Why can't we be surprised *whether* it rains in Amsterdam? A semantics for factive verbs and embedded questions.

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written by

Michele Herbstritt
(born January 28th, 1988 in Borgomanero, Italy)

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Date of the public defense:	**Members of the Thesis Committee:**
September 24th, 2014	Dr Jakub Szymanik (chair)
	Prof Dr Jeroen Groenendijk
	Prof Dr Martin Stokhof
	Prof Dr Frank Veltman
	Dr Maria Aloni
	Dr Floris Roelofsen

INSTITUTE FOR LOGIC, LANGUAGE AND COMPUTATION

Abstract

This thesis is about the semantics of embedded questions and question-embedding verbs. In particular, we focus on so-called *responsive* verbs, i.e. verbs that can embed both declarative and interrogative complements (Lahiri, 2002). Among these verbs, the classes of emotive factives (such as *surprise*) and epistemic factives (such as *realise*) have been extensively studied in the literature, as the verbs belonging to these classes exhibit interesting properties that pose a challenge to the classic semantic approaches to embedded questions. In particular, we focus on the so-called *whether*-puzzle, i.e. the fact that these verbs fail to embed polar and alternative questions, while they can felicitously embed *wh*-questions.

In the first chapter of the thesis we lay out the theoretical background and the empirical scope of the thesis. In particular, we briefly recall the classic approaches to (embedded) questions by Hamblin (1973), Karttunen (1977) and Groenendijk and Stokhof (1984) and we extensively summarise a body of recent works concerning the semantics and pragmatics of *surprise* and *realise*.

In the second chapter we present a novel approach to the semantics of responsive verbs and the complements they embed, focusing on *know*, *surprise* and *realise* and showing how to account for the *whether*-puzzle. Our account crucially relies on the adoption of an additional dimension of sentential meaning aimed to capture the anaphoric potential of a sentence, which is introduced and independently motivated in the first part of the chapter, following the work by Roelofsen and Farkas (forthcoming). In the second part, we develop a semantic system in which the meaning of a complement is spelled out in terms of its semantic content and its anaphoric potential and we introduce our lexical entries for *surprise* and *realise*, showing how the interplay between these entries and the semantic analysis of complements can solve the *whether*-puzzle.

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Chapter 1

Background: embedded questions and factive verbs

In this chapter we lay out the theoretical background and the empirical scope of our work. In Section 1.1 we introduce the reader to the semantics of (embedded) questions, briefly recalling the classic approaches by Hamblin (1973), Karttunen (1977) and Groenendijk and Stokhof (1984). The formal concepts introduced in the first section will be useful in the remainder of the chapter, in which we introduce and discuss the semantics of factive responsive verbs. In particular, in Section 1.2 we look at factive responsive verbs in general, while in Sections 1.3, 1.4 and 1.5 we dive into the details of the linguistic behaviour of two classes of responsive verbs, i.e. the so-called *emotive* and *epistemic* factives.

1.1 Introduction to question semantics

Traditionally the meaning of a sentence is spelled out in terms of its truth-conditions, i.e. the way in which the worlds should be in order for the sentence to be true. More formally, the meaning of a sentence is modelled as a set of possible worlds (often called *proposition*). A set of possible world embodies a certain piece of information, namely the factual information compatible with the worlds contained in the set. Adopting a dynamic view on language interaction dating back to (Stalnaker, 1978) we can say that when a sentence is uttered in a conversation the information embodied by its meaning is added to the common ground of the conversation, which is in turn modelled as a set of possible worlds. In this way the common ground of a conversation is updated with the new information and the shared knowledge of the participants is refined.

This simple picture of information exchange through linguistic interaction is limited first and foremost because it does not consider uses of language other than providing information. However, it is an obvious observation that an essential role is played in a conversation by utterances that request information to the other participants. Questions play a crucial role in our linguistic interactions and as such they have received the attention of semanticists and linguists in general.

The literature on this topic is huge and many different approaches have been proposed over the years. A critical introduction to (some of) the main approaches can be found in (Groenendijk and Stokhof, 1997). In this section we limit ourselves to a brief summary of the the main features of the classic approaches by Hamblin (1973), Karttunen (1977) and Groenendijk and Stokhof (1984), so that the reader can get acquainted with the terminology and formal tools adopted throughout this work.[1]

First of all, notice that we are concerned with the semantics of questions (or interrogative sentences), in the sense that we will be asking ourselves how the meaning of these sentences can be formally represented and how this meaning is combined and interacts with the meanings of other natural language expressions. The works by Hamblin, Karttunen and Groenendijk and Stokhof will provide the conceptual and formal starting points to try to answer these questions.

