiped out. The definition runs as follows:

Definition 4.5 (Update Semantics)

- $S[\![\phi]\!]_{\mathcal{M},g} = \{\vec{\alpha}\vec{\epsilon}w \mid \vec{\epsilon}w \in S \;\&\; \mathcal{M}_w, g, \vec{\alpha} \models \phi\}^*$ with
- $T^* = \{\vec{\epsilon}w \mid \vec{\alpha}\vec{\epsilon}w \in T\}$ for the longest $\vec{\alpha}$ such that: $D(T) = D(T^*)$

According to the first clause an update of S with ϕ consists of *eliminating* sequences $\vec{\epsilon}w$ incompatible with the information provided by ϕ and *adding* sequences $\vec{\alpha}$ to the remaining sequences $\vec{\epsilon}w$ provided these sequences $\vec{\alpha}$ satisfy the questions of ϕ in w. The star on the satisfaction set that results from this update makes sure that resolved questions are popped. This operation removes answers from the top of the sequence if it is the same in all remaining possibilities. For instance, suppose the last interrogative has been $?p$ and the last (subsequent) indicative has been that p. The initial result of the update of initial set S is the set:

- $T = \{i\vec{\epsilon}w \mid \vec{\epsilon}w \in S \;\&\; i = I_w(p) \;\&\; I_w(p) = \mathbf{1}\}$

(Where i figures as a meta-variable for truth values.) Since all sequences in this set provide the same answer $\mathbf{1}$ to the last question, it can figure as the sequence $\vec{\alpha}$ in the definition above, so that

- $T^* = \{\vec{\epsilon}w \mid \mathbf{1}\vec{\epsilon}w \in T\} = \{\vec{\epsilon}w \mid \vec{\epsilon}w \in S \;\&\; I_w(p) = \mathbf{1}\}$

and clearly $D(T) = D(T^*)$.

4.4 Strategic Inquiry with Questions and Answers

We now have a satisfaction semantics for a language with indicatives and interrogatives, as well as an update semantics defined in terms of it. Not only does such an enterprise serve the purpose of giving an account of the interpretation of discourse, but it may also serve to define what constitutes a good, or structured, or coherent, or optimal discourse. And here comes the main point of the paper. I do not believe one can say much about this issue of optimality if one adopts a local perspective, that is by focusing on sentence pairs and discourse

relations only, and ruling some 'coherent', or 'felicitous', or 'congruent', and others not. A whole series of authors has studied such pairs, and made very interesting observations about them, e.g., (Mann and Thompson (1988), Lascarides and Asher (1993), Groenendijk (1999)). Of course, asserting "John comes to the party, and no other students do." can be relevant in response to a question "Who will come to the party?", but almost any other utterance (indicative or inquisitive) can be relevant as well. We are perfectly able to make sense of other replies such as "Mary goes to the movies.", "There's a basketball match on TV tonight.", "Will you come?", "Is there beer in the fridge?", and I don't see why a response like "Patty will come to the PARTY!!??" should be deemed ungrammatical, incoherent, infelicitous, incongruous, or whatever, except, maybe, for the sake of defining one's own notion of felicity, congruence, or what.

I believe a pragmatic, or global, perspective should be the one to be adopted. This observation is definitely not new, as Grice has already initiated it, as a strong defense of it is given in relevance theory (Sperber and Wilson (1986)), as it has been adopted by many other authors and as indeed also Asher and Lascarides advocated it. However, as Sperber and Wilson observe, Grice's own perspective is still quite limited, being based on cooperativity and rationality assumptions with the interlocutors; besides, the ideas of Grice and the work done in relevance theory is very informal; theories of information structure like that of (Büring (1999), Ginzburg (1996), Hulstijn (2000), Roberts (1996)) are indeed theories of information *structure*, but they do not supply a (too) unrestrictive notion of an optimal discourse; finally, a global and formal account is offered by (van Rooij (2003)) in a very innovative way, but it requires us to adopt the apparatus of decision theory. I believe that a global and formally well-defined notion of an optimal inquiry can be defined, which can be motivated by rationality and cooperativity, but which does not presuppose interlocutors to be rational and cooperative, and which does not require them to calculate probability and utility measures. In fact, I will offer such a notion here.

