Questions

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Questions

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19.1 Introduction

In this chapter we give an overview of the research area which studies the meaning of questions. We start with explaining some general notions and insights in this area, and then zoom in on the three most influential semantic theories of questions, which all attempt to characterize question meaning in terms of "answerhood conditions". (They are thus following up on the notion of "truth conditions" as the core notion of a formal semantics for indicative sentences.) Next, we discuss some special topics in the study of questions and answers, where we focus on issues which are concerned with identity and questions which have to do with scope. Finally, we describe some pragmatic features of answering questions and the general role that questions play in the dynamics of discourse, leading up to a concise introduction of the recent framework of inquisitive semantics.[1]

[1] Some of the introductory material in this chapter is based on Dekker et al. (2007). See Groenendijk and Stokhof (1997), Hagstrom (2003), Krifka (2011) and Cross and Roelofsen (2014) for other excellent surveys of question semantics.

19.2 Questions in formal semantics

Questions can be studied from various perspectives. For a syntactician, questions are linguistic entities, sentences of a certain kind with distinctive formal features. In English they typically display a change in word order (*Is Marco smart?* versus *Marco is smart*), they host *wh*-expressions with characteristic syntactic features (*who*, *what*, *where*, *how*, but also *which students*, *which Canadians* and the like), and in spoken language a question normally, but not invariably, comes with specific intonation, while in written language it is accompanied by a question mark.

For a semanticist, questions are abstract objects taken as the denotations of the above-described type of syntactic expressions. A semanticist here may take his cue from the (formal) study of indicative sentences. There the aim is to uncover a domain of denotations (labeled "propositions" mostly), as, for instance, an algebra which hosts logical constructions (like that of conjunction, disjunction, negation) and logical relations (like entailment, synonymy, and (in-)consistency). In the semantic study of interrogatives the aim is to establish a corresponding domain of denotations that underlies suitable notions of question entailment and answerhood.

From a pragmatic perspective, questions are essentially events in a discourse or dialogue. In response to the utterance of an interrogative sentence one may legitimately ask "Was that a question?" Questions, then, are certain acts in a conversation the very performance of which is subject to linguistic and pragmatic rules. According to Fregean speech act theorists, simple sentences just have some propositional content as their semantic value, and a question is the act of bringing it up with a request of determining whether the proposition is true.

Questions are also the objects of wonder and doubt and can be studied from an epistemological or philosophical perspective. Questions are the things which cognitive beings can be concerned with, the questions which a person may have. Judy may ask herself whether or not she will be in Paris next year, and she may also wonder "Who am I?", "Does God exist?", or "How will the stock market develop?", all of this without explicitly asking anybody, or ever putting the questions into words.

One may wonder whether the four sketched perspectives on questions have a common focus, or whether they concern different aspects of eventually one and the same underlying phenomenon. Of course, the semantic study of questions most often takes the syntactic notion of an interrogative as given and as its point of departure, or, conversely, one can take interrogatives to be the syntactic means for expressing them. Furthermore, a semantic question can be taken to be issued in a discourse, and then a suitable pragmatic question is under what circumstances is this appropriate, and what would constitute, under given circumstances, a good reply. Finally, we may at least start from the pragmatic assumption that epistemology and semantics draw from the same domain, that the objects of wonder and doubt are the possible meanings of interrogatives. Whether our concerns in life are semantic is a question we modestly postpone to a later date.

Having made these equivocating assumptions, some ambiguities remain to be settled. Something which gets described under one label (that of a question) may turn out to be different things after all. At least we should realize that when the term *question* is used, it can be ambiguous. A phrase like *Menno's question* can refer to an interrogative sentence which Menno has uttered, or some associated abstract semantic object that he referred to in a questionnaire, or a speech act he performed on television, or just what we think is currently troubling Menno's mind. In this chapter the notion of a question is reserved entirely to that of the semantic denotation of interrogative expressions (the syntactic notion). For the pragmatic and epistemic notions of a question we try to systematically use the terms *question posed* and *question faced*, respectively.

19.2.1 The Semantics of questions

What is the meaning of an interrogative sentence? Maybe it is worthwhile reconsidering a similar question about indicative sentences, the answer to which is probably more widely known. While interrogative sentences are normally used to pose questions, and imperative sentences to issue commands, indicative sentences are normally used to convey information about the world around us. What information? That the actual world or situation is like it is said to be by the indicative, in other words, that the indicative gives a true description of that world/situation. There is more to be said about the meaning of indicatives, but if we focus on this aspect of meaning, then we can say that a hearer understands an indicative sentence if he knows what a world or situation should be like for the sentence to be true. As Wittgenstein (1922, 4.024) has put it:

> Einen Satz verstehen, heißt, wissen was der Fall ist, wenn er wahr ist. (To understand a proposition means to know what is the case, if it is true.)

Insights like this, the roots of which can be traced back to the work of Frege, Russell and later Tarski, have evoked the slogan "Meaning equals truth conditions", and this slogan in turn has prompted the semanticist to try and specify, for every sentence of a given language, under what circumstances it is or would be true.

Interrogative sentences can be approached in a similar spirit, be it not in terms of truth, but in terms of answerhood. Interrogative sentences are normally used to pose questions, and the purpose of posing a question normally is to get a good answer to it. Obviously, *Marco came to the party yesterday*, even if true, cannot count as an answer to the question *Did Muriel visit Prague?* (even though sometimes it can, in pragmatically deranged situations). Proper answers include *Yes, Muriel did*, and *No, Muriel never did.* The question appears to dictate what counts as an answer, a confirmation or denial, a certain proposition, or some typical constituent part of a proposition. In case of polar questions like the one we are facing here (also known as *yes/no*-questions), there are always two possible answers, basically *Yes* and *No*. However, in cases of *wh*-questions, those with a *wh*-phrase inside, there usually are many more possible answers. Consider the question: *Who wants to join us on a trip to the beach?* Again, *Marco came to the party yesterday* does not count as a proper answer, but *Marco, Michelle, and Muriel want to join* does count as an answer, as does *Nobody wants to.* As a matter of fact, taking the sentence frame "... want to join" and filling in the dots with any list of names, one gets a sentence expressing a possible answer.

In the case of questions, the conclusion that suggests itself is that one knows the meaning of an interrogative sentence if one knows, given the circumstances, what counts as an answer to the question it expresses. Since, however, this ought to be perfectly general, that is, since one should be supposed to know what would be an answer in all possible circumstances, this means that the meaning of a question resides in its answerhood *conditions*.

19.3 Three classical theories of questions

The insight that the meaning of a question resides in its answerhood conditions has been developed in three different, but obviously related, ways, which we will consecutively discuss in the next three subsections. We briefly compare the three approaches in the fourth.

19.3.1 Proposition set theory

The earliest formal linguistic treatment of questions is from Hamblin (1973). There, "answerhood conditions" are spelled out as the set of possible propositional answers to a question. Adopting notation introduced in Groenendijk and Stokhof (1997), let us use ? as a question forming (sentential) operator, one that may bind variables $x_1 \ldots x_n$ which figure as the variables that are questioned. Intuitively, $?x_1 \ldots x_n\varphi$ queries among the valuations of the variables $x_1 \ldots x_n$ whether the proposition that φ holds under that valuation. For example, consider the question in (1):

(1) Who called? ($?xCx$)

The question is interpreted as the set of possible answers that Marco called, that Michelle called, that Muriel called, that Don called, and so on. This may be rendered formally as follows (where D is the relevant domain of individuals and $[\![\varphi]\!]_g$ the interpretation of φ relative to some assignment g of values to the free variables in φ).

$$[\![?xCx]\!]_g = \{p \mid p = [\![Cx]\!]_{g[x/d]} \ \& \ d \in D\}.$$

Thus, the meaning of the question is considered to be the set of propositions p so that p is the proposition that d called, for any individual d in the relevant domain of individuals. Analogously, (2) is also interpreted as the set of possible answers that Marco interviewed Prof. Arms, Michelle interviewed Prof. Baker, Muriel interviewed Prof. Charms, and so on where Marco, Michelle and Muriel are students and the professors are professors, of course.

(2) Which student interviewed which professor? ($?xy(Sx \wedge Py \wedge Ixy)$)

This can be expressed formally as follows:

$$[\![?xy(Sx \wedge Py \wedge Ixy)]\!]_g = \{p \mid p = [\![Sx \wedge Py \wedge Ixy]\!]_{g[x/d,y/d']} \ \&\ d, d' \in D\}.$$

(This may not be the intended interpretation, but at this level of detail it is the most likely one.)

For polar questions, in which case the ?-operator does not bind any variable, Hamblin introduces a separate rule. Consider the following example:

(3) Did anybody call? ($?\exists xCx$)

The question in (9) is interpreted in a way that the two possible answers are that somebody called and that nobody called. This can be expressed formally as follows:[2]

$$[\![?\exists xCx]\!]_g = \{p \mid p = [\![\exists xCx]\!]_g \ or\ p = [\![\neg\exists xCx]\!]_g\}.$$

Hamblin has provided a nice and elegant formal idea of questions in terms of their possible answers. However, it has been questioned on three scores. Karttunen (1977) has argued that it should not just be the possible answers, but the possible *true* answers that we are interested in. Groenendijk and Stokhof (1984) have argued that it is the *exhaustive (or complete)* answers. Krifka (2001a), among many others, has argued that answers need not be propositional, but can be constituent answers as well.