What is the meaning of an interrogative? In analogy to what happens with a declarative, whose meaning is represented with its truth-conditions, we can say that the meaning of an interrogative is represented by its answerhood-conditions. Intuitively, to know the meaning of an interrogative amounts to know what counts as an answer to it. Hamblin, Karttunen and Groenendijk and Stokhof all take this observation very seriously, and yet their accounts of the meaning of interrogatives differ considerably. This is so because the concept of an answer is an intuitive one, and there are several possible ways in which it can be formalised. The mentioned approaches mainly differ with respect to the way in which they formally spell out what counts as an answer to a given interrogative.

Let us start from Hamblin's approach. The main idea is that the answerhood-conditions of a questions can be captured simply by collecting all its possible *basic* answers. What counts as a basic answer can be easily understood with some examples. As regards polar questions such as *Is it raining in Amsterdam?*, the basic answers are simply taken to be *Yes, it's raining* and *No, it's not raining*. As regards *wh*-questions such as *Who came to the party?*, the basic answers are taken to be expressed by all the sentences of the form *x came to the party*, where x denotes an individual. Let $?\varphi$ be a polar question and $?x.\varphi$ be a *wh*-questions. If we assume a usual first-order language $\mathcal{L}$, a domain of individual D and a standard intentional interpretation function $[\![\bullet]\!]_{w,g}$, the spirit of Hamblin's semantic can be captured with the following definitions, where p ranges over sets of possible worlds:[2]

Definition 1.1. Semantics of questions (Hamblin, 1973)
$[\![?\varphi]\!]_{w,g} := \{p \mid p = \{w \mid [\![\varphi]\!]_{w,g} = 1\} \text{ or } p = \{w \mid [\![\varphi]\!]_{w,g} = 0\}\}$
$[\![?x.\varphi]\!]_{w,g} := \{p \mid p = \{w \mid [\![\varphi]\!]_{w,g[x/d]} = 1\} \text{ for } d \in D\}$

[1] Throughout this section we will abstract away from many complications and we will not consider the details of the mentioned works, limiting our exposition to a summary of the fundamental ideas underlying the semantic analyses proposed in these works.

[2] More in detail, $[\![\bullet]\!]_{w,g}$ yields the denotation of the expression to which it is applied relatively to the possible world w and the first-order assignment g. In particular, the denotation of a sentence will be either 0 or 1, i.e. a truth value.

Going back to our examples, it is easy to check that the denotation of *Is it raining in Amsterdam?* is predicted to be a set containing two propositions, namely the proposition that it is raining in Amsterdam and the proposition that it is not raining in Amsterdam, while the denotation of *Who came to the party?* is predicted to be the set containing the proposition that John came, the proposition that Mary came and so on. It is worth noticing that the denotation of a question is the same in every possible world, in that it contains *all* the possible answers to the question.

Hamblin's semantics perfectly exemplifies what is known as the *propositions set approach* to interrogatives, in that the denotation of an interrogative is taken to be a set of sets of possible worlds, i.e. a set of propositions. Karttunen's semantics is not different in this respect, and can be seen as a refinement of Hamblin's idea.

In contrast with Hamblin, Karttunen focuses his attention on embedded questions, i.e. interrogative sentences that occur within larger sentences, as complements of an embedding verb. For example, in (1) and (2) the questions *whether it is raining in Amsterdam* and *who came to the party* are embedded under the verb *know*:

(1) John knows whether it's raining in Amsterdam.

(2) John knows who came to the party.

Karttunen's observation concerning the denotation of interrogatives is that what matters for the truth of (1) and (2) is not the set of *all* the possible answers to the embedded interrogatives, but only the set of the *true* possible answers. Intuitively, in order to know whether it is raining in Amsterdam, John needs to know that it is raining if it is raining, and that it is not raining if it is not raining. Similarly, John knows who came to the party only if, for all the people who came, he knows that he or she came.[3]

According to Karttunen, then, the answerhood-conditions of an interrogative are captured by the set of its true basic answers. The denotation of an interrogative becomes world-dependent, in that it contains only the answers to the interrogative that are true in the world of evaluation.