One of Grice's aims was to show that certain general principles constrain and guide the intention and interpretation of utterances of (linguistic) agents which are deemed rational and cooperative. The assumption of rational cooperative behaviour advances the agents involved in a conservation to obey, or to pretend to obey, the maxims of quality, quantity, relation and manner. These maxims require a speaker not to say things for which she lacks adequate evidence, not to say more nor less than is required for the purposes of the conversation, to advance relevant propositions, and to be well-behaved.

These maxims can be understood and formalized in the following way without adopting rigid rationality and cooperativity assumptions. It is important, as will also become clear from examples discussed below, that we do not try to characterize specific utterances as more or less felicitous, but that we indeed adopt a global perspective, which can be used to render whole discourses more or less optimal. So think of a game of information exchange as consisting in getting one's questions answered in a reliable and preferably pleasant way. Interlocutors engage in a multi-speaker dialogue Φ which can be deemed optimal if Φ answers their questions, while its contents are supported by the information the interlocutors have, and the communication is smooth:

Definition 4.6 (Optimal Inquiry) Given a set of interlocutors A with states $(\sigma)_{i \in A}$ a discourse $\Phi = \phi_1, \ldots, \phi_n$ is optimal iff:

- $\forall i \in A$: $D([\![\Phi]\!]) \cap D(\sigma_i) \models \sigma_i$ (relation)
  $\bigcap_{i \in A} D(\sigma_i) \models D([\![\Phi]\!])$ (quality)
  Φ is minimal (quantity)
  Φ is well-behaved (manner)

An optimal discourse is one in which all questions of all interlocutors get answered in the first place (relation). For each agent $i \in A$, it requires that the data provided by the discourse $D([\![\Phi]\!])$ together with the data the agent had in the first place $D(\sigma_i)$, resolve ($\models$) all the initial questions the agent had. Of course, we are not satisfied with any arbitrary answer, we want *true* answers, and since we cannot be absolutely certain about the truth, we have to live with the data our interlocutors have. This is what the second line (quality) requires: the data provided by the discourse $D([\![\Phi]\!])$ must be supported by the combined initial information of the interlocutors, given as $\bigcap_{i \in A} D(\sigma_i)$.

When agents engage in a cooperative conversation, it is reasonable that they make clear what questions they have, and that they provide information which they have support for. The above notion of an optimal inquiry accounts for this. Here is a simple example of an optimal exchange. Suppose A wishes to know whether Sue comes to the party ($?s$), and B wants to know whether Tim comes to the party ($?t$), and assume that each of them knows the answer to the other one's question. The two information states can be defined as follows, σ being A's state, τ being that of B:

- $\sigma = \{\ [\![s]\!] \cap [\![\neg t]\!]\ ,\ [\![\neg s]\!] \cap [\![\neg t]\!]\ \}$
  $\tau = \{\ [\![s]\!] \cap [\![\ \ t]\!]\ ,\ [\![\ \ s]\!] \cap [\![\neg t]\!]\ \}$
  $CG_0 = W$

Indeed we see that no worlds are considered possible in which t is true according to σ and that this state distinguishes between the worlds in which s is true or false. Similarly, τ only calculates with worlds in which s is true, and distinguishes between those among them in which t is true or false. The following dialogue is optimal then:

(4) *A:* Will Sue come?
B: Yes.
Will Tim come?
A: No.

Both questions are answered, by information which was initially there distributed over the two initial information states. The exchange is, intuitively, also minimal, and well-behaved except maybe for the fact that there are no ceremonies, greetings, or the like. The update of the common ground proceeds as follows:

(5)	*A:*	Does Sue come?	$CG_1 = \{iw \mid w \in W \ \& \ i = I_w(s)\}$
	B:	Yes.	$CG_2 = \{iw \mid w \in W \ \& \ i = I_w(s) = \mathbf{1}\}^* = [\![s]\!]$
		Does Tim come?	$CG_3 = \{iw \mid w \in [\![s]\!] \ \& \ i = I_w(t)\}$
	A:	No.	$CG_4 = \{iw \mid w \in [\![s]\!] \ \& \ i = I_w(t) = \mathbf{0}\}^* = [\![s]\!] \cap [\![\neg t]\!] = \sigma' = \tau'$

Formally, the requirements in definition (4.6) are satisfied. Example (4) can also be used to show that some standard felicity requirements (like informativity, non-redundancy, consistency, and congruence of answers with questions) can be derived from the requirements we have stated above, and I leave it to the reader to check this out. Most importantly, however, as has already been indicated, they are no absolute requirements.

