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Semantic theories of questions*

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Summary This survey article discusses two basic issues that semantic theories of questions face. The first is how to conceptualise and formally represent the semantic content of questions. This issue arises in particular because the standard truth-conditional notion of meaning, which has been fruitful in the analysis of declarative statements, is not applicable to questions. The second issue is how questions, when embedded in a declarative statement (e.g., in *Bill wonders who called*) contribute to the truth-conditional content of that statement. Several ways in which these issues have been addressed in the literature are discussed and compared.

Keywords semantics of questions, alternative semantics, partition semantics, inquisitive semantics, interrogative complements, clause-embedding predicates.

1 Introduction

Formal semantic theories traditionally construe the meaning of a sentence in terms of its *truth-conditions*: to know the meaning of a sentence is to know the conditions under which the sentence is true, and those under which it is false. This notion of meaning has been very fruitful in the analysis of declarative statements, but it does not straightforwardly apply to *questions*, which are not naturally thought of as being true or false in a given situation. Thus, the most basic issue that semantic theories of questions need to address is the following:

- **Issue 1:** How should the semantic content of a question be conceptualised, and how should it be represented formally?

Questions are not only of interest in their own right. They can also be part of declarative statements and as such contribute to the truth-conditional content of such statements. For

*The view presented here on the landscape of semantic theories of questions has developed through close collaboration over the last 10 years with Maria Aloni, Ivano Ciardelli, Donka Farkas, Jeroen Groenendijk, and Nadine Theiler. In particular, Section 2 draws on Ciardelli (2017); Ciardelli, Groenendijk, and Roelofsen (2018); Roelofsen and Farkas (2015), and Section 3 on Theiler, Roelofsen, and Aloni (2017, 2018). Further, I am very grateful to Justin Bledin and an anonymous reviewer for detailed comments on a previous version of the article, and to the Netherlands Organisation for Scientific Research (NWO) and the European Research Council (ERC, grant agreement number 680220) for financial support.

instance, a question can serve as the argument of clause-embedding predicates like *wonder* and *know*, as illustrated in (1) and (2):[1]

(1) Bill wonders who called.

(2) Mary knows whether Susan called.

This shows that statements and questions cannot be fully understood in isolation from each other; rather, they need to be analyzed in an integrated way. Specifically, the following issue needs to be addressed:

- **Issue 2:** How do questions, when embedded in a declarative statement, contribute to the truth-conditional content of that statement?

This entry discusses and compares various ways in which these two issues have been addressed in the literature. Section 2 is devoted to the first issue and Section 3 to the second.

Other important topics in the semantic literature on questions include the role of questions in discourse and the way in which the semantic content of a question should be derived compositionally. However, a proper discussion of these topics would require more space than available here. For recent surveys paying specific attention to the role of questions in discourse, the interested reader is referred to Ginzburg (2010) and Dekker, Aloni, and Groenendijk (2016); for discussion of how question meanings are compositionally derived, see Krifka (2011), Dayal (2016), and Ciardelli et al. (2018).

2 The semantic content of questions

This section discusses how the semantic content of questions is conceptualised and formally represented in a number of theoretical frameworks, focusing on so-called *proposition-set frameworks*. What these have in common is that they formally represent the semantic content of a question as a set of propositions—where each proposition is, as usual, a set of possible worlds.

However, the various frameworks differ in how exactly they conceptualise the propositions that make up the semantic content of a question: in *alternative semantics* (Hamblin, 1973; Karttunen, 1977) they are thought of as representing the *possible answers* to the question, in *partition semantics* (Groenendijk & Stokhof, 1984) they are thought of as representing *exhaustive answers*, and in *inquisitive semantics* (Ciardelli, Groenendijk, & Roelofsen, 2018) they are thought of as pieces of information that *resolve* the issue that the question expresses. These subtle conceptual differences have important repercussions.

One consequence, as will be discussed in more detail below, is that the three frameworks differ in which kinds of proposition-sets they regard as proper question meanings. In Figure 1,

[1] Besides serving as arguments of certain predicates, questions can also function as adjuncts in so-called unconditional statements, exemplified in (i):

(i) Whether it rains or not, Mary is going to the park.

For reasons of space, such constructions will not be discussed here. The interested reader is referred to Rawlins (2013), Ciardelli (2016a), and Bledin (2018).

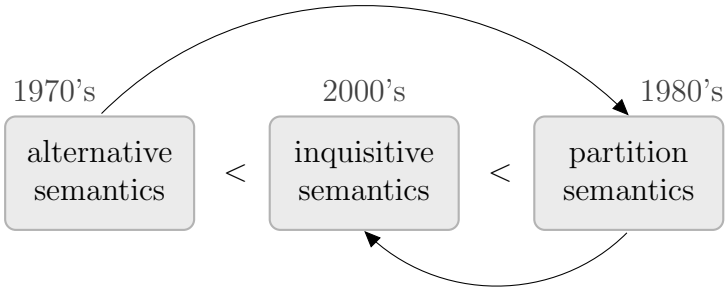

Figure 1: Proposition-set theories, ordered chronologically and in terms of restrictiveness.