19.3.2 Structured meanings

An approach to the semantics of interrogatives formally different from the one above, is the so-called categorial or structured meanings approach (e.g., von Stechow, 1991a; Krifka, 2001a). This type of approach also seeks the key to the meaning of interrogatives in terms of their possible answers, but it does not take propositional answers as the fundamental notion, but so-called constituent answers.

[2] Under a general rule that interprets $?x_1 \ldots x_n\varphi$ in a way that it also applies when ? does not bind any variable and delivers the results along the lines exemplified above for cases where it does, the result would be that for a polar question only the "positive" answer is captured. This can be remedied if for (1) we also add the proposition that nobody called as an answer, and for (2) the proposition that no student invited any professor. Then the general scheme would also deliver the negative answer to a polar question.

The main idea is that questions basically are propositional functions, with *wh*-elements indicating arguments of these functions to be filled in in order to get propositional answers.

Consider the following examples, where we use λ-abstraction to represent propositional functions:

(4) Who called? $(\lambda x\, Cx)$
Marco. $((\lambda x\, Cx)(m) \Leftrightarrow Cm)$

(5) Which boys saw which girls? $(\lambda xy\, Sxy)$
Marco Judy. $((\lambda xySxy)(m, j) \Leftrightarrow Smj)$

(6) Is it raining? $(\lambda f\, f(r))$
No. $((\lambda f\, f(r))(\lambda p\, \neg p) \Leftrightarrow (\lambda p\, \neg p)(r) \Leftrightarrow \neg r)$

Question (4) can be naturally understood as a request to fill in a true instantiation of the variable x for the sentential function Cx. If any argument is supplied by means of a constituent answer, like *Marco* (m), it fills the open place (x) and delivers a Hamblin-style answer, that Marco called (Cm). The difference with the propositional approach consists in the fact that question and answer combine by functional application. Questions are functions requiring arguments supplied by, hopefully satisfying, answers. If an interrogative hosts multiple *wh*-elements, as in Example (5), it denotes a function that demands tuples of objects as an argument to produce a proposition. In the case above, the pair consisting of Marco and Judy supplies this argument. Marco and Judy fill in, respectively, the first (x) and the second (y) open space in the relevant propositional function, thus yielding the propositional answer that Marco saw Judy. In the case of a polar question (6), the question is a propositional function demanding a valuation of the proposition that it is raining (r) itself. The type of argument thus is itself a function on the domain of propositions, a confirmation function, *Yes* $(\lambda p\ p)$ or a falsifying function, *No* $(\lambda p\, \neg p)$.

Obviously, the structured meanings approach properly deals with non-sentential ("constituent") answers.

(7) Is it raining?
Is it not raining?

(8) Who wants an ice cream?
Who does not want an ice cream?

The proposition set approach predicts that the two questions in (7) are equivalent. A good answer to the first question of these pairs also fully answers the second, intuitively, as well as formally. However, an affirmative reply (*Yes*) to the first question in (7) implies that it is raining; whereas as a reply to the second question in (7) it implies that it is not raining.[3] This comes out right

[3] Roelofsen and Farkas (2015) have however shown that the phenomena of polarity particle responses are more complicated than is reported here.

on the structured meanings approach. Similarly, a constituent answer like *Judy* to the first of the questions in (8) means that Judy wants an ice cream, while if it answers the second question it means that Judy does not want one. Also this directly follows from the structured meanings approach.

From this elementary exposition, it may already be clear that the structured meanings approach to questions can do anything with them, in a direct or otherwise indirect way, that the propositional approaches can do, including the partition approach discussed in the next section. For, formally, a framework of structured meanings is more fine-grained than an unstructured one, and unstructured propositions can in principle be constructed from the components contributed by the structured meanings approach. This, however, comes at the price of having meanings – questions and their characteristic answers – live in a variety of categories. They can be functions and arguments of all kinds of types. This may, but need not of course, obscure some structural characteristics of questions and answers which may be more immediately visible at the propositional level. For instance, logical relations of answerhood and entailment between questions are most naturally dealt with on such a propositional level. Furthermore, question-embedding verbs such as *wonder* and *know* (as in *wonder whether*, *know who*) cannot directly, intuitively, apply to the meanings of their embedded arguments if they can be any type of functions. The partition theory of questions sets out to address these issues.

19.3.3 Partition theory

In the Groenendijk and Stokhof treatment of interrogatives, questions "partition logical space". (See, e.g., Groenendijk and Stokhof, 1984, 1997; see also, Higginbotham and May, 1981; Higginbotham, 1996; Haida, 2007.) The partitions are derived from "abstracts", which are essentially the kinds of meanings employed in structured meanings semantics, and which are used to group together situations or possibilities in which the same answers are true. *Sameness* of answers, of course, induces an equivalence relation on the set of possibilities, hence the derived objects are indeed partitions of logical space. As it happens, this approach works uniformly for both polar questions and (multiple) constituent questions.

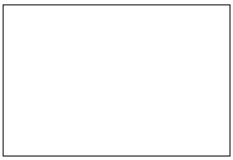
Formally a partition semantics assumes a standard predicate logical vocabulary and a question operator $?\vec{x}$ (where $\vec{x}$ is a possibly empty sequence of variables) that turns an indicative formula φ into an interrogative formula $?\vec{x}\varphi$. If $\vec{x}$ is an empty sequence of variables, $?\varphi$ is a polar (*yes*/*no*) question; otherwise, $?\vec{x}\,\varphi$ is a (multiple) constituent question. The question operator $?\vec{x}$ queries the possible values of the variables $\vec{x}$ under which the embedded formula φ is true.

Groenendijk and Stokhof's semantics of interrogatives can be stated relative to models of modal predicate logic $M = \langle W, D, I \rangle$, where W is a set of possibilities, D a domain of individuals, and I an interpretation function for the individual and relational constants, relative to each possibility. Variables are dealt with by means of the usual assignments g of values to variables and by $g'[\vec{x}]g$ we mean that assignment g' which is like g except (possibly) for the values it assigns to the variables in $\vec{x}$. In this setting, the interpretation of an interrogative can be defined in two steps:

$$[\![?\vec{x}\,\varphi]\!]_{M,g,w} = \{w' \mid \forall g'[\vec{x}]g : [\![\varphi]\!]_{M,w',g'} = [\![\varphi]\!]_{M,w,g'}\};$$
$$[\![?\vec{x}\,\varphi]\!]_{M,g} = \{[\![?\vec{x}\,\varphi]\!]_{M,g,w} \mid w \in W\}.$$

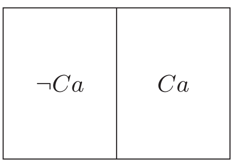
Relative to a particular world w, a question denotes a proposition (set of possibilities) which is true in exactly those possibilities where exactly the same valuations of the variables $\vec{x}$ render φ true, respectively false. The general notion of a question, the *meaning* of an interrogative, is the set of all of these propositions. Each proposition associates each possibility with the complete true answer to the question in that possibility. Upon this definition, $?\vec{x}\varphi$ cuts up the space of possibilities W in non-overlapping propositions (regions of logical space). In all possibilities in one and the same cluster the very same answer is the complete true answer to the question at stake.

The partition theory is conveniently illustrated with pictures. Logical space can be pictured as a geometric space of logical possibilities.



The points in the rectangle should be taken to constitute or cover the possibilities. An indicative sentence like *Anna is in Copenhagen* (formally: *Ca*) is true in some possibilities and false in others. If it is asserted, the claim is that the actual world is among the *Ca*-worlds, the worlds in which Anna is in Copenhagen. This is a region in logical space.

Now consider the question *Is Anna in Copenhagen?* (formally: ?*Ca*). The polar question has a positive and a negative possible answer. The possibilities in which the answer is positive can be grouped together, and the same can be done with the possibilities in which the answer is negative, and the two regions (i.e., propositional answers) have to be distinguished.



$?Ca$

This picture is meant to indicate an interest in knowing on which side of the line the actual world resides: are we in a *Ca*-world, one in which Anna is in Copenhagen, on the right side, or in a ¬*Ca*-world, where she is not there, on the left? The differences between worlds on the same side of the line are immaterial to this question.

We can subsequently add the question whether Ben is in Copenhagen, (formally: *?Cb*). This leads to an orthogonal distinction, this time indicated by means of a horizontal line:

	$\neg Ca \wedge \neg Cb$	$Ca \wedge \neg Cb$
$?Cb$	$\neg Ca \wedge Cb$	$Ca \wedge Cb$

$?Ca$

If we now, for the purpose of exposition, make the simplifying assumption that Anna and Ben are the only relevant individuals, then the last picture is the same as the next one representing the question *Who is in Copenhagen?* (formally: ?*x Cx*):

	$\neg \exists x Cx$	$Ca \wedge \neg Cb$
$?x\ Cx$	$\neg Ca \wedge Cb$	$\forall x Cx$

The basic assumption in the partition semantics is that *wh*-questions do not ask for some possible instantiation of the *wh*-term, but that they require a full specification of it, an *exhaustive* answer, that is. In order to answer the question *Who is in Copenhagen?* it is not sufficient to say that Anna is, because that only tells us that the actual world is on the right of the vertical line, and it does not tell us its location relative to the horizontal line. The answer does not tell us whether Ben is there or not. In that sense the mere proposition that Anna is in Copenhagen is at best a partial answer to the *wh*-question. A proper answer, in other words, is a full answer, and directly or indirectly dictates which individuals are, and which are not, in Copenhagen. Fully generally, an answer in a partition semantics specifies which sequences of individuals do, and which do not, stand in a questioned relation. They give a full, propositional specification, of the extension of such a relation.