Definition 1.2. Semantics of questions (Karttunen, 1977)
$[\![?\varphi]\!]_{w,g} := \{p \mid w \in p \text{ and } p = \{w \mid [\![\varphi]\!]_{w,g} = 1\} \text{ or } p = \{w \mid [\![\varphi]\!]_{w,g} = 0\}\}$
$[\![?x.\varphi]\!]_{w,g} := \{p \mid w \in p \text{ and } p = \{w \mid [\![\varphi]\!]_{w,g[x/d]} = 1\} \text{ for } d \in D\}$

This definition crucially differs from Definition 1.1 in that the denotation of an interrogative at a world w is computed by collecting only the relevant propositions that are true at w. Going back to our examples, this means that the

[3] Clearly this does not hold for every question-embedding verbs. For example, consider the verb *agree*: in order for the sentence *John and Mary agree on what city is the capital of Luxembourg* to be true, it does not matter that John and Mary agree on the true answer to the embedded interrogative *what city is the capital of Luxembourg*: they may very well be both wrong and agree that, say, Bruxelles is the capital of Luxembourg. As we will see, in this thesis we will be concerned with so-called *factive* and *veridical* verbs, i.e. embedding verbs that pattern with *know* in this respect and make reference to the true answer(s) to the embedded interrogatives.

denotation at w of a polar question such as *Is it raining in Amsterdam* will contain the proposition that it is raining if it is indeed raining in w and the proposition that it is not raining if it is not raining in w, while the denotation of a *wh*-question such as *Who came to the party?* will contain those propositions of the form *x came to the party* that are true in w.

What is important about Karttunen's approach is his notion of a *complete true answer* to a question, which plays a crucial role for embedded *wh*-questions. As we said, it seems that John cannot be said to know who came to the party unless he knows, for any person who came, that he or she came. In other words, John must know the complete true answer to the embedded question. Let Q be any question and $[\![Q]\!]_{w,g}$ its denotation at w along the lines of Definition 1.2. According to Karttunen, the complete true answer to Q at a world w (denoted with $\mathsf{ANS}_K(Q, w)$) is nothing but the proposition resulting from the intersection of all the basic true answers to Q:

Definition 1.3. Complete true answer (Karttunen, 1977)

$$\mathsf{ANS}_K(Q, w) := \begin{cases} \bigcap [\![Q]\!]_{w,g}, & \text{if } [\![Q]\!]_{w,g} \neq \emptyset; \\ \{v \mid \ [\![Q]\!]_{v,g} = \emptyset\}, & \text{if } [\![Q]\!]_{w,g} = \emptyset. \end{cases}$$

If Q is a polar question, then $[\![Q]\!]_{w,g}$ is a singleton, thus the complete true answer to Q at w coincides with the basic true answer to Q at w. If Q is a *wh*-question, then the complete true answer to Q at w amounts to the intersection (i.e. the conjunction) of the basic true answers to Q at w. For example, if Ann and Bob were the only ones who came to the party, the complete true answer to *Who came to the party?* is predicted to be the intersection between the proposition that Ann came and the proposition that Bob came, i.e. the proposition that Ann and Bob came to the party. Finally, if nobody came to the party, the complete true answer to the the question is the proposition that nobody came to the party.

The concept of a complete true answer is used by Karttunen to define the semantics of the embedding verb *know*, in order to evaluate sentences such as (1) and (2). Let Q be a question and let X denote an agent; the spirit of Karttunen's analysis of interrogatives embedded under *know* can be captured by the following semi-formal definition:

Definition 1.4. Know+Q (Karttunen, 1977)
A sentence of the form X *knows* Q is true at w iff X believes $\mathsf{ANS}_K(Q, w)$ at w.

It is easy to see that *knowing whether* and *knowing wh-* are reduced to *knowing that*.[4] More precisely, the semantic contribution of a question embedded under *know* is the proposition expressed by the complete true answer to the question. For example, the sentence *John knows whether it's raining* is true at w if and only if John knows that it is raining if it is raining at w and John knows that it is not raining if it is not raining at w. As for *John knows who came to the party*, we can say that John knows who came to the party if and only if John

[4]We make the simplifying assumption that believing a true proposition p is sufficient in order to know p.

knows, for any person that actually came, that he or she came: e.g., if Ann and Bob are the only ones who came, the sentence is true if and only if John knows that Ann and Bob came. Finally, if nobody came then in order to know who came John must believe that nobody came.