the three frameworks are ordered from left to right in terms of restrictiveness—i.e., the extent to which they constrain the kinds of proposition-sets that qualify as question meanings. The development through time is indicated by the curved arrows. Alternative semantics, developed in the 1970s, is the least restrictive among the three, i.e., the one that imposes the fewest constraints on which sets of propositions qualify as question meanings. This, as we will see below, leads to problems of overgeneration. Partition semantics on the other hand, developed in the 1980s and 1990s, is the most restrictive framework—leading to problems of undergeneration. Finally, inquisitive semantics, developed in the 2000s and 2010s, tries to strike a balance between its two predecessors, so as to avoid the problems of over- and undergeneration.[2]

Alternative semantics will be discussed in Section 2.1, partition semantics in Section 2.2, and inquisitive semantics in Section 2.3. Finally, Section 2.4 will discuss some limitations shared by all proposition-set frameworks in their basic form, and some ways in which these limitations have been addressed in more fine-grained semantic frameworks (Ginzburg, 1995; Ginzburg & Sag, 2000; Krifka, 2001, 2013; Aloni & van Rooij, 2002; Aloni, 2005; Roelofsen & Farkas, 2015, among others).

2.1 Alternative semantics

Alternative semantics is based on the idea that:

> "questions set up a choice-situation between a set of propositions, namely those propositions that count as answers to it" (Hamblin, 1973, p.48)

One way to implement this idea is to take a question to denote, in a world w, the set of propositions that correspond to a possible answer to the question (Hamblin, 1973). Another way to implement the same idea is to let a question denote, in a world w, the set of propositions that correspond to its *true* answers in w (Karttunen, 1977). In both systems, the intension of a question is a function from worlds to sets of propositions. In Hamblin's system, this function maps every possible world to the same set of propositions, corresponding to

[2]The transition from partition semantics to inquisitive semantics involved two intermediate steps. First, in the 1990's, partition semantics was given a *dynamic* twist (Jäger, 1996; Hulstijn, 1997; Groenendijk, 1999). This, in turn, led to the 'first-generation' inquisitive semantics framework developed in Mascarenhas (2009) and Groenendijk (2009). For reasons of space, these are not discussed here; see Ciardelli et al. (2018, Ch.9).

the set of all possible answers; in Karttunen's system, every world is mapped to a subset of all possible answers, namely those that are true in the given world. As noted by Karttunen (1977, p.10), the difference is inessential. In both cases, the meaning of a question is fully determined by—and can be identified with—the set of all propositions corresponding to a possible answer.

This classical view on question meanings faces three fundamental problems.

Problem 1: what are possible answers? The first problem, discussed in detail in Ciardelli et al. (2018) and Ciardelli (2017), is that the framework's core notion—that of a *possible answer*—is difficult to pin down. Of course, Hamblin and Karttunen do provide a compositional semantics for a fragment of English, and thereby specify what they take to be the possible answers to the questions in that fragment. But in order to assess such a compositional theory, or even to properly understand what its predictions amount to, we first need to have a pre-theoretical notion of possible answers, one that the theoretical predictions can be evaluated against. The problem is that such a pre-theoretical notion is difficult, if not impossible to identify. To illustrate this, consider the question in (3) and the responses in (4):

(3) What is Alice's phone number?

(4) a. It's 055-9090231.
b. It's 055-9090231 but she prefers to be contacted by email.
c. It's either 055-9090231 or 055-9090233.
d. It starts with 055-9090.

In principle, the propositions expressed by the declaratives in (4) could all be seen as possible answers to (3). For Hamblin and Karttunen, only (4a) counts as such. However, it is not clear what the precise criteria are for being considered a possible answer, and on which grounds (4a) is to be distinguished from (4b-d).

Problem 2: entailment A second problem, pointed out in Groenendijk and Stokhof (1984), is that it is not clear how a suitable notion of *entailment* could be defined in this framework which would capture, for instance, that a question like (3) above subsumes the one in (5) below.

(5) Does Alice's phone number end with a 4?

The absence of a suitable notion of entailment also makes it difficult to give a principled account of the interaction between questions and logical connectives and quantifiers. In particular, the standard treatment of conjunction and disjunction as *meet* and *join* operators (see, e.g., Partee & Rooth, 1983; Keenan & Faltz, 1985; Winter, 2001; Champollion, 2015) cannot be maintained, since these operators are defined in terms of entailment.[3]

[3]For critical discussion of some concrete notions of entailment that may be introduced in alternative semantics, see Roelofsen (2013) and Ciardelli, Roelofsen, and Theiler (2017).

Problem 3: overgeneration A third problem, noted in Ciardelli and Roelofsen (2017), is that there are question meanings in alternative semantics which seem impossible to express in natural languages. These are question meanings containing two propositions p and q such that one is strictly contained in the other, $p \subset q$.

One may think that such meanings may be expressible by disjunctive questions, where each disjunct contributes one of the two propositions. However, in order to get that $p \subset q$, we would have to construct the question in such a way that one disjunct entails the other. As illustrated in (6) and (7) below, such questions are infelicitous.

(6) #Is John American or is he Californian?

(7) #Is the value of x different from 6 or is it greater than 6?

It has been well-known since Hurford (1974) that disjunctive declaratives where one disjunct entails the other are generally infelicitous as well.

(8) #John is American or he is Californian.

(9) #The value of x is different from 6 or it is greater than 6.