As we said, in the pictures above, the relevant distinctions are the ones indicated. The question is in which of the blocks of a partition we are, in which *block* the actual world resides. What *kind* of world are we in? It shows no interest in just *any* specification of the kind of world we are in. A certain question, and the picture of it, displays indifference toward the issue whether we are in one of two worlds which both feature in the same block. They simply are, or are not, of the kind that we are interested in. For the purpose of a specific question two worlds in the same block count as equivalent, in a rather literal sense.

It turns out that when questions are formulated as partitions, equivalence relations, we get a neat notion of question conjunction and question entailment in return. Conjunction of questions is intersection of equivalence, and answerhood entailment is subsumption of indifference. The ensuing logic of questions and answerhood has been dealt with in detail in Groenendijk and Stokhof (1984). The logic of interrogatives will be further discussed in the section on inquisitive semantics below.

19.3.4 Comparison

There are interesting connections and differences between the three (types of) theories dealt with in the three preceding subsections. Obviously, most of them relate to the issues of constituent answers, and exhaustiveness.

Considering the proposition set approach and the partition theory first, we may observe that they are focused on propositions as possible answers. Interrogative *sentences* are assumed to be paired with indicative *sentences*. (Cf. *What is the situation? This is the situation!*) The major difference between the two approaches is that the first allows for any basic, positive answer. If one is asked who was at the parade yesterday, mentioning any random visitor may count as a good answer. On the partition theory, this would not be sufficient. The theory requires a full, exhaustive, specification of all who were there – among a relevant set of individuals of course. We will come back to this issue later in this section.

While the structured meanings approach also focuses on a notion of answerhood, it is stated in the mentioned categorial fashion, where questions denote functions which take answers as their arguments. Only the combination of the two, by functional application, eventually yields a proposition. The two types of approach have obvious benefits and drawbacks.

On the one hand, constituent answers (*Who comes? Menno*) are easily dealt with in a structured meanings approach. For a proposition set approach, or a partition theory, such constituent answers require some further work (Krifka, 2001a). As we have seen, in the partition theory, propositional answers are derived from constituent answers, figuring as argument of the so-called abstracts, which are assumed to be present at some underlying level of representation. A similar assumption is conceivable on the proposition set approach.

On the other hand, on the structured meanings approach full propositional answers can only be derived from constituent answers in conjunction with the original questions. Thus, the fact that *Menno comes* may provide the right kind of information in response to the question *Who comes?* only because it is one of the possible, propositional, values that the propositional function $\lambda x\, Cx$ may yield. At some level, then, propositional answers will have to play a role as well. Such a resort to propositions appears, for example, inescapable once it comes to embedded uses of questions. The coordination between *that*-clauses and various kinds of *wh*-clauses in sentences like *John knows that there will be a party, who has been invited and whether Mary is going to come* seems most appropriately dealt with at the propositional level (see Krifka, 2001a, for an account of question embedding in the structured meaning approach).

It may finally be noticed that the structured meanings approach does not uniformly abstract over obvious constituents in polar questions. As we have seen, a question like *Does anybody know the answer?* does not abstract over any constituent of the questioned proposition, but it abstracts over possible (positive or negative) evaluations of the proposition that somebody knows the answer. As we have seen, a typical positive answer *yes* ($\lambda p\, p$) returns the original proposition (that somebody knows the answer); a negative reply *no* ($\lambda p\, \neg p$) negates it.

In contradistinction, the partition theory uniformly applies to polar and constituent questions. For, if $\vec{x}$ is the empty sequence, then relative to some world w, $?\varphi$ denotes the set of possibilities $\{w' \mid [\![\varphi]\!]_{M,w',g} = [\![\varphi]\!]_{M,w,g}\}$, which is the set of worlds w' relative to which φ has the same truth value as in w. So this is the proposition that φ if φ is true in w, and the proposition that not φ, if φ is false in w.

A concern with exhaustive answers sets the partition theory apart from the two other approaches. On the partition approach, the question *Who comes?* ($?x\, Cx$) denotes in w the proposition that (the set of worlds in which it is true that) X come, where X are all and only the individuals who come in w. This way of modeling questions and answers allows for a set-theoretic analysis of conjunction and subsumption of questions. That is to say, for example, that the (constituent) question (9) entails the (polar) question (10).

(9) Who called?

(10) Did Marco call?

For any (full) answer to the first question entails (subsumes) a (full) answer to the second. Likewise, (11) simply amounts to the conjunction (intersection) of the answers to the questions in (12).

(11) Who (among Marco and Menno) called?

(12) Did Marco call? And did Menno?

From a formal logical perspective, this is surely a benefit of the partition approach. As we will see in Section 19.4, the partition approach can also be given a pragmatic, decision-theoretic motivation, precisely because the blocks in a partition can be taken to correspond to an agent's decision options.

Another claimed benefit of the partition approach is that its (exhaustive) semantics of unembedded interrogatives directly applies to embedded interrogatives (Groenendijk and Stokhof, 1984; Heim, 1994b). Consider the following examples of embedded questions.

(13) Marco knows who called.

(14) Muriel wonders who called.

Example (13) can be taken to express that there is a true answer to the question *Who called?* and even though the speaker may fail to know the answer, she expresses that Marco knows it. According to Karttunen (1977), what Marco is said to know is the conjunction of all the true basic answers to the question, so, for example, if Menno and Judy called, Marco must know the proposition that Menno and Judy called. However, imagine a scenario wherein Marco believes that everybody called; in such a situation Marco would know that Menno and Judy called without knowing who called contrary to Karttunen's predictions. For these and other reasons, Groenendijk and Stokhof (1984) argued that what Marco is said to know is not just a conjunction of singular propositions of the form *Menno called*. Rather, (13) says that, relative to a domain of relevant individuals, Marco knows of each of them whether he or she called or not – indeed the exhaustive interpretation. Likewise, in example (14), Muriel is not said to be concerned with the truth or falsity of a conjunction of singular propositions of the form *Judy called*, but with the question which proposition fully answers the question *Who called?*, and trying to figure out which possibly full answer is the actually true one. In both cases, then, the exhaustive interpretation of the embedded interrogative is the right object of knowledge and doubt (see also Heim, 1994b). Recent experiments reported by Cremers and Chemla (2014), however, have shown that *know*, besides a so-called *strongly exhaustive* interpretation (the one predicted by the partition theory, see (15a)), also allows for so-called *intermediate exhaustive* readings, illustrated in (15b) (Preuss, 2001; Klinedinst and Rothschild, 2011), while no clear evidence was found concerning the availability of the reading predicted by Karttunen's (1977) analysis, later labeled as *weakly exhaustive*, see (15c).[4]

(15) John knows who called.
   a. Strongly exhaustive interpretation:
      For each person who called, John knows that she called, and he knows that nobody else called.
   b. Intermediate exhaustive interpretation:
      For each person who called, John knows that she called, and John does not have false beliefs about persons who didn't call.

[4] Other verbs like emotive factive, *surprise* have instead been argued to have only weakly exhaustive readings (e.g., Heim, 1994b; Sharvit, 2002). However, see George (2011) for arguments against the availability of weakly exhaustive interpretations even for emotive factive verbs.

c. Weakly exhaustive interpretation:
For each person who called, John knows that she called.

The above considerations concern exhaustive interpretations of interrogatives. However, certain types of examples appear to favor non-exhaustive interpretations, so-called "mention-some" readings (Groenendijk and Stokhof, 1984; George, 2011). Examples (16) and (17) are typical.

(16) Who has got a light?

(17) Where can I buy an Italian newspaper?

These types of questions are normally (not invariably!) used to ask for one verifying instance only. If I have found someone who has a light, I do not care about who else has got one. Moreover, if I want to buy an Italian newspaper, one close enough place suffices, and a specification of all places around town where you can buy one seems pedantically superfluous. The question now is, do interrogatives have various types of meanings? Are they ambiguous? Or can we derive one of them from the other? Beck and Rullmann (1999) have presented a sophisticated and flexible response to this question, but it still remains an open issue.

19.4 Old and open issues

There are some old and open issues in the theory of questions and answers. We will discuss a few of them in this section in two groups: issues which have to do with identity, and issues which have to with scope.

19.4.1 Knowing who and which

Identity constitutes a perennial problem in the philosophy of language and in epistemology. Questions of identity also cause problems for semanticists, but for some more technical, and, hence, solvable, reasons. One issue is best explained in terms of the partition theory, even though it can be taken to trouble any approach. In a model $M = \langle W, D, I\rangle$ for partition semantics, names or individual constants are usually assumed to be "rigid designators", that is, they denote the same individual in every possibility. There is a solid reason for this assumption. Rigidity of names guarantees that a reply like *Judy called (and nobody else)* counts as a complete answer to the question *Who called?* This can be seen if we compute the denotation of this question in a world w and relative to an arbitrary variable assignment g, according to the partition theory.

$$\begin{aligned}
&\{w' \in W \mid \forall g'[x]g : [\![Cx]\!]_{M,w',g'} = [\![Cx]\!]_{M,w,g'}\}\\
&\quad = \{w' \in W \mid \forall d \in D : [\![Cx]\!]_{M,w',g[x/d]} = [\![Cx]\!]_{M,w,g[x/d]}\}\\
&\quad = \{w' \in W \mid I_{w'}(C) = I_w(C)\}
\end{aligned}$$

The above-mentioned reply expresses the following proposition.

$$\{w' \in W \mid \forall d \in D : d \in I_{w'}(C) \text{ iff } d = I_{w'}(j)\}$$
$$= \{w' \in W \mid I_{w'}(C) = \{I_{w'}(j)\}\}$$

If *Judy* is rigid, say $I_{w'}(j) = d$ for any possibility $w' \in W$, this is the full true answer to the question in any possibility w' such that $I_{w'}(C) = \{d\}$. If, however, *Judy* were not rigid, the reply would not be the true answer in w and would not correspond to any of the possible answers to our question in any world w'.