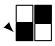
Definition (4.6) may serve as a guideline for things to work out well in ideal circumstances. However, the guidelines do not presuppose participants to be cooperative and reliable in general. That is to say, even though we have sketched a model in which example (4) is produced in an ideal case, of course the interlocutors may be wrong, may lie, or may know or just think they are unreliable or lying. Thus, as a result of the very same example, A might very well conclude that B wants her to know that Tim is not coming, for instance, if A happens to know that B is a pathological liar. Such fancy complications of the ideal Gricean case of course draw from a lot of epistemic logic reasoning. It suffices here to observe that these considerations and conclusions are based upon a Gricean model of the ideal case, and upon the interlocutors' understanding of what would count as an ideal case, that is, if the formulated guidelines are not understood in a categorially imperative

sense.

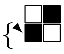
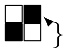
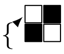
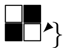
Apart from delusions and deliberate betrayal, there are also apparent deviations from the strict Gricean schemes which do remain cooperative. Quite surprisingly, it can be useful to ask for more information than one actually needs. In the next section I discuss two such cases, one more formal, and one more intuitive, and will then show how these cases can be used to explain some phenomena that have plagued the literature on the semantics of questions.

4.5 Superquestions and 'Mention Some'

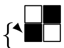
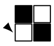
Here is a formal example of a useful superquestion. Let the actual world be a simple 2×2 chessboard with agent A at position $a1$, as in:

- 

A knows she is on the chessboard, but she does not care at which position she is, although she does care whether she is at a black or a white square. Her epistemic state can be characterized as follows:

- $\sigma = \{ \{$, $\}$, $\{$, $\} \}$

A has no idea, and doesn't care, which of the four positions she occupies, but she indeed cares about being on a black or a white square. Her addressee B does know on which position A is, but she does not know what the chessboard looks like. Given that B does not have any questions himself, his state can be characterized as:

- $\tau = \{ \{$, $\} \}$

Now the following discourse unfolds:

(6) *A:* Am I on a black square?
B: I don't know.
A: On which square am I?
B: You're on $a1$.
A: Then I am on a black square.

This discourse is perfectly reasonable because A first asks what she wants to know, and B indicates he doesn't know the answer and then A asks something more specific than she wants to know, any answer to which also answers her question. B has a motivated reply to that question, and A's original question is resolved.

The previous example is a bit artificial, and it could be amended. For, as we already remarked above, A's 'real' question is whether, given that she is right, she is on a black square, or more precisely whether she is on $a1$ or $b2$, if these are the black fields indeed. By the same token B

could have directly solved A's question by replying that "Yes, if $a1$ is black." or with the counterquestion "What colour is $a1$, which is your current position?" But in practice it is not always obvious to see what is the optimal reply or question and the following example is meant to show this in some more detail.

Consider the following situation. There is a party which may be visited, apart from the speaker S (Sonja), by the professors Arms A, Baker B, Charms C, and Dipple D, which gives $2^4 = 16$ configurations. S's decision to go or not will be based on the question whether it is useful to do so, and it is going to be useful if S can speak to professor A or C. So A or C must be there, but there are some further complications. If, besides A, B is there as well B will absorb A if B doesn't absorb C, that is, if C is not absorbed by D; furthermore, if neither B and C are present, D will absorb A. The following table lists the configurations under which it is useful for Sonja to go:

•

	C & D	C & $\neg D$	$\neg C$ & D	$\neg C$ & $\neg D$
A & B	-	+	-	-
A & $\neg B$	+	+	-	+
$\neg A$ & B	-	-	-	-
$\neg A$ & $\neg B$	-	+	-	-

Of course, Sonja could ask: "Will I go there?", but this is normally not up to her interlocutor to decide. Given her requirements and expectations, Sonja wants to know if she is in a + or - situation, and that will help her enough to make here decision. Normally this corresponds to a polar question, a positive answer to which would mean that she is in a + type world, and a negative answer the opposite, which would indeed help her to decide whether to go or not. But without any further assumptions it seems she can hardly do better than asking:

(7) $(A\ AND\ [(B\ AND\ C\ AND\ \neg D)\ OR\ (\neg B\ AND\ (D \to C))])\ OR$ $(C\ AND\ \neg B\ AND\ \neg D)$?