The degradedness of such declarative sentences has been given an appealing account in terms of *redundancy* (Simons, 2001; Katzir & Singh, 2013; Meyer, 2014). Essentially, in a truth-conditional semantics, the stronger disjunct is redundant in the sense that it does not contribute anything to the truth conditions of the sentence.

However, in alternative semantics, the disjunctive questions in (6) and (7) do not contain any redundant disjunct: each disjunct contributes one element to the proposition-set associated with the question. Thus, in alternative semantics, the redundancy-based explanation does not carry over from declaratives to questions.

2.2 Partition semantics

In partition semantics (Groenendijk & Stokhof, 1984) a question denotes, in each world in which its presuppositions are satisfied, a single proposition embodying the *true exhaustive* answer to the question in that world. For instance, if w is a world in which Paul and Nina are coming for dinner, and nobody else is coming, then the denotation of (10) in w is the proposition expressed by (11).

(10) Who is coming for dinner?

(11) Only Paul and Nina are coming.

The intension of a question, then, is a function from worlds to propositions. These propositions are taken to have two special properties: they are *mutually exclusive* (since two different exhaustive answers are always incompatible), and together they form a *cover* of the set of all possible worlds in which the presuppositions of the question are satisfied (since in every such world the question is assumed to have a true exhaustive answer). So the meaning of a question can be identified with a set of propositions which form a *partition* of the set of possible worlds that satisfy the question's presuppositions.

Problem: undergeneration For some questions, it is intuitively clear what their true exhaustive answer is in any given world, and it is also clear that fully resolving the question requires establishing such an answer. A case in point is the constituent question in (10). However, as first extensively argued in Belnap (1982), there are many kinds of questions for which it is either unclear what their true exhaustive answer is in a given world, or which can be fully resolved without establishing an exhaustive answer. For example, this holds for the mention-some question in (12), the approximate value question in (13), and the disjunctive question in (14).

(12) Where in Pittsburgh can I get gas on a Sunday? (after Belnap, 1982)

(13) How many stars are there in the Milky way, give or take 10? (Yablo, 2014)

(14) Where can we rent a car or who has one we could borrow? (Ciardelli et al., 2018)

For instance, an exhaustive answer to (12) would specify all places in Pittsburgh where one can get gas on a Sunday, and would moreover establish that there are no other such places. However, (12) has a prominent reading under which it does not require such an exhaustive response; rather, it suffices to specify just one place in Pittsburgh where one can get gas on a Sunday. This cannot be captured in partition semantics without substantially complicating the theory (see Groenendijk & Stokhof, 1984). And similarly for (13) and (14).

2.3 Inquisitive semantics

In inquisitive semantics (Ciardelli et al., 2018) the semantic content of a question is intended to capture its *resolution conditions*. Formally, the semantic content of a question is still represented as a set of propositions, but these propositions do not necessarily correspond to possible or exhaustive answers. Rather, they embody pieces of information that resolve the issue expressed by the question. As a consequence, the set of propositions associated with a question Q is always *downward closed*. That is, if it contains a proposition p, it must also contain any stronger proposition $p' \subset p$. After all, if p resolves Q, any $p' \subset p$ will do so as well.

For instance, the question in (10) is associated with the set of propositions which establish exactly who is coming for dinner. On the other hand, the mention-some question in (12) is associated with the set of propositions which establish for some place in Pittsburgh that one can get gas there on a Sunday. The approximate value question in (13) is associated with the set of propositions which establish for some n that the number of stars in the Milky Way is between $n-10$ and $n+10$. And the disjunctive question in (14) is associated with the set of propositions which either establish of some place that we can rent a car there or establish of some person that they have a car we could borrow. Thus, inquisitive semantics is less restrictive than partition semantics; it can be applied to a wider range of question types.

The shortcomings of alternative semantics are also addressed. First, pre-theoretical intuitions about whether a certain piece of information resolves a given question seem much more clear-cut than intuitions about what constitutes a 'possible answer'. For instance, the question in (3) is clearly resolved by the propositions expressed by (4a) and (4b), but not by those expressed by (4c) and (4d).

Second, entailment between questions can simply be defined as set inclusion, just as

entailment between statements in truth conditional semantics. This captures, for instance, the fact that the question in (3) subsumes the one in (5), since every proposition that resolves the former also resolves the latter. Moreover, given this notion of entailment, conjunction and disjunction can simply be treated as *meet* and *join* operators, and similarly for other logical connectives and quantifiers (Roelofsen, 2013; Ciardelli et al., 2017).

Third, the overgeneration problem that alternative semantics faces no longer arises. Since question meanings are assumed to be downward closed, inquisitive semantics predicts that questions like (6) and (7) involve a redundant disjunct, which means that the redundancy-based account of declarative Hurford disjunctions can straightforwardly be lifted to questions (Ciardelli & Roelofsen, 2017). This result is a direct consequence of the fact that inquisitive semantics is more restrictive than alternative semantics, which in turn is due to the fact that the set of propositions associated with a question, viewed as issue-resolving pieces of information, is always downward closed.

2.4 Limitations and extensions of proposition-set theories

Proposition-set theories are designed to capture a certain fundamental semantic property of questions, namely their resolution/answerhood conditions. Other semantic properties of questions are beyond the immediate scope of these theories. In order to capture such properties several approaches have been pursued, often within semantic frameworks that are more fine-grained than the standard possible worlds framework. For instance, the approach of von Stechow (1991) and Krifka (2001) is couched in a structured meanings framework, that of Ginzburg and Sag (2000) in situation semantics, that of Ginzburg (2005) and Cooper and Ginzburg (2012) in type theory with records (TTR), those of Aloni, Beaver, Clark, and van Rooij (2007) and Haida (2007) in dynamic semantics, and that of Blutner (2012) in ortho-algebraic semantics.