A rigid interpretation of names thus seems to be required. However, it has a nasty by-effect. Consider the question *Who is Judy?* ($?x\ x = j$), on the assumption that *Judy* is rigid. Then there is a specific $d \in D$ such that $I_{w'}(j) = d$ for any possibility $w' \in W$. The denotation (complete answer) in w then is the following proposition (set of worlds).

$$\{w' \in W \mid \forall g'[x]g : [\![x = j]\!]_{M,w',g'} = [\![x = j]\!]_{M,w,g'}\}$$
$$= \{w' \in W \mid \forall d' \in D : [\![x = j]\!]_{M,w',g[x/d']} = [\![x = j]\!]_{M,w,g[x/d']}\}$$
$$= \{w' \in W \mid \forall d' \in D : d' = d \text{ iff } d' = d\} = W.$$

The question turns out trivial, since it has only one possible answer, which is the trivial proposition, the proposition true in all possibilities. Obviously this is not what we want, because we can ask such questions as *Who is Judy?* in a non-trivial way, and we can make contingent assertions like *Marco knows who Judy is* and *Ben does not know who Judy is.* If *Judy* is interpreted rigidly this remains unexplained. Indeed, we face a dilemma: either we make *Judy* a proper answer to a *wh*-question, but then asking who Judy is becomes trivial; or we try and make sense of questions like *Who is Judy?* but then we cannot properly use the name to reply to a constituent question. We cannot have it both ways, it seems.

Aloni (2001) has shown a way out of this dilemma by a solution independently needed for the analysis of *de re* attitude reports. A detailed specification of the analysis would go beyond the confines of the present chapter, so we will only sketch the outlines. The basic idea is that even though quantification and reference are ultimately concerned with a domain of individuals, they are mediated by the perspective of a *conceptual cover*, by a way of "seeing" the domain.

We can assign names (and variables) a non-rigid interpretation, as *individual concepts*, that is, functions which assign a, possibly different, individual in each possibility as the referent of the name (or variable). Under ideal circumstances, the set of (interpretations of) names constitutes a conceptual cover, in the sense that each individual is named once in each possibility, but such that one and the same name may happen to denote different individuals in different possibilities. As has already been pointed out by Hintikka (1969), there are many other ways of epistemically viewing the domain. The idea then is that individuals are quantified over, and questioned, through the mediation of specific conceptual covers. The net effect is that if the question operator in $?x\ x = j$ is interpreted from a "naming" cover, then indeed the question is trivial. This is like asking *Who among Marco, Judy, . . . , and Muriel is Judy?*, which is quite silly indeed. However, if the question operator is interpreted from another perspective the question is no longer trivial. For instance, if you have a list of the names of the soccer players, about whom you know quite a bit from the newspapers, and if you see all of the players on the soccer field, it is quite legitimate to ask which of the persons you see there on the field is this player so-and-so on your list. This situation is straightforwardly accounted for once one adopts varying conceptual covers.

Aloni's approach explains why the very same answer to the very same question can be appropriate or inappropriate depending on the circumstances, or, more particularly, on the assumed perspective. Thus, to adapt an example from Aloni, a teacher can ask in the classroom:

(18) Do you know who Sandra Roelofs is?

A proper answer in this situation seems to be something like *The Dutch wife of the former Georgian president Mikhail Saakashvili.* However, if you are at a party where Sandra Roelofs is known to be present, and if you want to ask her to open the next Tbilisi symposium, then the very same reply to the very same question does not make much sense. Rather, you would expect or hope your interlocutor points out one of the visibly present individuals. (Conversely, your classroom teacher would not be very happy if, in response to her question, you were to go out, persuade Sandra Roelofs to accompany you to your classroom, and say, *This is Sandra Roelofs.*) With Aloni's conceptual covers, these cases can be smoothly dealt with, even independently of the particular general framework in which the interpretation of questions is formulated.[5]

Which-questions constitute another persistent challenge to any semantic account of interrogatives. Karttunen (1977), for instance, predicts that (19) entails (20):

(19) Ben knows who called.

(20) Ben knows which students called.

The reason is that if, for instance, Marco and Muriel are the only students that called, Karttunen's denotation for (20) will be {Marco called, Muriel called}, which is a subset of his denotation of (19). As a consequence one can be said to know, on Karttunen's interpretation, which students called without knowing which people are students. Groenendijk and Stokhof (1984)

[5] See Aloni (2008) and Aloni and Roelofsen (2011) for a more recent application of conceptual covers to the case of so-called concealed questions (Heim, 1979; Romero, 2005; Nathan, 2006; Frana, 2010).

point out that this result may be correct for a so-called *de re* reading of Example (20), but that it is wrong on its most prominent reading, which they label *de dicto*. So-called *de dicto* knowledge of which students called should include knowing that the student callers are students. Groenendijk and Stokhof analyze the sentence, roughly, as $?x\ (Sx \wedge Cx)$, and upon this analysis the *de dicto* reading is accounted for. Ben is said to know that the students who actually called are the students who called.[6] (Beck and Rullmann, 1999 proposed a quite different representation of the *de dicto* readings which does not use partitions. See Heim, 2011b for a detailed comparison.) The interpretation of *which*-questions is not fully settled, though. The following pair of examples clearly shows that we need to be more distinctive.

(21) a. Which men are bachelors?
     b. #Which bachelors are men?

Upon Groenendijk and Stokhof's "flat" analysis, the questions in examples (21) are rendered as $?x\ (Mx \wedge Bx)$ and $?x\ (Bx \wedge Mx)$, which are obviously equivalent. They both ask for a full specification of the male bachelors, i.e., of the bachelors. But obviously the two questions are different. The first (21a) makes sense, while the second (21b) is trivial.

Krifka's structured meanings approach presents us with one way out of the problem. According to Krifka (2001a), question (21a) denotes a *partial* propositional function, which is defined only for individuals that are male. This function is non-trivial because some of the males may be bachelors, and others may not be. In contrast, question (21b) denotes a propositional function that is defined for bachelors only, and, trivially, it assigns to each bachelor the proposition that he is male. Obviously, the idea of using partial functions, or partial interpretations, can be generalized, and exported to other frameworks.

Krifka's proposal neatly squares with the idea that quantified noun phrases in natural language (including, here, *which*-phrases) *presuppose* their domain of quantification. This idea can be taken to derive from Aristotle, and in the linguistics literature it has been independently argued for by Milsark (1974), Diesing (1992b) and Moltmann (2006). If we apply the same idea to *which*-phrases, the facts seem to fall right into place (see Aloni et al., 2007a, among others). Consider again *Which males are bachelors?* According to the previous suggestions, this implies that the domain of males is given, or under discussion, and that it asks for a distinction in that domain between the ones that are and those that are not bachelors. This intuitively makes sense, of course. Conversely, *Which bachelors are male?* implies that we are talking about the domain of bachelors and questions which of them are male and which are not. Given the assumptions about bachelors previously

[6] We, like most authors, here completely ignore problems with knowledge of the identity of these students – see the previous section.

stated, this question is indeed trivial, since all the bachelors are, by definition, known to be male.

We will not dwell further upon this issue here, because domain presuppositions constitute an independent and open subject of a more general theory of presupposition and quantification, and that is beyond the scope of the present chapter.

19.4.2 Questions and scope

An old and actual issue is whether questions can be outscoped and if so under what conditions. In English at least, it appears to be impossible to form the negation of an interrogative sentence, and indeed it is hard to conceive what the negation of a question could possibly mean. However, as we will see, conditional questions like *If Marco goes to the party, will Mona then go as well?* seem to be appropriately characterized, also semantically speaking, as questions in the nuclear scope of a conditional construction. Also, it is hard to see what *Is somebody unhappy*? could mean, assuming that *somebody* would outscope the question. Of course, somebody may say *Yes, I am unhappy*, but this would simply, positively, answer the polar question whether there is anybody who is unhappy. Since, taking *somebody* to have wide scope, it would be indefinite whom the question is about, it would be unclear, indefinite, what an appropriate answer could be. Things are different, however, with a universal quantifier.

Consider the following constituent question with a universal quantifier:

(22) Which book did every girl read?

This example may yield the following characteristic responses, with labels added indicating the assumed reading of the example:

(23) a. [Every girl read] *The Tractatus*. (single const. reading)
b. [Every girl read] Her favorite book. (functional reading)
c. Anna [read] *the Tractatus*, Michelle *War and Peace*, and Muriel *Lolita*. (pair-list reading)

It is particularly the “pair-list” reading, illustrated by the latter response, which is relevant for the current issue on whether questions can be outscoped. The fact that, for each girl, an exhaustive list of books may have to be issued suggests that indeed it is a question that is in the scope of the universal quantifier.

The availability of a pair-list reading depends on both the nature of the quantifier and the syntactic configuration of the sentence.

(24) Which book did most/several/no girls read?
a. *The Tractatus.*
b. Her favorite book.
c. #Anna [read] *the Tractatus*, Michelle *War and Peace*, and Muriel *Lolita*.

(25) Which girl read every book?
 a. Anna.
 b. #The girl that liked it best.
 c. #*The Tractatus* by Anna, *War and Peace* by Michelle, and *Lolita* by Muriel.