Apparently, this is a somewhat cumbersome question. Alternatively it would also do to simply ask:

(8) Who come?

Any full answer to this question would answer S's main question, but notice that (8) asks for more specific information than she actually needs. Nevertheless (8) is a much more efficient means than (7) for S to solve her decision problem whether to go or not.

Once we realize that the requested information can be more specific than the information actually needed, we can react accordingly. For instance, if I happen to know more about Sonja's preferences, I

might reply:

(9) Arms will not come, but Baker does.

Formally, this is only a partial answer to Sonja's question in (8), since it does not mention Charms and Dipple, but it does tell her enough: the party is going to be of the - type, so she can safely stay home.

In cases like this it is important to distinguish the decision problem which an agent faces, which is inherently indexical and subjective, and the objective question which she actually asks. Of course, Sonja might have asked "Will I be at the party tonight?", and this makes sense if, for instance, she wants to go there and it depends on the help of others whether she can make it. In the current situation, however, it is her own decision problem whether she will go, and then it seems up to irrational to ask others to decide it. So while it normally does not make sense that people directly express their decision problem ("Will I be at the party or not?"), we may realize that the objective questions they actually do ask ("Who will be at the party?") can originate from such subjective decision problems. I believe this distinction between subjective decision problems and factual questions, and their relation, together with some pragmatic reasoning, also throws light on the so-called "mention some" problem. To finish this section I will elaborate a bit on this point.

The following are relatively standard examples from the literature:

(10) Who's got a light?

(11) How can / do I open a gzip file?

(12) Where do they serve Thai food?

(13) How can / do I get to the station?

Normally, when such examples are used, they do not ask for an exhaustive answer. If the reply to (10) is that Peter can give me a light, that suffices for me and I do not need to know about others who could give me a light. It is also enough to know one method to open a gzip file, if it is a good one, and one does not need to know all alternatives. Similarly, a reply to (12) does not need to list all Thai restaurants out here, and hardly anybody would use (13) to ask for all possible routes to the station—which may be infinitely many.

Since these examples can be used with the intention of soliciting only one instance of the queried predicate, if that belongs to their meaning, and the meaning of a question resides in its answerhood conditions, then, as has been argued, the meaning of a question is not its full exhaustive answer, but rather a kind of disjunction of its possible instances. These examples thus cast doubt on the notion of the

meaning of a question as it has been elaborated by, e.g., Groenendijk and Stokhof. I cannot discuss, here, all of the relevant literature on the subject, but I stick to a discussion of how these examples fit in the Groenendijk and Stokhof-style picture developed in this paper.

First, it should be noticed that the above examples in principle can be used with the intention to solicit an exhaustive reply anyway. For instance, a salesman might be interested in all Thai places where he can sell his own Taro root. And example (13) can be used if somebody is interested, given a suitable restriction of the domain of quantification, in all possible ways to reach the station, by car, bicycle, tram, bus or by foot. Acknowledging that the above examples can be used for both 'mention all' and for 'mention some' requests, should we therefore conclude that they are ambiguous between these two interpretations? Grice has taught us not to multiply meanings beyond necessity, so, if we can derive one of the interpretations from the other by pragmatic means, then we should do so.

Secondly, it should be noticed that any 'mention all' reply entails any 'mention some' reply. If we know all places where they serve Thai food, then we also know some places where we can go, provided that there are any. Thus, semantically there is nothing wrong with an exhaustive reply, since it satisfies the question on its 'mention some' interpretation, except that it can be boring, and too long-winded. Moreover, even though the meaning of a question is spelled out, above, as it is in Groenendijk and Stokhof, in terms of exhaustive answerhood, the analysis of actual replies is not. As I have shown more in detail in my other contribution to this volume, in reply to the question "Who gave what to whom?", a constituent answer "John a book to Mary." is only taken to assert that John gave a book to Mary, and it requires a (possibly implicit) indication like "Nobody anything to anything else." that the full answer is supposed to be given now.