In Section 2.4.1 we will briefly discuss two of the phenomena that have given rise to these more fine-grained theories. In Section 2.4.2 we will turn to a number of contextual parameters that play a role in the semantics of questions, again requiring further refinements of the basic proposition-set theories surveyed above.

2.4.1 Beyond resolution conditions: anaphora and bias

Compare the polar question in (15), the alternative question in (16), and the tag question in (17).

(15) Is the door open?

(16) Is the door open or closed?

(17) The door is open, isn't it?

These questions have exactly the same resolution conditions. Namely, a proposition resolves the issue expressed by any of them if and only if it either implies that the door is open, or that the door is closed. Thus, in inquisitive semantics, (15)-(17) are all associated with the same set of propositions, namely those propositions that either consist only of worlds where the door is open, or only of worlds where the door is closed. Similarly, since the true

exhaustive answer to all three questions either is the proposition that the door is open (in worlds in which it's open) or the proposition that the door is closed (in worlds in which it's closed), (15)-(17) are also semantically equivalent in partition semantics. Finally, the standard assumption in alternative semantics is that (15)-(17) all have the same possible answers, which again renders them semantically equivalent.[4]

It is evident that certain important properties of (15)-(17) are left unaccounted for in this way. After all, while these questions indeed have the same resolution conditions, they differ in their overall conversational effects. For instance, (15) allows for *yes*/*no* answers and other anaphoric continuations, while (16) does not, as seen in (18) and (19), respectively.

(18) A: Is the door open?
B: Yes. / No. / I think so.

(19) A: Is the door open or closed?
B: #Yes. / #No. / #I think so.

Moreover, (17) conveys a bias on the part of the speaker that the door is open, while (15) and (16) do not. That is, a speaker who is known to have no evidence whatsoever as to whether the door is open or closed can felicitously ask the polar question in (15) or the alternative question in (16), but not the tag-question in (17).

Basic proposition-set theories are not equipped to capture such differences. Dealing with *yes*/*no* answers and other anaphoric continuations requires a framework in which the semantics of a question does not only capture its resolution/answerhood conditions, but also the antecedents that the question makes available for subsequent anaphoric expressions. Concrete analyses of *yes*/*no* answers have been developed in dynamic versions of alternative semantics (Krifka, 2013) and partition semantics (Aloni et al., 2007), a version of inquisitive semantics enriched with 'highlighted' propositions (Roelofsen & Farkas, 2015), as well as in situation semantics (Ginzburg & Sag, 2000), in ortho-algebraic semantics (Blutner, 2012) and in a structured meaning framework (Krifka, 2001). For a recent survey of some of these approaches to *yes*/*no* answers, see Roelofsen and Farkas (2015).

As for the bias conveyed by tag questions like (17), this may be captured by integrating proposition-set theories of questions with commitment-based models of discourse (e.g., Gunlogson, 2001; Farkas & Bruce, 2010), allowing for various kinds and levels of speaker commitment. For such approaches, see Krifka (2015), Malamud and Stephenson (2015), and Farkas and Roelofsen (2017).

2.4.2 Contextual parameters

Just like the truth conditions of a declarative sentence, the resolution conditions of a question are rarely completely determined by grammar alone; rather, they may depend on the

[4]It should be noted that there is no universal agreement among alternative semantics based theories that (15)-(17) should be associated with the same set of propositions. For instance, Biezma and Rawlins (2012) associate the polar question in (15) with a singleton set containing only the proposition that the door is open, while they associate (16) with a set containing both the proposition that the door is closed and the proposition that the door is open. It is unclear, however, how this choice could be motivated on principled grounds. Certainly, the proposition that the door is closed would seem to constitute a possible answer to (15) as much as it does to (16).

conversational context in various ways.[5] Some of the relevant contextual factors can be illustrated by considering the following examples.

(20) a. Which students passed the exam?
b. What is the winning card?
c. Who is driving to the party tonight?
d. Where is Mary?

A first important contextual parameter is the intended *domain of quantification*. For instance, the issue expressed by (20a) depends on the set of students which are relevant in the context of utterance. Clearly, dependency on a contextually determined domain is not specific to questions, but rather a general aspect of quantification (see, e.g., von Fintel, 1994).

A second important contextual parameter manifests itself in (20b). The issue expressed by this question does not only depend on the intended domain of quantification, but also on the intended *method of identification* (Aloni, 2005). Suppose that the question is asked in a situation in which there are two cards on the table, face down. If (20b) is asked by someone who wants to pick the winning card, it is resolved by any piece of information that conveys whether the winning card is the one on the left or the one on the right. On the other hand, if (20b) is asked by someone who doesn't know the rules of the game and wants a description of the winning card in terms of suit and number, then it is resolved by a piece of information that conveys, e.g., that the winning card is the Ace of Hearts.