There is no generally agreed upon analysis of the data in the literature. We can distinguish two main approaches. Engdahl (1980, 1986) and Chierchia (1993) adopt a functional approach that derives the three interpretations of (22) as special cases of a functional reading and, therefore, deny the necessity of quantification into questions. Groenendijk and Stokhof (1984) and Moltmann and Szabolcsi (1994) argue for a quantificational approach and deem quantification into questions unproblematic. Krifka (2001b) has given this discussion a new twist by suggesting that in sentences like (22) the quantifiers actually take scope over the *speech act* that a question is. Assuming that speech acts can only be conjoined (but not negated or disjoined), a ready account of why only universals can outscope questions – as illustrated in (24) – obtains.

Krifka's proposal thus raises the discussion to a broader level, since the issue no longer is whether questions can be outscoped, but whether other types of speech acts can. Indeed, we observe striking similarities with imperatives that cannot be negated (or so it seems; they can be refused, of course) and that can be conditionalized (see Schwager, 2007, but also Portner, Chapter 20, and further references there).

Questions do seem to occur in embedded positions when they figure under doxastic operators, in *wonder who*- and *know whether*-constructions. Groenendijk and Stokhof distinguished between *intensional* and *extensional* question embedding operators. On their account, intensional verbs (e.g., *wonder*, *ask*) express a relation with a question as such, which is a partition of logical space on their account. Extensional verbs (e.g., *know*, *discover*), instead, express a relation to the proposition that is the value of the question (its true answer) in the actual world. Extensional verbs take both declarative and interrogative complements (26); by contrast, intensional verbs take only interrogative complements (27).

(26) a. Ben knows/discovered who cheated in the final exam.
 b. Ben knows/discovered that Marco cheated in the final exam.

(27) a. Ben wonders/asks who cheated in the final exam.
 b. #Ben wonders/asks that Marco cheated in the final exam.

It appears that only intensional verbs seem to allow for embedded "root" questions, such as we find in (28).

(28) Which novel did she have to read, Muriel wondered / asked / #knew / #discovered.

Krifka (2001b) explains this fact assuming that intensional verbs, like certain quantifiers, actually embed question speech acts rather than plain *wh*-clauses. (Notice that the analogy with imperatives seems to break down here.)

Karttunen (1977) has proposed another characterization of question-embedding attitude verbs, distinguishing between those that are factive and those that are not. Karttunen observed that attitude verbs receive a factive interpretation (that is, presuppose the truth of their complement) even if their non-interrogative variant is not factive. For example, (30), and not (29), implies that Muriel told the truth about what Marco was doing.[7]

(29) Muriel told Ben that Marco is coming.

(30) Muriel told Ben whether Marco is coming.

This observation is explained, on the accounts of both Groenendijk and Stokhof and Karttunen, because they take interrogatives to denote their true (exhaustive) answers. Therefore (30) expresses a relation between Muriel, Ben, and the true answer to the question *whether Marco is coming*. This factivity effect may also serve to explain why a verb like *believe*, which differs from *know* only because it lacks factivity, does not embed questions.

(31) Muriel knows that Marco is coming. $\models$ Marco is coming

(32) Muriel believes Marco is coming. $\not\models$ Marco is coming.

(33) Muriel knows whether Marco is coming.

(34) #Muriel believes whether Marco is coming.

Also Krifka (2011) endorses an explanation along these lines. See, for example, Ginzburg (1995a,b), Sæbø (2007), and Egré (2008) for alternative analyses.

Berman (1991) observed an interesting interaction between questions, question-embedding attitude verbs, and quantifying adverbs. Consider the following example.

(35) Ben mostly knows who cheated in the final exam.

Berman observed that sentence (35) has a reading that can be paraphrased as "For most people who cheated in the final exam, Ben knows that they cheated." Berman deemed this phenomenon an instance of "quantificational variability" (*QV*), after a similar effect observed with indefinites.

(36) A student usually works hard.

[7] Karttunen's observation, however, has been recently challenged by Spector and Egré (2015) who discuss the following cases showing that *tell* can be factive with respect to its declarative complement and non-factive (or non-veridical responsive) with respect to its interrogative complements:

(i) a. Every day, the meteorologists tell the population where it will rain the following day, but they are often wrong.
b. Did Sue tell anyone that she is pregnant? (presupposes that Sue is pregnant).

Sentence (36) has a meaning that can be paraphrased as "Most students work hard". Inspired by a Lewis/Kamp/Heim analysis of (36) (e.g., Lewis, 1975a), Berman proposed that *wh*-phrases, like indefinites, behave like free variables, which can be bound by a quantifying adverb. Example (35) thus can be rendered as in (37).

(37) For most *x* [*x* cheated][Ben knows that *x* cheated].

Of course, it remains to explain how a tripartite structure like (37) gets generated. Berman assumes a form of presupposition accommodation that puts the presupposition of the nuclear scope of quantificational adverbs in their restriction. He predicts that only factive verbs, which indeed presuppose their complement, allow for *QV*-readings.

Lahiri (2002), however, showed that factivity is not a decisive factor in *QV*. There is a class of non-factive verbs like *agree* or *be certain about* that does allow for *QV* interpretations.

(38) Ben and Marco agree, mostly, on which girls are asleep.

Lahiri assumes that *QV*-structures quantify over propositions (the true answers to the questions) rather than over individuals. Sentence (35) is hence analyzed as in (39):

(39) For most *p* [*p* truly answers "Who cheated?"][Ben knows that *p*].

Questions are here analyzed as in the propositional approach. The denotation of *who cheated* is taken to be the set of possible answers {that Marco cheated, that Michelle cheated, . . .}. This time, the tripartite *QV*-structure is taken to arise not from presupposition accommodation as in Berman but as a result of movement (Interrogative Raising). Movement is invoked to repair the type-mismatch which arises when a question (denoting here sets of propositions) occurs in the scope of a verb like *know*, which is assumed to operate exclusively on propositions.

It may be noticed that the analyses of *QV* by Berman and Lahiri are formulated adopting a propositional approach to questions and seem to be irreconcilable with the partition theory. Groenendijk and Stokhof (1993) and Beck and Sharvit (2002) have proposed alternatives, which do appear to be compatible. All in all, this serves to show that which approach to the semantics of questions is best remains an issue for debate.

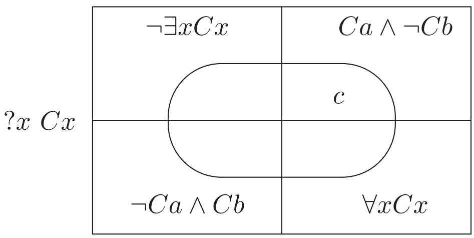
19.5 Recent theoretical perspectives

While philosophers and linguists have been happy for decades to study the semantics of indicatives out of context, for questions it is more difficult to ignore their contextual role. In the first two subsections, we touch upon some insights developed from a pragmatic and dynamic outlook on questions. In the last subsection, which elaborates on this, we introduce in some detail the recent framework of inquisitive semantics.

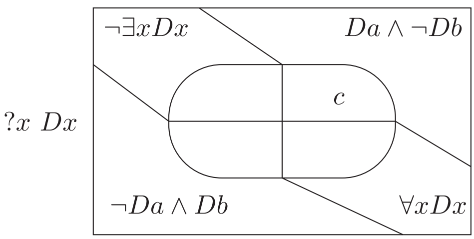
19.5.1 Pragmatics of questions and answers

It is generally acknowledged that utterances (such as assertions, questions) are never or hardly ever evaluated against an empty contextual background. Language is always used against a background of common knowledge or belief, private knowledge and belief, and information the interlocutors have about the information of others. Groenendijk and Stokhof already acknowledged this in their 1984 dissertation and developed a notion of a "pragmatic answer".

Consider the following picture, the same as the one for $?x\,Cx$, but now with an additional oval (labeled c) which is supposed to represent the current state of contextual information:



The oval labeled c must be understood as indicating that the actual world is assumed to be inside of it and that all possibilities outside the oval have been dismissed as being non-actual. The above picture indicates that, while the semantic question cuts up logical space into four big blocks, it is the division of the oval into four parts that is pragmatically relevant (since everything outside the oval is deemed non-actual and therefore irrelevant). This means, however, that a question different from $?x\,Cx$ might do the very same job, pragmatically speaking. Consider the next picture with a different possible question $?x\,Dx$:



The two questions are logically independent. For example, the answer $\neg\exists xCx$ to the question $?x\,Cx$ does not entail any answer to the question $?x\,Dx$, and the answer $Da \wedge \neg Db$ to the question $?x\,Dx$ does not entail any answer to

$?x\,Cx$. So, semantically, there is no entailment relation between the two questions. However, inside the oval the two questions coincide. So, pragmatically speaking, against the contextual background c, the questions are equivalent. This is interesting because it serves to explain how, after all, in certain contexts, (41) can be a sound answer to (40).

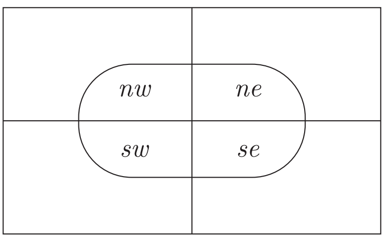
(40) Who wants to join us on a trip to the beach?

(41) Marco came to the party yesterday.

For if it can be assumed, in conjunction with the background information, that Marco visiting a party entails that he does (or does not, for that matter) want to join us on a beach trip, then the reply is surely, pragmatically, felicitous. Thus, if it is common knowledge that Marco is a total loss after having visited a party, a reply with (41) means that we can count him out.