The semantics sketched in Definition 1.2 captures a reading of embedded questions commonly known as the *weakly exhaustive reading* (Heim, 1994). What plays a role for the truth of *John knows who came to the party* is only the information about the individuals who actually came to the party: if Ann and Bob came, then John must know that they came. The information about whoever did not come does not play any role. For example, suppose Ann and Bob came to the party and Cindy did not; no matter what John knows or believes about Cindy, if he knows that Ann and Bob came to the party then we must conclude that John knows who came to the party.

Groenendijk and Stokhof (1984) argue that this is not a desirable prediction. Let us assume that John knows what the relevant domain of individuals is, i.e. that he knows who was invited to the party; then if John does not know that Cindy did not come or worse he falsely believes that she came, intuitively it is not true that John knows who came to the party. Groenendijk and Stokhof argue that, under the assumption that John knows who was invited, the reading involved in *John knows who came to the party* is stronger than the one captured by Karttunen's analysis: what plays a role for the truth of the sentence is not only the information that John has about who came but also the information about who did not come. In order to know who came to the party, for any person that came John must know that he or she came and for any person that did not come John must know that he or she did not come.

Let us now turn to Groenendijk and Stokhof's semantics of questions, in order to see how they implement the so-called *strongly exhaustive reading*. The first difference with Karttunen's proposal concerns the type of semantic objects associated with questions. The denotation of a question at a world is not taken to be a set of propositions, as in Definition 1.2, but it is a proposition itself. More precisely, the denotation of a question at a world is taken to be the strongly exhaustive answer to the question at that world. In order to see what a strongly exhaustive answer is, let us introduce a semantic definition in the spirit of Groenendijk and Stokhof's approach:

Definition 1.5. Semantics of questions (G&S, 1984)
$[\![?\varphi]\!]_{w,g} := \{v \mid [\![\varphi]\!]_{v,g} = [\![\varphi]\!]_{w,g}\}$
$[\![?x.\varphi]\!]_{w,g} := \{v \mid \forall d \in D,\ [\![\varphi]\!]_{v,g[x/d]} = [\![\varphi]\!]_{w,g[x/d]}\}$

The denotation of *Is it raining?* at w, its strongly exhaustive true answer, is the proposition that it is raining if it rains at w and the proposition that it is not raining if it does not rain at w. In other words, as far as polar questions are concerned, the strongly exhaustive answer coincides with the complete answer in Karttunen's sense.

The difference between the two readings becomes apparent for *wh*-questions. The denotation of *Who came to the party?* at w is the proposition containing exactly the possible worlds which agree with w as to whether d came to the party or not, for any individual d in the domain. For example, suppose that at w Ann and Bob came to the party and Cindy did not come. According to Definition 1.5, the denotation of *Who came to the party?* at w is the proposition that contains exactly those worlds that agree with w as regards the set of people who came to the party, i.e. it contains exactly those worlds in which Ann and Bob came and Cindy did not come.

Now, the semantic analysis of sentences containing questions embedded under *know* proposed by Groenendijk and Stokhof can be captured by the following definition:

Definition 1.6. Know+Q (G&S, 1984)
A sentence of the form X *knows* Q is true at w iff X believes $[\![Q]\!]_{w,g}$ at w.

Again, *knowing whether* and *knowing wh-* are reduced to *knowing that*. We consider (2) again, repeated as (3):

(3) John knows who came to the party.

It is easy to see that Definition 1.6 yields the wanted predictions in the situation considered above, i.e. the world w where Ann and Bob came to the party and Cindy did not come. The sentence in (3) is true at w just in case John believes the proposition $[\![\text{Who came to the party?}]\!]_{w,g}$, which is the proposition containing exactly the worlds where Ann and Bob came and Cindy did not come. Now, if John believes that Ann and Bob came and Cindy did not come, then (3) is predicted to be true, but, crucially, if John does not believe that Cindy did not come, then his beliefs are compatible with worlds in which Cindy came, so he cannot believe the said proposition and (3) is predicted to be false.

It does not fall within the scope of this introductory section to argue in favour of any of the analyses summarised above. As already mentioned, the aim of the section is to provide a toolbox of concepts that will be useful in the following sections. In particular, we will be making constant reference to the notions of weakly exhaustive reading and strongly exhaustive reading of a question. Now, as shown by Heim (1994), Karttunen's analysis of questions is actually flexible enough to define both readings. For the sake of uniformity, then, we will take Karttunen's analysis as our basic starting point in question semantics (especially in the first chapter).