The issue expressed by (20c) depends, again besides the intended domain of quantification, also on the kind of goal that the questioner is trying to achieve in asking the question (van Rooij, 2003). For instance, she may be trying to identify someone who could give her a ride to the party, or she may want to draw up a list of all the people driving to the party. In the first case, the question gets a *mention-some* interpretation: to resolve it, it suffices to specify one person who is driving to the party. In the second case, the question gets a *mention-all* interpretation: in this case, to resolve the question it is necessary to specify the complete set of people who are driving to the party.

Finally, the issue raised by (20d) depends on the intended *level of granularity* (Ginzburg, 1995). In some contexts, the information that Mary is, say, at home is sufficient to resolve the question. In other contexts, Mary's location needs to be determined more precisely, for instance by determining which room she is in.

It seems that the techniques that have been developed to deal with these contextual factors (see Ginzburg, 1995; van Rooij, 2003; Aloni, 2005, among others) can in principle be combined with proposition-set theories of any flavour. That is, issues of context-sensitivity seem orthogonal to the choice between alternative semantics, partition semantics, and inquisitive semantics.

[5] We will concentrate in this subsection on the context-sensitivity of resolution conditions, but essentially the same observations could be made for (exhaustive) answerhood conditions.

3 Question embedding

We now turn to embedded questions, i.e., interrogative complement clauses, and the predicates that take such clauses as their argument. A first important observation to make is that there are predicates that take both interrogative and declarative complements, exemplified in (21), but also ones that take only interrogative or only declarative complements, as seen in (22) and (23), respectively.

(21) a. Mary knows/predicted that John left.
b. Mary knows/predicted who left.

(22) a. *Mary wonders/investigated that John left.
b. Mary wonders/investigated who left.

(23) a. Mary believes/hopes that John left.
b. *Mary believes/hopes who left.

Predicates that license both kinds of complements are referred to as *responsive* predicates, ones that only license interrogative complements as *rogative* predicates, and ones that only license declarative complements as *anti-rogative* predicates.

As depicted in Figure 2, theories of question embedding can be divided into two kinds: on the one hand (the left branch of the tree), there are several approaches that assume a *type-distinction* between interrogative and declarative complements. On the other hand (the right branch), there are approaches that do not assume such a type-distinction, pursuing a *uniform* treatment of the two kinds of complement. We will discuss the type-distinction approaches in Section 3.1, and the uniform approaches in Section 3.2. Finally, in Section 3.3 we will compare the most promising type-distinction approach and the most promising uniform approach with each other.

3.1 Type-distinction approaches

The type-distinction approaches that we will discuss here all assume that an interrogative complement denotes a set of propositions, while a declarative complement denotes a single proposition.[6] Prima facie, it is unexpected under this view that there are predicates like *know* and *forget* which take both declarative and interrogative complements as their argument. Various ways to resolve this tension have been proposed.

Most authors assume that responsive predicates want a single proposition as their input—not a set of propositions. This means that if the complement of a responsive predicate is interrogative, a type mismatch arises. Heim (1994), Dayal (1996), and Beck and Rullmann (1999), among others, propose that this type mismatch is resolved by a type-shifting *answer operator*, which transforms the set of propositions generated by the interrogative clause into a single proposition and then feeds this proposition to the predicate. Lahiri (2002) proposes that the type mismatch is resolved by raising the interrogative clause to a higher position in the syntactic structure, leaving a proposition-type variable in the predicate's argument slot.

[6]For reasons of space we restrict our attention here to theories that are couched in possible worlds semantics. Theories based on other frameworks, such as situation semantics (e.g., Ginzburg, 1995; Ginzburg & Sag, 2000), typically also assume a type-distinction between interrogative and declarative complements.