In terms of such semantic and pragmatic notions of answerhood, Groenendijk and Stokhof (1984) developed an overall comparative notion of answerhood depending on contextual background information. The evaluation of answers they propose is guided by considerations directly linked to the Gricean conversational Maxims that make up his Cooperative Principle (Grice, 1975).

Van Rooij (2003b) argued that basic concepts from decision theory, in particular the concept of a decision problem, closely relate to such partitions. Consider an agent who wants to eat in a Thai restaurant and who faces a decision problem: which direction to go? Let us assume she is at a junction, where she could take four directions: northwest (*nw*), northeast (*ne*), southwest (*sw*), and southeast (*se*). Let us assume as well that she has information that there is exactly one Thai restaurant to be found in one of these directions, but that she has no information which direction that is. She could try all directions in some random order, but that is quite troublesome. She could also ask some passer-by for the direction to the restaurant, something displayed by the following diagram.



A full and hopefully true answer to her question would directly help to solve her decision problem. If the restaurant is to be found in direction northeast, then that is the way to go. A partial answer, like *Northeast or southwest*, however, would not help her out. Of course, she could skip considering northwest and southeast, but she still would not know where to go. This example shows that if one has to make a choice, where only one choice can or should be made among alternatives, then a very appropriate thing to do is to pose a question in which every possible answer corresponds to exactly one possible choice, that is, *given the background information*. Van Rooij (2003b) has not only noted this kind of formal correspondence between notions of decision theory and the partition semantics but also worked out decision-theoretic notions for comparing the relevance of questions and of answers.[8]

19.5.2 Questions in discourse

In the final decades of the last century, the meaning of an indicative sentence has been formulated in terms of its so-called context change potential, instead of its familiar truth conditions. Under this dynamic perspective, assertions are made with the intention to update the discourse context, which can be taken to be the "common ground" of the conversation, a representation of the contents of a discourse, or simply the information the interlocutors have of the situation they are in. Interrogatives most naturally fit this picture as well. Simply imagine how utterly awkward it is to disregard a question once it has been posed.

Questions in discourse and dialogue have been studied in a variety of semantic frameworks (Roberts, 1996; Hulstijn, 1997; Asher and Lascarides, 1998b; Cooper, 1998; Ginzburg and Sag, 2000; Büring, 2003; Groenendijk, 2006). In such approaches a discourse is taken to be aimed at the exchange of information, and they are therefore conceived of as games of stacking and answering "questions under discussion" (Ginzburg, 1995a,b) or as processes of "raising and resolving issues" (Hulstijn, 1997). These exchanges are governed by various kinds of rules, ranging from what can be deemed structurally linguistic, discourse configurational principles, to the very pragmatic principles of reasonable or rational coordination. By adopting a dynamic outlook upon interpretation, such systematic principles and effects have been characterized in a transparent manner.

The relevant type of information (of the interlocutors, or in the "common ground") concerns the information that has been established in a discourse up to some point. It can be modeled as a set of possibilities, and updates of information then consist in the elimination of possibilities. If we know or learn more, fewer possibilities turn out to be compatible with the information we have, and in the extreme case we could be left with only one possibility, specifying totally how exactly (we think) things are (Roberts, 1996).

Of course, hardly anybody purchases the specific goal of gaining total information. Updates in discourse are limited to and guided by the questions we actually have, the ones we factually pose, or those that others decide we might be interested in. Here is where Ginzburg's (1995a) and

[8] In van Rooij (2003a) these ideas are extended to account for the felicity of negative polarity items in questions. For an alternative account of this phenomenon, see Guerzoni and Sharvit (2007); Beck (2006); Nicolae (2013).

Roberts' (1996) "questions under discussion" kick in, and, likewise, the "raising and resolving issues" from Hulstijn (1997). At any point in a discourse or dialogue, several questions may be "alive" because they are explicitly or implicitly raised, or assumed to be relevant. In order to account for such a state in discourse, it is not sufficient to only have at our disposal the set of possibilities compatible with the information assumed and exchanged so far. We also need the relevant differences between possibilities which the interlocutors wish to distinguish, or the (discourse) goals they wish to establish.

In the tradition of model-theoretic semantics, updates of information and issues have given rise to dynamic variants of the partition approach to questions (Jäger, 1995; Hulstijn, 1997; Dekker, 2004; Groenendijk, 2006). To be able to model not only the update of a discourse context with information, but also with issues, a context is not identified with a set of possibilities, modeling information, but with an equivalence relation over a set of possibilities, sometimes called an *indifference relation*. That two possibilities in a discourse context are connected by the indifference relation means that the ways in which these possibilities may differ are *not at issue* in that context. So, thus conceived, discourse contexts can model both information and issues.

Unlike the update of a discourse context with an assertion, an update with a question typically does not lead to an *elimination of possibilities*, but to *disconnecting possibilities* that were hitherto connected by the indifference relation, thereby making the differences between the disconnected possibilities an issue in the discourse context.

Since an equivalence relation over a set corresponds to a partition of it, we can also picture a discourse context as a partition of the set of possibilities that are not excluded by the current contextual information. For an assertion to compliantly address the current issue in a discourse context, an update of the context with the information it provides should eliminate all the possibilities within at least one block in the partition.

There is an immediate connection here with the topic of the previous subsection: pragmatics of questions and answers, since to *compliantly address the contextual issue* (or not) is typically a matter of adhering to the Gricean Cooperative Principle, more in particular the Gricean Maxim of Relation. This link between dynamic partition semantics and Gricean pragmatics is discussed in Groenendijk (2006).

Also directly related is the dynamic approach to contextually restricted quantification in Jäger (1995). A minimal pair of the kinds of examples dealt with is provided in (42).

(42) a. Who is wise? Only Socrates is wise.
b. Which Athenian is wise? Only Socrates is wise.

The reply in (42a) typically states that Socrates is the only wise person in the universe of discourse. Restricted by the question preceding it, the same reply in (42b) can be taken to mean that Socrates is the only wise Athenian. (See Aloni et al., 2007a, for an elaboration of this approach and further references.)

Of course, there are alternative dynamic approaches to the semantics of discourse not tied to the partition-style approach and variations thereof. See, for example, Asher, Chapter 4 on discourse semantics and Ginzburg, Chapter 5 on the semantics of dialogue. In the next subsection, we introduce in some detail a semantic framework which is in the spirit of the dynamic variants of the partition semantics but leads to a more general notion of meaning that can accommodate most of the approaches to the semantics of questions discussed above.

19.5.3 Inquisitive semantics

Recently, Ciardelli, Groenendijk, and Roelofsen have developed a general semantic framework, called *inquisitive semantics*, for dealing with informative and inquisitive aspects of meaning in an integrated way (Ciardelli and Roelofsen, 2011; Ciardelli et al., 2012, 2013; Roelofsen, 2013).[9] We introduce the basics of the framework here in relation to theories of questions in discourse, in particular the dynamic variants of partition semantics, as discussed in the previous subsection.[10]

As we have seen above, what generically underlies theories of questions in discourse is that discourse contexts are conceived of as consisting of a certain body of information and certain questions or issues that are contextually relevant. Here we make the simplifying assumption that a single issue is at stake.

So, schematically, a context c can be viewed as a pair $(\mathsf{info}_c, \mathsf{issue}_c)$ of which the two elements represent the *contextual information* and the *contextual issue* respectively. Standardly, info_c is modeled as an *information state*, which is the set of all possibilities that are not excluded by the current contextual information.

As we have seen above, in dynamic partition semantics, issue_c is modeled as an *indifference relation*, an equivalence relation over info_c, which gives rise to a partition of info_c into a number of mutually exclusive substates of it that jointly cover it.

In inquisitive semantics, issue_c is directly modeled as a set of substates of info_c, namely *all of its substates where the contextual issue is settled*. This straightforwardly models a contextual issue from a dynamic perspective: the elements of issue_c directly reflect which *updates* of the current information will settle the current issue. It follows immediately from viewing the contextual issue in this way that issue_c has to be a *downward closed set of states* because, if

[9] These papers concern basic inquisitive semantics and logic. Papers on variations and extensions of the basic system, and on linguistic and logical-philosophical applications, can be found at www.illc.uva.nl/inquisitivesemantics.

[10] This introduction is based on Ciardelli et al. (2013).

the current contextual issue is settled in some state $s \subseteq \mathsf{info}_c$, then that also holds for any more informed state $t \subset s$.

Just as in dynamic partition semantics, every possibility in info_c must be included in one of the blocks in the partition induced by issue_c, in inquisitive semantics it is required, that no possibility in info_c is excluded from *all* possible ways to settle the issue, that is, issue_c is required to be a *cover* of info_c.[11]

Finally, in dynamic partition semantics the contextual issue is *trivial* when the indifference relation that issue_c corresponds to is a *total* relation on info_c, in which case info_c itself is the one and only block in the partition that issue_c gives rise to.

Similarly, in inquisitive semantics the contextual issue is *trivial* when it is already settled by the contextual information, that is, in case $\mathsf{info}_c \in \mathsf{issue}_c$. This means that even in an initial context where no issue has been raised yet, issue_c is *not empty*, which we find as a general constraint in the definition of an issue over an information state in inquisitive semantics:

- $\mathcal{I}$ is an *issue over a state s* iff $\mathcal{I}$ is a non-empty set of substates of s such that:
  (i) $\mathcal{I}$ is downward closed: if $t \in \mathcal{I}$ and $t' \subseteq t$, then $t' \in \mathcal{I}$; and
  (ii) $\mathcal{I}$ is a cover of s: $\bigcup \mathcal{I} = s$.
  $\mathcal{I}$ is a *trivial issue* over s iff $s \in \mathcal{I}$.