So, thirdly, the only thing we need is an explanation why the examples (10–13) can be reasonably understood as requiring a 'mention some' reply only. Now our distinction between what is an agent's decision problem, and what she actually asks about the world to actually solve it becomes highly relevant. If a hearer understands that what somebody actually asks, semantically, is more specific than what she needs to know, as in example (9), if he can dig what it might be that she actually needs to know, and if the speaker can be confident that the hearer will understand all this, then there is nothing left to explain.

Let me briefly comment on some situations where a 'mention some' reading of the examples (10) and (12) is appropriate. A typical

‘mention some’ understanding of example (10) obtains in a situation where our agent Sonja has gone to the party, where we find Arms, Baker and Charms (amongst a lot of other irrelevant people), she lifts a cigar out of her pocket and utters (10). It is easy to decide what Sonja wants then (a light), but it is not so easy to describe what her ‘decision problem’ is. She has to step forward to some participant and get a light from him or her, but whom? If she doesn’t ask anything in public, she can try and ask each of the participants until she has got a light, but in which order to ask these participants? So maybe her decision problem is: “Shall I ask Arms first, Baker next, etc., or shall I ask Baker first, Charms next, etc., etc.” Obviously, this is an even more cumbersome question than the one in (7). A reply to her actual question (10) need not resolve this problem, but it can make life much easier. If the answer is “Charms, and also Erdvik.” she can try and get a light from Charms first, and if Charms’a lighter happens to be out of gas, she can try Erdvik. In any case, if the respondent(s) understand what the situation is like, if they understand that the question actually posed is different from, but much more easily formulated than, the underlying decision problem, and if they also realize that the order of lighter-owners is practically immaterial, then they know a fully exhaustive reply is unnecessary, and as a matter of fact Sonja can expect that they realize this.

A ‘mention some’ use of (12) is similar. Suppose Tim is on a junction where he can go North, East, South or West. He can only go one way, so that is partly his decision problem: which of the four ways to go? He does, however, want to go a way where he will find a Thai restaurant. Indeed, if he gets a full specification of all directions in which he can find a Thai restaurant, he can make up his mind, so an exhaustive reply to (12) will definitely help him. That is good about using (12).

In the same situation, a direct formulation of his decision problem must be really something like the conjunction of the following four or five questions: “Will I go North and find a Thai restaurant?”, “Will I go East and find a Thai restaurant?”, . . . , “Or will I go nowhere?”. Not only is this a cumbersome question, it is also hard to answer. I might know that he can find a nice Thai restaurant if he goes North and West, but of course I don’t know which of the two ways he will go. Understanding what the motivation for Tim’s question (12) can be, however, I can simply reply “North and West.” and with this reply I don’t exclude he could go South and find a nice Thai restaurant, but, if I got his question right, it ought to be helpful. The notion of an optimal inquisitive discourse, and assumptions about the knowledge

and reasoning capacities of the interlocutors thus may serve to explain when exhaustive questions are used to elicit partial answers.

Conclusion

In formal theories of conversation and question-answering the focus is often on either rigid principles of behaviour (like Grice's conversational maxims) or structural answerhood relations (discourse relations from Thompson and Mann and Asher and Lascarides, Krifka's congruence, Groenendijk's notion of pertinence), or quantitative (decision theoretic) reasoning (Merin, van Rooy).

In this paper I have argued for a more liberal perspective, which is based upon but does not presuppose Gricean or decision theoretic rationality and cooperativity assumptions, and which can be used to give a formal account of what can be called "optimal discourses". My account is based on the interests of the discourse participants, and sticks to the usual qualitative type of reasoning. It is not regulative, and does not presuppose cooperativity.

The main conclusion is, in the first place, that utterances in dialogues should be apprehended from a global perspective, which takes into account the information and possible intentions of the dialogue participants, rather than from a local perspective, which focuses on local discourse relations only. In the second place, the conclusion is that such an account can be appropriately formalized. Indeed, the discussion in the last section of this paper was by and large programmatic, but if one adds one's own favourite type of epistemic logic, together with some suitable assumptions about the way agents are, all the results ought to be computable.

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