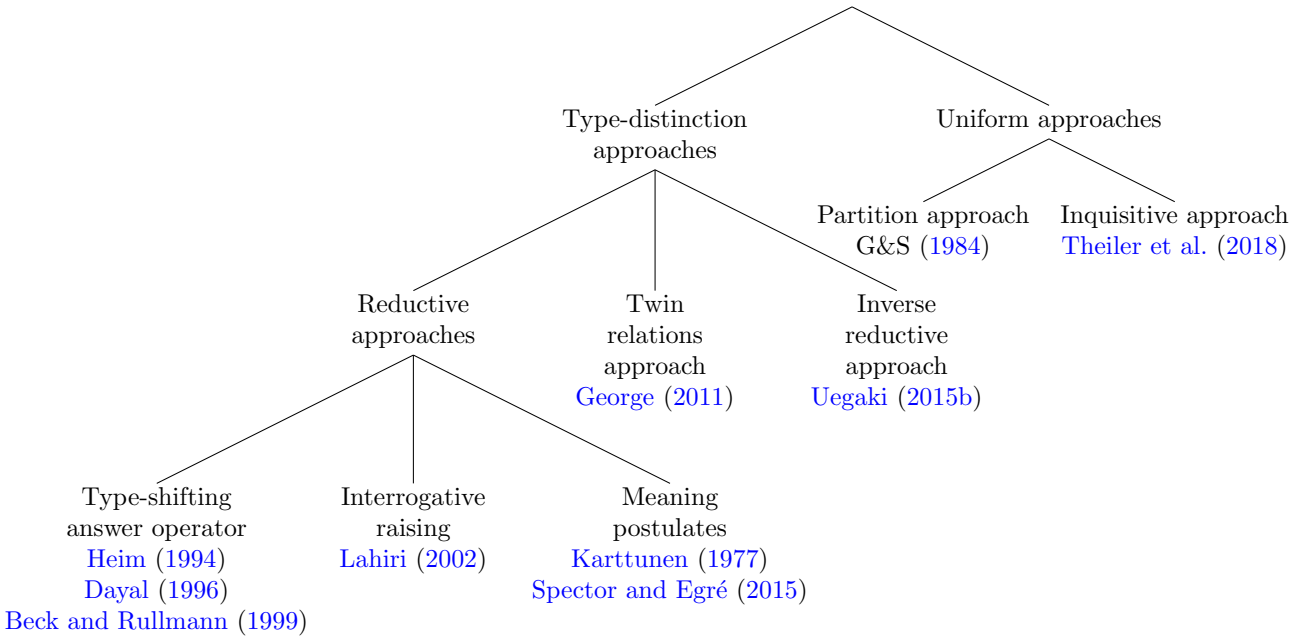

Figure 2: Different approaches to the semantics of interrogative and declarative complements.

A different strategy, briefly suggested by Karttunen (1977) and elaborated in detail by Spector and Egré (2015), is to assume two lexical entries for every responsive predicate, one for each kind of complement. For instance, for *know* we would have two lexical entries, $know_d$ and $know_i$, taking declarative and interrogative complements, respectively. Spector and Egré then formulate a general meaning postulate which, given the declarative entry P_d of a predicate P, determines the corresponding interrogative entry P_i.

These different strategies all have one thing in common. Namely, they take the declarative-embedding interpretation of responsive predicates to be basic, and *reduce* the interrogative-embedding interpretation of any given predicate in one way or another to its declarative-embedding interpretation. For this reason, all these strategies are referred to as *reductive* approaches.

George (2011, 2013a) identifies a general problem for reductive approaches. Namely, she observes that whether an individual stands in the knowledge relation to a certain interrogative can sometimes depend not only on the individual's true propositional knowledge, but also on whether she believes any *false answers* to that interrogative. This 'false answer sensitivity' implies that interrogative knowledge attributions cannot generally be reduced to true propositional/declarative knowledge attributions.

In reaction to this, George (2011) considers two alternative approaches. The first, which she calls the *inverse reductive* approach, reduces the declarative-embedding interpretation of responsive predicates to their interrogative-embedding interpretation, rather than the other way around. The second alternative, which George calls the *twin relations* approach, derives both the declarative-embedding interpretation and the interrogative-embedding interpretation of responsive predicates from a common lexical core. George (2011) spells out a concrete

twin relations theory, and also briefly sketches a concrete inverse reductive theory. The latter has been developed in much greater detail by Uegaki (2015b).

A phenomenon that allows us to tease apart the twin relations theory from the inverse reductive approach (as well as standard reductive approaches) is discussed by Elliott, Klinedinst, Sudo, and Uegaki (2017). The crucial observation is that so-called *predicates of relevance*, such as *care* and *matter*, carry a certain presupposition when taking a declarative complement which is absent when the complement is interrogative. For instance, (24a) presupposes that John knows that Mary left, while (24b) does not presuppose that John knows or believes of any particular girl that she left.

(24) a. It matters to John that Mary left.
b. It matters to John which girl left.

Elliott et al. show that this is problematic for standard reductive approaches.[7] Uegaki (2018) shows that it is also problematic for George's twin relations theory. On the other hand, it can easily be accounted for on the inverse reductive approach.[8]

3.2 Uniform approaches

Uniform approaches treat declarative and interrogative complements as being of the same semantic type. The first such approach was taken in partition semantics (Groenendijk & Stokhof, 1984).[9] On this account, both declarative and interrogative complements are taken to denote propositions. A declarative complement denotes the same proposition in every world, namely the one expressed by the corresponding declarative root clause. On the other hand, the proposition denoted by an interrogative complement in a world w encodes the true exhaustive answer in w to the issue expressed by the interrogative clause. As discussed above, these exhaustive answers together form a partition of the set of all possible worlds.

On this theory, the existence of responsive predicates like *know*, which license both types of complements, does not come as a surprise and needs no particular explanation. Predicates of relevance like *care* and *matter* can also be handled straightforwardly, unlike on reductive theories and the twin relations theory. However, certain issues remain.

First, partition theory is, so to speak, still too close to the reductive approach to be able to deal with George's (2011) observations concerning false answer sensitivity. That is, it still

[7] A similar argument was made by Groenendijk and Stokhof (1984, p.94) against the reductive theory of Karttunen (1977). Elliott et al.'s argument, however, is more explicit and targets reductive approaches in general rather than only Karttunen's specific theory.

[8] Uegaki and Roelofsen (2018) discuss another phenomenon which can be accounted for on the inverse reductive approach but not on the reductive approach or the twin relations theory. This involves the interpretation of the Japanese modal particle *darou* which, when combined with a declarative clause, roughly means 'I believe', but when combined with an interrogative clause, translates as 'I wonder'. For reasons of space, we will not discuss this phenomenon in detail here and will leave it out of consideration in the discussion below.

[9] The idea to treat declaratives and interrogatives uniformly actually goes further back, at least to Hamblin (1973, p.48). However, Hamblin was exclusively concerned with *root* clauses; he did not explicitly consider declarative and interrogative *complements*, let alone the repercussions of a uniform treatment of complements for the analysis of predicates that take such complements as their argument.