We started out by taking a context as a pair $(\mathsf{info}_c, \mathsf{issue}_c)$, but when we take issue_c to be an issue over info_c, then just issue_c suffices to characterize a context, since it determines that $\mathsf{info}_c = \bigcup \mathsf{issue}_c$. In other words, we can *identify* a context with a non-empty downward closed set of states. In the definition we use ω to denote the set of all possibilities.

- A *context* $\mathcal{C}$ is a non-empty downward closed set of states.
  The *contextual information* in $\mathcal{C}$ is $\mathsf{info}(\mathcal{C}) = \bigcup \mathcal{C}$.
  A context is *inquisitive* iff $\mathsf{info}(\mathcal{C}) \notin \mathcal{C}$.
  A context is *informed* iff $\mathsf{info}(\mathcal{C}) \neq \omega$.

A special context, which could be dubbed *the initial context*, is the unique context that is neither informed nor inquisitive. It equals the powerset of the set of all possibilities ω, that is, the set of all states.

Although there are global correspondences in the architecture of contexts in dynamic partition semantics and in inquisitive semantics, there are also crucial differences. One way to illustrate this is by introducing the notion of the *alternatives* in a context $\mathcal{C}$ as the maximal elements of $\mathcal{C}$. These correspond to minimal extensions of the current information where the contextual issue is settled.

- s is an *alternative* in $\mathcal{C}$ iff $s \in \mathcal{C}$ and there is no $t \in \mathcal{C} : s \subset t$.

[11] We can look upon the situation where this would *not* be the case as one where the issue has a certain *presupposition* that is *not satisfied* by the current contextual information. We do not allow for such a situation.

Although, likewise, in dynamic partition semantics, the blocks in a partition are the maximal sets of possibilities that are totally related by the indifference relation, there is a significant difference between the two cases. In inquisitive semantics the alternatives in a context $\mathcal{C}$ may mutually exclude each other and form a partition of $\mathsf{info}(\mathcal{C})$, but they may just as well overlap. This means that the notion of a contextual issue is essentially richer in inquisitive semantics than it is in dynamic partition semantics, as we will further illustrate below.

Having introduced a notion of context that fits a theory of questions in discourse, we now turn to a corresponding notion of meaning, viewed from a dynamic perspective as a contextual update. In the most basic classical versions of update semantics, contexts and propositions are taken to be semantic objects of the same kind, and both are typically conceived of as sets of possibilities, that is, "classical propositions". Then, if $[\varphi]$ is the proposition expressed by a sentence φ, the corresponding update of a context c with φ can simply be taken to be $c \cap [\varphi]$. Moreover, the dynamic meaning of φ is given by the update function $\lambda c.\ c \cap [\varphi]$.

This classical pattern can easily be reproduced in dynamic partition semantics where a context is an indifference relation. Interrogative sentences already correspond to such relations in standard partition semantics, and declarative sentences can be made to fit by associating them with an indifference relation which totally relates all the possibilities in the proposition that it classically expresses.

Contexts and meanings of sentences are semantic objects of the same kind, where declarative sentences share the properties of non-inquisitive contexts. Furthermore, since relations correspond to sets of pairs, and the intersection of two indifference relations is always guaranteed to be an indifference relation itself, we can formulate the update of a context with a sentence in terms of plain intersection.

In inquisitive semantics it holds as well that the intersection of two issues is itself an issue. This means that if we also take the proposition expressed by a sentence to be a non-empty downward closed set of states, updating a context with the meaning of a sentence can be taken to be plain intersection. Moreover, this is, indeed, how propositions are modeled in inquisitive semantics, leading to a notion of meaning in which informative and inquisitive content are fully integrated.

- A *proposition* $\mathcal{P}$ is a non-empty downward closed set of states.
  The *informative content* of $\mathcal{P}$, $\mathsf{info}(\mathcal{P}) = \bigcup \mathcal{P}$.
  $\mathcal{P}$ is an *inquisitive* proposition iff $\mathsf{info}(\mathcal{P}) \notin \mathcal{P}$.
  $\mathcal{P}$ is an *informative* proposition iff $\mathsf{info}(\mathcal{P}) \neq \omega$.

Conceptually, inquisitive semantics takes the utterance of a sentence that expresses a proposition $\mathcal{P}$ to be a *proposal* to the participants in the conversation to jointly cooperate in establishing an update of the current contextual information $\mathsf{info}(\mathcal{C})$, the current common ground, in such a way that a new context $\mathcal{C}'$ results, where $\mathsf{info}(\mathcal{C}') \in \mathcal{P}$. In order to reach this goal, the participants in the conversation have to be able to accept the information that $\mathcal{P}$ provides, if it is informative, and to provide information that settles the issue $\mathcal{P}$ raises, if it is inquisitive. More succinctly put, a proposition is a proposal to the participants in the conversation to update the common ground in one or more ways.

The notion of the alternatives in a context defined above also applies to propositions.[12] Given how inquisitiveness is defined, if there is more than one alternative for a proposition, then it is inquisitive. Conversely, if there is only a single alternative for a proposition, then it is not inquisitive. Such non-inquisitive propositions are called *assertions*, and non-informative propositions are called *questions*.

So in inquisitive semantics we can uniformly assign propositions as meanings to all sentences, but having the properties of assertions in case of declarative sentences, and the properties of questions in case of interrogative sentences.[13]

Whether we view contexts and propositions as indifference relations, as in dynamic partition semantics, or whether we view them as non-empty downward closed sets of states, as in inquisitive semantics, we can straightforwardly define an *entailment* relation between them, which integrates informative and inquisitive content and applies uniformly, irrespective of whether $\mathcal{P}$ or $\mathcal{Q}$ is a question, assertion, neither, or both.

- (*Entailment*) $\mathcal{P} \models \mathcal{Q}$ iff $\mathcal{P} \subseteq \mathcal{Q}$.

Given the following fact, we can also look upon entailment in both cases from an *update perspective*:

- $\mathcal{P} \models \mathcal{Q}$ iff $\mathcal{Q} \cap \mathcal{P} = \mathcal{P}$.

Before we end this introduction to inquisitive semantics by providing a handful of examples, we first make some rather technical remarks concerning the comparison of partition semantics and inquisitive semantics that may also serve to motivate our particular choice of examples.

As is shown in Roelofsen (2013), under the entailment relation defined above, the set of all propositions in inquisitive semantics forms a Heyting algebra, with operators that can be associated in the standard way with the logical constants in a logical language: meet (conjunction and universal quantification), join (disjunction and existential quantification), and relative and absolute pseudo-complement (implication and negation respectively).

12 This use of the term *alternatives* is closely related to its use in the framework of *alternative semantics* (Kratzer and Shimoyama, 2002; Simons, 2005; Alonso-Ovalle, 2006; Aloni, 2007, among others). The connection between inquisitive semantics and alternative semantics is discussed in detail in Roelofsen (2013), Theiler (2014), Ciardelli and Roelofsen (2015).

13 The framework of inquisitive semantics as such does not dictate such a sharp semantic distinction between declaratives and interrogatives. It allows for hybrid cases of sentences, or sequences thereof, which are both informative and inquisitive. The issue is discussed extensively in Ciardelli et al. (2015).

The set of propositions when viewed as indifference relations, as in dynamic partition semantics, has a different algebraic structure under the entailment relation, which lacks a relative pseudo-complement operator. (It forms a pseudo-complemented lattice.) As a consequence, unlike in inquisitive semantics, in partition semantics there is no principled general way to obtain an interpretation of implication that can deal uniformly with conditional assertions and conditional questions.[14] Furthermore, although the algebraic structure we obtain has a join operator, unlike in the case of inquisitive semantics it does not correspond to taking plain unions of propositions. The reason behind this is that a union of indifference relations is not guaranteed to be an indifference relation itself, and is not guaranteed to give rise to a partition. A union of indifference relations will preserve reflexivity and symmetry but may lack transitivity and hence fail to be an equivalence relation. The join operator in the algebra underlying partition semantics corresponds to taking the transitive closure of the relation that results from taking plain unions of propositions as indifference relations.[15]

It is this difference in the nature of the join operator in the two algebras that lies behind the fact that, unlike in inquisitive semantics, partition semantics cannot deal properly with mention-some interpretations of constituent questions, as exemplified by (16)–(17) above,[16] nor can it deal generally with disjunctive questions.

By way of illustration of the inquisitive semantic framework, we depict in Figure 19.1 a plausible assignment of a proposition as its meaning for the five sentences (43)–(47) and discuss the semantic properties of these propositions and the logical relations between them.

In the last example, we use ↑ to indicate rising intonation, which has an influence on how the sentence is interpreted.

(43) Peter will attend the meeting.

(44) Will Peter attend the meeting?

(45) Who of Peter and Maria will attend the meeting?

(46) If Peter attends the meeting, will Maria attend it too?

(47) Will Peter↑ attend the meeting, or Maria↑?

[14] This does not preclude an analysis of conditional questions as such in a partition semantics. E.g., they are dealt with by Isaacs and Rawlins (2008) in a dynamic partition framework which involves stacked contexts.

[15] What naturally suggests itself, see Mascarenhas (2009), is to drop transitivity as a necessary property of indifference relations. One can then look upon an issue as the set of all *pairs of possibilities* where it is settled. As discussed in Ciardelli et al. (2015), such a "pair semantics" actually suffices for an adequate treatment of conditional questions along the lines of Velissaratou (2000). However, as has been conclusively shown in Ciardelli (2009) and Ciardelli and Roelofsen (2011), one has to generalize from pairs to sets of arbitrary size to enable a general proper treatment of disjunctive and mention-some constituent questions.