Before moving to the next section, let us see how we can capture the strongly exhaustive reading of a question Q on the basis of its denotation in the spirit of Karttunen's analysis. To do so we follow Heim (1994). We have seen that $\mathsf{ANS}_K(Q, w)$ is the complete true answer to Q at w, defined as the intersection of all the basic true answers to Q at w. For example, if Q is *Who came to the party?* and only Ann and Bob came at w then $\mathsf{ANS}_K(Q, w)$ is the proposition that Ann and Bob came. Clearly, if we move to a world w' where, say, Ann came but Bob did not, then the complete answer to Q will be different, i.e. $\mathsf{ANS}_K(Q, w')$ will be the proposition that Ann came, and so on. On the other hand, any world v that agrees with w concerning the fact that only Ann and Bob came is a world where the complete answer to Q will be the same as the complete answer to Q in w. Now, if we collect every such world, we get a proposition which is true at a world just in case only Ann and Bob came to the party at that world, i.e. the proposition that *only* Ann and Bob came. But this is exactly the proposition that corresponds to what we called the *strongly exhaustive answer to* Q. Summing up, we can formally define the strongly exhaustive answer to a question Q in w (denoted $\mathsf{ANS}_{GS}(Q,w)$) as follows:

Definition 1.7. Strongly exhaustive answer (Heim, 1994)
$\mathsf{ANS}_{GS}(Q,w) := \{v \mid \mathsf{ANS}_K(Q,v) = \mathsf{ANS}_K(Q,w)\}$

1.2 Responsive verbs and factivity

In this work we are concerned with so-called *responsive* verbs, i.e. embedding verbs that can embed both declarative and interrogative complements.[5] One example of a responsive verb was given in the previous section; the verb *know* is responsive:

(4) a. John knows that Bob called Kate.
b. John knows whether Ann will come to the party or not.
c. John knows who came to the party yesterday.

Other responsive verbs are *tell, surprise, predict, agree, realise* and many others. For completeness, let us briefly point out that not every embedding verb is responsive: for example, *believe* can embed declarative complements but not interrogative complements, while *wonder* exhibits the opposite behaviour:

(5) a. Kate believes that Bob is a nice guy.
b. # Kate believes whether Bob is a nice guy or not.
c. Kate wonders whether Bob is a nice guy or not.
d. # Kate wonders that Bob is a nice guy.

The verb *know* instantiates also another interesting property of embedding verbs, usually called *factivity.* In general, a verb V that embeds a declarative complement P is said to be factive just in case the sentences of the form XVP, where X denotes a subject, presuppose the truth of the embedded complement P. This is to say that if P is false, the sentence XVP cannot be evaluated as being true nor false. That this is the case for *know* can be shown with the following examples, where the implied content in (6a) is preserved under negation and in a question:[6]

(6) a. John knows that Bob called.
$\rightsquigarrow$ Bob called.
b. John doesn't know that Bob called.
$\rightsquigarrow$ Bob called.

[5]This terminology follows Lahiri (2002)'s typology.
[6]The arrow $\rightsquigarrow$ indicates non-logical implication.

c. Does John know that Bob called?
$\rightsquigarrow$ Bob called.

Factivity is clearly a property of verbs that embed declarative complements. However, it can be related in interesting ways to verbs that embed interrogative complements too. First of all, let us introduce another property of embedding verbs, i.e. *veridicality*: in general, a verb V that embeds a declarative complement P is said to be veridical just in case a sentence of the form XVP entails the truth of the embedded complement P. Clearly factivity entails veridicality: if a sentence such as *John knows that Bob called* presupposes that Bob called and if such a sentence is true, then it is also true that Bob called (i.e. that Bob called is entailed by the sentence).

Now, it has been argued by Égré (2008) that if a declarative-embedding verb is veridical, then it is also responsive, i.e. it can also embed interrogative complements. According to this generalization, then, factive embedding verbs are always responsive. Moreover, Spector and Égré (2014) argue that a responsive verb is veridical with respect to its declarative complement if and only if it is also veridical with respect to its interrogative complement. This latter notion needs to be defined. Following Spector and Égré, we say that a verb V that embeds an interrogative complement Q is veridical with respect to Q just in case a sentence of the form XVQ entails the truth of a sentence of the form XVP, where P is a true answer to Q. For example, the sentence *John knows whether Bob called* entails that John knows the true answer to the question *Did Bob call?*; if Bob did call, for example, and it is true that John knows whether Bob called, then John must know that Bob called as well.