		False answer sensitivity	Predicates of relevance	Flexibility SE	IE	MS
Type-distinction	Reductive theories	−	−	+	+	+
	Twin relations theory	+	−	+	−	+
	Inverse reductive theory	+	+	+	+	±
Uniform	Partition semantics	−	+	+	−	±
	Inquisitive semantics	+	+	+	+	+

Table 1: Pros and cons of the various approaches to embedded questions.

wrongly predicts that if two individuals have the same propositional knowledge, they must stand in the knowledge relation to exactly the same interrogative complements as well.[10]

A second limitation of partition theory, already discussed in Section 2, is its lack of flexibility. That is, while it straightforwardly derives so-called strongly exhaustive (SE) readings for interrogative complements, it needs to invoke substantial additional machinery to derive non-exhaustive/mention-some (MS) readings. Moreover, in the case of embedded questions (unlike in the case of root questions) it has been argued that there is also a reading that is weaker than the SE reading but stronger than the MS reading (e.g., Spector, 2005; Klinedinst & Rothschild, 2011). Recent experimental results seem to show that such intermediate exhaustive (IE) readings indeed exist (Cremers & Chemla, 2016).[11,12] This cannot be accounted for in partition semantics.

The more recent uniform approach of Theiler, Roelofsen, and Aloni (2018) is cast in inquisitive semantics and aims to overcome the main limitations of its partition-based predecessor. Most fundamentally, it does not treat declarative and interrogative complements as denoting propositions, but as denoting sets of propositions. In the case of interrogative complements, these propositions do not encode what the true exhaustive answer to the interrogative is in a given world w, but rather what its *truthful resolutions* are in w. Such truthful resolutions need not be exhaustive, and need not even be true in w; they just need to be 'truthful', which means that they should not imply any false information that is directly relevant w.r.t. the issue expressed by the interrogative. For instance, if Mary is currently watching the sunset, then the proposition that she is watching the sunset drinking a martini is a truthful resolution of the question *whether Mary is watching the sunset* even if she is in fact not drinking a martini. This switch from true exhaustive answers to truthful resolutions makes it possible to provide a general account of the false answer sensitivity observed by

[10]In view of this prediction, George actually classifies partition theory as a reductive theory. This classification, however, blurs the fact that Groenendijk and Stokhof (1984, p.93-94) themselves very explicitly argued against the reductive approach—understood as one that takes declarative and interrogative complements to be of different types and derives the interrogative-embedding interpretation of responsive predicates from their declarative-embedding interpretation. Instead, they chose to pursue a uniform approach. The classification adopted here, depicted in Figure 2, is a refinement of Groenendijk and Stokhof's classification, distinguishing various non-uniform approaches that did not exist yet in 1984.

[11]To exemplify, under an intermediate exhaustive reading 'John knows which squares are blue' is true just in case (i) of all squares which are in fact blue, John knows that they are blue, and (ii) of all other squares, John does not falsely believe that they are blue.

[12]Yet another possible reading, called the weakly exhaustive reading, has also been suggested in the literature (e.g., Heim, 1994; Beck & Rullmann, 1999). However, the existence of such readings remains highly controversial. See George (2013b) for discussion.

George (2011), and to derive not only strongly exhaustive readings but also mention-some and intermediate exhaustive readings in a straightforward way. Moreover, as in the earlier partition-based theory, predicates of relevance are unproblematic.

The considerations put forth so far are summarised in Table 1.[13] As far as these considerations go, the inverse reductive account of Uegaki (2015b) is the most attractive option among type-distinction approaches, and the inquisitive semantics account of Theiler et al. (2018) is the most successful among uniform approaches. The next subsection briefly compares these two accounts.

3.3 Inverse reductive versus inquisitive

The inverse reductive approach and the inquisitive one are very close in spirit and in empirical reach. Both assume, unlike the other approaches reviewed above, that responsive predicates always apply to a *set* of propositions rather than a single proposition. The difference is that on the inquisitive approach, declarative and interrogative complements are uniformly treated as denoting sets of propositions, while on the inverse reductive approach, a declarative complement is in principle taken to denote a single proposition, but when combined with a responsive predicate, this proposition p must be type-shifted into the singleton set $\{p\}$.

As far as responsive predicates go, then, the two approaches are difficult if not impossible to tease apart.[14] The approaches do differ, however, in their take on *anti-rogative* predicates like *believe* and *hope*. On the inverse-reductive approach, these predicates are lexically specified to select for complements that denote a single proposition rather than a set of propositions, which accounts for the fact that they license declarative complements but not interrogative ones. On the inquisitive approach, this option is not available: since declarative and interrogative complements are taken to have the same semantic type, the selectional restrictions of rogative and anti-rogative predicates cannot be accounted for in terms of a type mismatch.[15]

At first sight, this may seem a point in favor of the inverse reductive approach. But the issue is more subtle. After all, for the account sketched above to have any *explanatory value* it has to be supplemented with independent reasons to assume that predicates like *believe*, *hope*, and *assert* select for complements denoting a single proposition while closely related predicates like *know*, *predict*, and *announce* select for complements denoting sets

[13] A possible concern for inverse-reductive and uniform theories that we have not discussed explicitly is that they do not make any direct predictions as to how the interrogative-embedding interpretations of responsive predicates are related to their declarative-embedding interpretations (George, 2011; Spector & Egré, 2015). Proper discussion of this subtle issue is beyond the scope of this survey. For a defense of the uniform and inverse-reductive theories, we refer to Theiler et al. (2018).