[16] This does not preclude a pragmatic account of mention-some readings based on a partition semantics, as proposed in van Rooij (2003b).

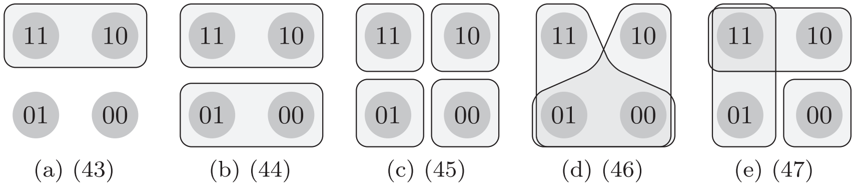


Figure 19.1 *Propositions expressed by examples (43)–(47)*

Whereas with *falling* intonation on its last disjunct (47) expresses a so-called *alternative question*, which is widely taken to presuppose that one and only one of the disjuncts holds, with *rising* intonation on the last disjunct it has no such presupposition and leaves open the options that both or neither of the disjuncts holds. For this reason, the question that (47) expresses is called an *open disjunctive question*.[17]

Since only the two individuals Peter and Maria figure in these examples, and only the property of attending a certain meeting plays a role, a logical space of four possibilities suffices for our illustrations: one possibility where both Peter and Maria will attend, one where only Peter will, one where only Maria will, and one where neither Peter nor Maria will attend. In the pictures in Figure 19.1, these possibilities are labeled 11, 10, 01, and 00, respectively.

The demarcated areas in the pictures of the propositions represent the *alternatives* for each proposition. Only the maximal states in a proposition are depicted explicitly, but keeping in mind that propositions are downward closed sets of states, this fully determines a proposition.

In what follows, we will use the labels of the sentences (43)–(47) also to refer to the propositions assigned to them. And since propositions and contexts are objects of the same kind, we also use these labels to refer to the corresponding contexts.

Of our five examples, only (43) is not inquisitive, since only this proposition has a single alternative. It is an *informative assertion* since its informative content, which coincides with its unique alternative, excludes the two possibilities where Peter will not attend.

The other four propositions (44)–(47) are all not informative, since the union of their alternatives, and hence of all the states they contain, covers the whole logical space. Moreover, since their pictures show more than one alternative, they are *inquisitive questions*. The alternatives for the polar question (44) and for the constituent question (45) form a partition of the logical space. This is not so for the conditional question (46) and the open disjunctive question (47), which have two overlapping alternatives.

[17] We have chosen this example of a disjunctive question because the basic inquisitive semantic framework presented here does not deal with presuppositions. However, there are natural ways to extend the framework in such a way that presuppositions can be captured (see AnderBois, 2011; Ciardelli et al., 2015). (For discussions of disjunctive questions, see, among others, Han and Romero, 2004; Beck and Kim, 2006; Aloni et al., 2013; Roelofsen and van Gool, 2010; Biezma and Rawlins, 2012; Pruitt and Roelofsen, 2013; Uegaki, 2014.)

Consider the relation between the assertion (43) and the polar question (44). As generally holds for assertions, the single alternative for (43) equals its informative content. And since $\mathsf{info}(43) \in (44)$, the information the assertion provides settles the issue the polar question poses. Owing to downward closure, $\mathsf{info}(43) \in (44)$ also means that $(43) \subseteq (44)$, and hence that (43) entails (44). Viewing entailment from an update perspective: if we consider $(44) \cap (43)$, the resulting context equals (43), and hence unlike the original context (44), its update with (43) is no longer inquisitive.

These observations do not hold for this assertion in relation to the constituent question (45): (43) does not entail (45). Showing this from the update perspective, if we update the context where the constituent question (45) is the issue with the assertion (43), the resulting context $(45) \cap (43)$ is still inquisitive. Its picture consists of the top half of (45), and hence there are still two alternatives.[18]

The resulting updated context is informed about whether Peter will attend the meeting, but the issue remains whether Maria will attend as well. However, one can say that although the updated context is still inquisitive, it is *less inquisitive* than the one we started out from.

We now turn to the conditional question (46). There are two overlapping alternatives for (46) which correspond to the informative contents of the two conditional assertions in (48).

(48) a. If Peter attends the meeting, then Maria will as well.
b. If Peter attends the meeting, then Maria won't attend.

Consider the relation between the assertion (43) and the conditional question (46), where the former affirms the antecedent of the lattter. The situation is the same as discussed for (43) in relation to the constituent question (45) insofar as $(46) \cap (43) = (45) \cap (43)$, which we have seen to be inquisitive. However, there is also a difference in that whereas we saw that $(45) \cap (43)$ is *less inquisitive* than (45), this does not hold for $(46) \cap (43)$ as compared to (46). Although less remains of the two alternatives for (46), two alternatives do remain. This relates to the intuition that, by default, a response to a conditional question that affirms the antecedent is not a very happy conversational move.

In a different sense, the latter also holds for the negation of (43), which *denies* the antecedent of (46) and, unlike (43), *does* entail it. In other words, it settles the issue it poses but does so by *dismissing the supposability* of the antecedent.[19]

As for the last example, the relation between the assertion (43) and the open disjunctive question (47) is much the same as we already described for

[18] To see this by inspecting the pictures, you have to take into account that they only explicitly show the alternatives for a proposition, but that due to downward closure, all subsets thereof are elements of the proposition as well.

[19] The special status of the denial of the antecedent of a conditional is not accounted for in the semantics presented here. It is addressed in Groenendijk and Roelofsen (2015).

the relation between this assertion and the polar interrogative (44). In particular, (43) entails (47), as do the assertions in (49). Unlike (43), the assertions in (49) also entail the constituent question (45).

(49) a. Only Peter will attend the meeting.
b. Both of them will attend the meeting.
c. Neither of them will attend the meeting.

However, the same does not hold for the relation between the *negation* of (43), namely (50), and the open disjunctive question (47).

(50) Peter will not attend the meeting.

In this case, whether we update a context where (47) is the issue or a context where (45) is the issue with (50), the result is the same. The resulting context corresponds to the bottom half of the context depicted in (45), that is the resulting context is still inquisitive, but *less inquisitive* than the context we started out with. In case of the open disjunctive question (47), the alternative where Peter will attend has been eliminated from the picture.

A last remark on the question depicted in Figure 19.1e. This proposition can also plausibly be assigned to a mention-some constituent question, exemplified by (16) and (17) above, for the simplified case where the relevant domain consists of two individuals.

This ends our illustration of the basic inquisitive semantic framework. It is a framework, and not a linguistic theory about which meanings are to be assigned to specific sentences in a language like English, if only because such a theory is typically *compositional*. To make it possible to formulate such a theory, one needs to lift inquisitive semantics to a full-fledged intensional type theory. However, given that, despite its novelties, inquisitive semantics is logically rather conservative, as its algebraic features show, there is no need to be skeptical about the possibility of executing this lift. In fact, the first steps have been taken in Theiler (2014) and Ciardelli and Roelofsen (2015).

19.6 Conclusions

In this chapter we have given a concise overview of the findings and insights of the main types of semantic approaches to questions, and of some of the old and current debates on the interpretation of specific questions, as well as on general features of the analyses of questions that have been proposed. For the most part, a common thread has been the notion of answerhood conditions, as a specific semantic dimension of interrogative sentences, distinguishing them from indicatives, whose semantics has been framed in terms of truth conditions.

However, at the end of this chapter, we have also seen that more recent approaches, which are information-based rather than truth-based, have led to a more integrated treatment of the meanings of indicatives and interrogatives, where they are also no longer directly driven by the linguistic notion of answering a question, but rather by the more primary logical notion of settling an issue.

Being slightly biased, perhaps, we have emphasized the logical role that questions play precisely in terms of the notions of answerhood and settling an issue. More practically oriented approaches are dealt with in more detail in Asher, Chapter 4 on discourse semantics and Ginzburg, Chapter 5 on the semantics of dialogue.

No matter how static model-theoretic models may be, we have also given some idea of how the pragmatics and dynamics of questions can be dealt with along fairly classical lines, indicating how partition-style theories, but in principle other theories equally easily, have been extended so as to display the kind of structure relevant in the interpretation of discourse. Of course the exposition could only be indicative of the kind of work done, and we hope the references made, along with the other chapters in this book, may help readers to find their way in the literature.

One point has hardly been addressed. Most semantic theories of questions take their cue from English, with the corpus of examples employed in theoretical debates being in English as well. However, nobody nowadays would deny the importance of cross-linguistic data, and this should surely hold for the (semantic) theory of questions. It seems to be a fair assumption that the existence of questions is a universal across languages and that questions can be assumed to be universally realized syntactically, semantically, pragmatically, and epistemologically. Since different languages and cultures may show variety in these realizations, the cross-linguistic study of question meanings is of great importance. Unfortunately, however, at present we can only point to recent work and findings (see Beck, 2006; Haida, 2007; Cable, 2010; Slade, 2011; AnderBois, 2012; Roelofsen and Farkas, 2015; Uegaki, 2014, among others).

In this chapter we have also said little about the computation of questions, the generation of answers, and (automated) information retrieval. This is a pity in as far as the focus on the semantics and pragmatics of questions and answers should, in principle, allow the prospect of bridging theoretical and practical endeavors. The, modest, moral here can only be that the gap between these two types of approaches is still felt to be too large to be bridged in a single step. We think there is reason for hope, however, since the theoretical work is shifting its focus toward more practical matters, as indeed can be expected from research on the semantics/pragmatics interface.

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