If both generalizations are correct, then, we get that factive embedding verbs are responsive and veridical with respect to both kinds of complements that they embed. It is not within the scope of this work to evaluate to what extent these generalizations hold; however, we believe that they highlight an interesting connection between factivity and responsive verbs which holds at least for the two classes of verbs that we consider in this work. These are the so-called *emotive* factives, such as *amaze, surprise, disappoint* and *epistemic* factives, such as *realise* and *anticipate*.

1.3 Emotive and epistemic factives

We take *surprise* and *realise* as our main examples of emotive and epistemic factives, respectively. The examples in (7) and (8) show that *suprise* and *realise* are indeed factive. Furthermore, the fact that the arguments in (9) and (10) are intuitively valid shows that these verbs are also veridical with respect to their interrogative complements:

(7) a. It surprised John that Bob called.
$\rightsquigarrow$ Bob called.

b. It didn't surprise John that Bob called.
$\rightsquigarrow$ Bob called.

(8) a. Kate realised that Bob is a bad guy.
$\rightsquigarrow$ Bob is a bad guy.

b. Kate didn't realise that Bob is a bad guy.
$\rightsquigarrow$ Bob is a bad guy.

(9) It surprised John who called yesterday.
Only Bob called.
Therefore, it surprised John that Bob called.

(10) Kate realised who came to the party.
Only Ann came.
Therefore, Kate realised that Ann came.

We chose to focus our attention on emotive and epistemic factives because we believe that their behaviour when they embed interrogative complements raises interesting challenges for a semantic analysis of embedding verbs.

In the following two sections we review a number of classic and recent works concerned with these classes of verbs (in particular *surprise* and *realise*) with the aim of collecting the relevant data that a semantic theory of these verbs should be able to account for.

Before moving to the next section, let us consider the components of the meaning of *surprise* and *realise* when they embed declarative complements, beside factivity.

Let us begin with *surprise*. It is rather uncontroversial that one cannot be surprised by some proposition if he or she does not believe it. We can argue that this implication has a presuppositional nature rather than being a logical entailment by looking at the examples in (11), where the implied content is preserved under negation and in a question. The examples highlight another component of the meaning of *surprise*, i.e. its reference to the subject's expectations towards the relevant proposition. In this case, however, it is easy to see that the corresponding implication is not preserved under negation and in a question.

(11) a. It surprised John that Bob called.
$\rightsquigarrow$ John believes that Bob called.
$\rightsquigarrow$ John didn't expect Bob to call.

b. It didn't surprise John that Bob called.
$\rightsquigarrow$ John believes that Bob called.
$\not\rightsquigarrow$ John didn't expect Bob to call.
$\rightsquigarrow$ John expected Bob to call.

c. Did it surprise John that Bob called?
$\rightsquigarrow$ John believes that Bob called.
$\not\rightsquigarrow$ John didn't expect Bob to call.
$\not\rightsquigarrow$ John expected Bob to call.

The fact that the expectation of the subject is not presupposed but asserted is apparent from the contrast between (11a) and (11b): the sentence *It suprised John that Bob called* implies that John did not expect Bob to call, while the sentence *It didn't surprise John that Bob called* implicates the negation, i.e. that John *did* expect Bob to call. As for the question in (11c), neither implication is present.

To sum up these observations we give the following semi-formal semantic entry for *surprise*, when it embeds a declarative complement P:

Definition 1.8. Surprise+P
Presupposition: a sentence of the form *It suprised X that P* is defined at a world w iff P is true at w and X believes P at w.
Assertion: if defined at w, *It suprised X that P* is true at w iff X did not expect P.

We can now turn to *realise*. Clearly, if someone realised *that P* then he or she used not to believe P and later came to know it. As before, we can disentangle the asserted component from the presupposed material by looking at some examples.