[14] There are some differences in implementation between the accounts of Uegaki (2015b) and Theiler et al. (2018) which result in somewhat different predictions for certain responsive predicates. But these differences in implementation are not forced by the general approaches that the two accounts instantiate. Thus, the predictions that arise from these implementational choices cannot be used to tease the two approaches apart in general. See Theiler et al. (2018) for further discussion.

[15] Note that on the inverse reductive approach, the selectional restrictions of *rogative* predicates cannot be accounted for in terms of a type mismatch either, since it is assumed that the denotation of a declarative complement, i.e., a proposition p, can always be shifted into the singleton set $\{p\}$, which is of the same type as an interrogative complement denotation.

of propositions. Moreover, on the inquisitive approach, even if the selectional restrictions of rogative and anti-rogative predicates cannot be accounted for in terms of mismatching semantic types, they could possibly be explained in other ways, based on independently observable properties of the relevant predicates.

Recent work has explored both routes. On the one hand, Uegaki (2015a) has attempted to provide independent motivation for the assumption that predicates like *believe* select for complements denoting a single proposition while predicates like *know* select for complements denoting sets of propositions. However, Theiler et al. (2018) point out several problems for this proposal. On the other hand, Theiler et al. (2017), Mayr (2017), and Uegaki and Sudo (2017) have shown that it is possible to account for the selectional restrictions of *believe*, *hope*, and many other anti-rogative (as well as rogative) predicates in terms of independently observable properties of these predicates. They suggest that the relevant property of *believe* is that it is neg-raising (Zuber, 1982; Theiler et al., 2017; Mayr, 2017), while the relevant property of *hope* is that it is a non-veridical preferential predicate (Uegaki & Sudo, 2017).[16]

The debate is not settled at this point. Some anti-rogative predicates are neither neg-raising nor non-veridical preferential (e.g., speech act predicates like *assert* and *deny*) and therefore remain to be accounted for under the inquisitive approach. On the other hand, it may be possible after all to justify for at least some anti-rogative predicates that they select for complements that denote a single proposition. Addressing these open issues seems to offer a promising route towards establishing which of the approaches to question embedding is ultimately most appealing.

4 Further reading

There are a number of excellent recent survey articles and monographs on the semantics of questions, each focusing on slightly different aspects. Some of them are listed below, in chronological order.

- Groenendijk and Stokhof (1997) provide a thorough review of the literature up to 1997, focusing on partition semantics, but also supplying an in-depth discussion of the epistemic-imperative approach (Åqvist, 1965; Hintikka, 1976, 1983) and the treatment of questions in speech act theory (Searle, 1969; Vanderveken, 1990).

- Ginzburg (2010) supplements Groenendijk and Stokhof's survey listed above in the second edition of the Handbook of Logic and Language. It provides a concise overview of several analyses of questions not explicitly discussed here, including the *inferential erotetic logic* of Wiśniewski (2001, 2013), the treatment of questions in modal logic by Nelken and Francez (2002); Nelken and Shan (2006), the dialogue-based approach of Ginzburg (1996, 2012) and Roberts (1996), the SDRT based approach of Asher and Lascarides (1998), and the treatment of questions in *dynamic epistemic logic* developed by van Benthem and Minică (2009, 2012). For a further development of the latter,

[16] A recent initiative that is likely to spur many further contributions to this line of work is the development of large-scale datasets concerning the selectional restrictions and other semantic and syntactic properties of clause-embedding predicates (White & Rawlins, 2016, 2018).

incorporating insights from inquisitive semantics, see Ciardelli and Roelofsen (2015) and Ciardelli (2016b).

- Krifka (2011) provides an overview of alternative semantics, partition semantics, an early version of inquisitive semantics, and the structured meanings approach. Krifka discusses not only the *semantics* of questions, but also their *syntactic* and *prosodic* properties, supplying examples from a wide range of languages.

- Wiśniewski (2015) provides an extensive overview of logical theories of questions, with particular emphasis on inferential erotetic logic.

- Ciardelli (2016b) is an in-depth investigation of the logical foundations of inquisitive semantics, and also provides detailed comparisons with other logical approaches to questions.

- Dekker et al. (2016), besides offering an overview of proposition-set theories and the structured meanings approach, also reviews some specific issues in current research concerning identity questions, domain presuppositions of *which*-questions, pair-list questions, quantificational variability, and the selectional restrictions of clause-embedding predicates. Moreover, they discuss connections between partition semantics and decision theory (van Rooij, 2003) and dynamic implementations of partition semantics (e.g., Jäger, 1996; Hulstijn, 1997; Groenendijk, 1999).

- Dayal (2016) provides a book-length survey of work on questions in the alternative semantics tradition. It pays much attention to the syntax-semantics interface, viewed from a cross-linguistic perspective.

- Cross and Roelofsen (2018) provide a concise overview of proposition-set theories, the structured meanings approach, as well as the analysis of questions as part of the process of scientific inquiry in Philosophy of Science.

- Ciardelli et al. (2018) provides a book-length introduction to inquisitive semantics, as well as detailed comparison with alternative semantics and partition semantics.

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