(12) a. Kate realised that Bob is a bad guy.
$\rightsquigarrow$ Kate didn't believe that Bob is a bad guy.
$\rightsquigarrow$ Kate now believes that Bob is a bad guy.

b. Kate didn't realise that Bob is a bad guy.
$\rightsquigarrow$ Kate didn't believe that Bob is a bad guy.
$\not\rightsquigarrow$ Kate now believes that Bob is a bad guy.
$\rightsquigarrow$ Kate still does not believe that Bob is a bad guy.

c. Did Kate realise that Bob is a bad guy?
$\rightsquigarrow$ Kate didn't believe that Bob is a bad guy.
$\not\rightsquigarrow$ Kate now believes that Bob is a bad guy.
$\not\rightsquigarrow$ Kate still does not believe that Bob is a bad guy.

It can be noticed that the implication concerning the subject's past beliefs is preserved under negation and in a question, which points towards its presuppositional nature. On the other hand, the contrast between (12a) and (12b) as regards the implication concerning subject's present beliefs points towards the conclusion that this component of the meaning is asserted rather than presupposed.

As before, let us sum up these observations with the following semantic entry for *realise*, when it embeds a declarative complement P:

Definition 1.9. Realise+P
Presupposition: a sentence of the form *X realised that P* is defined at a world w iff P is true at w and X did not believe P.
Assertion: if defined at w, *X realised that P* is true at w iff X believes P at w.

1.4 *Surprise* and *realise* with interrogative complements

We can now focus on the behaviour of verbs such as *surprise* and *realise* when they embed interrogative complements. There are two main features of these verbs that have been extensively considered in the literature: first, the fact that when they embed a question they select for a reading which is weaker than the strongly exhaustive reading; and second, the fact that they can felicitously embed *wh*-complements but not *whether*-complements.

In this section (1.4) we focus on the former and we try to summarise the recent debate concerning which reading is exactly at play when *surprise* and *realise* embed interrogative complements. As we will see, there is no general agreement in the literature concerning this issue and the authors' intuitions are very different from each other. In this work we will not try to conclusively evaluate the different positions at play, nor to argue for a particular position; in fact, our main goal is to explain why *suprise* and *realise* fail to embed *whether*-complements. In the following section (1.5) we focus on this issue and we summarise and criticise two classes of recent approaches to it.

1.4.1 A weaker reading

At least since (Berman, 1991) and (Heim, 1994) it has been argued that the strongly exhaustive reading of a question in the spirit of (Groenendijk and Stokhof, 1984) cannot be the only reading involved in the semantics of embedded questions. In particular, emotive and epistemic factives have been argued to select for a weaker reading.

Let us consider the verb *surprise*: an essential component of the semantics of a sentence of the form *It surprised X Q*, where Q is a question, seems to be that the subject X did not expect (and she later came to know) the answer to Q. Following Berman (1991), Heim (1994) argues that the concept of a strongly exhaustive answer cannot be the one involved in this kind of constructions when Q is a *wh*-question. For example, the strongly exhaustive reading of the embedded *wh*-questions is too strong to account for the intuitive truth conditions of a sentence such as (13):[7]

(13) It surprised John who came to the party.

Suppose that John is informed about who was invited and he expected Ann, Bob and Cindy to come, but in fact only Ann and Bob showed up. We would say that (13) is false: after all, it was not who came that surprised John, but who did not come. Nevertheless, if we assign a strongly exhaustive reading to the embedded *wh*-question *Who came to the party?* we get the prediction that (13) is true. In fact, suppose we assume that (13) is true just in case John did not expect the true strongly exhaustive answer to *Who came to the party?*; now, the strongly exhaustive answer of (14a) is (14b):

[7] The example, in the spirit of Heim's argument, is adapted from (Guerzoni, 2007).

(14) a. Who came to the party?

b. Exactly Ann and Bob came.

In the described situation John did not expect (14b) to be true (we assumed that he expected Ann, Bob and Cindy), hence (13) is predicted to be true.

Now, Heim's well-known approach to this problem is to adopt a different, weaker notion of the exhaustive answer to a question. As we have seen, if $[\![Q]\!]_w$ is the denotation of the question Q relative to w in the spirit of Karttunen's semantics, the weakly exhaustive answer to Q true in w, denoted with $\mathsf{ANS}_K(Q, w)$, is defined as the generalized intersection of $[\![Q]\!]_w$.

Back to the example, if we decide to assign a weakly exhaustive reading to the embedded *wh*-question *who came to the party*, we will get the right prediction: in the situation where only Ann and Bob showed up, the weakly exhaustive answer to (14a) is the proposition resulting from the intersection between the proposition that Ann came and the proposition that Bob came, i.e. the proposition that Ann and Bob came; now, in the given situation John *did* expect this proposition to be true, hence (13) is false.

A similar argument works for *realise* too. We can assume that an essential component of a sentence of the form *X realised Q*, where Q is a question, is that X came to know the answer to Q (while she did not know it before). Now, suppose that the answer involved in these constructions is a strongly exhaustive answer and consider the following situation. Only Ann and Bob came to the party, but Kate believes that Ann, Bob and also Cindy came. In this situation the strongly exhaustive answer to *Who came to the party?* is the proposition that exactly Ann and Bob came, and Kate clearly does not know it. But suppose that later she comes to know that Cindy did not come. Now she knows the strongly exhaustive answer, hence we get the prediction that (15) is true:

(15) Kate realised who came to the party.

This prediction is wrong because, intuitively, Kate later came to know who *didn't* come to the party (Cindy), while she already knew who came. Again, we get the right prediction if we assume that the weakly exhaustive reading is the one involved in this sentence: Kate used to correctly believe that Ann and Bob came to the party, which is the weakly exhaustive answer to the embedded question, hence (15) cannot be true.

Notice that we say *cannot be true* instead of *is false* for a precise reason. If (15) is false, then (16) is obviously true:

(16) Kate didn't realise who came to the party.

But, in the given situation, this does not seem to be correct. It is not true that Kate did not realise who came because, intuitively, there was nothing left for Kate to realise: of every person that came, she already knew that that person came. Hence it seems that neither (15) nor its negation are true, i.e. that in the given situation (15) is undefined. We follow Guerzoni (2007) and we take this to show that the component of the meaning of *realise* which refers to the fact that the subject did not know the (weakly exhaustive) answer to the embedded question is presupposed rather than asserted. Back to the example, Kate already knew the weakly exhaustive answer (i.e. that Ann and Bob called) and *Kate realised who came to the party* is neither true nor false.

A similar observation can be made for *surprise* as well. In particular, it appears that the component of meaning that refers to the fact that the subject came to know the (weakly exhaustive) answer to the embedded question is presupposed rather than asserted. Certainly, a sentence such as *It surprised John who called* implies that John knows who called. But the following examples show that this implied content is preserved under negation and in question, hence it is not entailed but, more likely, presupposed:

(17) It surprised John who called.
$\rightsquigarrow$ John knows who called.

(18) It did not surprise John who called.
$\rightsquigarrow$ John knows who called.

(19) Did it surprise John who called?
$\rightsquigarrow$ John knows who called.

Moreover, it is possible to successfully apply Kai von Fintel's "hey, wait a minute" test to a sentence such as (20a):[8]

(20) a. *Mary:* It surprised John who called.
b. *Lucy:* Hey, wait a minute! He doesn't even know who called.

Wrapping up, we give now two semi-formal semantic entries for *surprise* and *realise* that sum up what has been observed so far concerning the meaning of these two verbs when they embed an interrogative complement:

Definition 1.10. Suprise+Q (weakly exhaustive)
Presupposition: a sentence of the form *It suprised* X Q is defined at a world w iff X believes $\mathsf{ANS}_K(Q,w)$ at w.
Assertion: if defined at w, *It suprised* X Q is true at w iff X did not expect $\mathsf{ANS}_K(Q,w)$.

Definition 1.11. Realise+Q (weakly exhaustive)
Presupposition: a sentence of the form X *realised* Q is defined at a world w iff X did not believe $\mathsf{ANS}_K(Q,w)$.
Assertion: if defined at w, X *realised* Q is true at w iff X believes $\mathsf{ANS}_K(Q,w)$ at w.

1.4.2 An even weaker reading?

Although these observations seem convincing enough, recently several authors have argued that the reading involved when *surprise* embed a *wh*-question is not the weakly exhaustive reading, after all.

[8] Cf. (von Fintel, 2004).

For example, George (2011, 2013) agrees that the argument given above for *surprise* shows that the strongly exhaustive reading is indeed too strong, but he argues that it does not prove that we need to adopt the weakly exhaustive reading instead: in particular, the argument does not allow us to discriminate between the weakly exhaustive reading and the so-called *mention-some* reading, in that both yield the correct prediction in the given situation.

Recall the situation from the previous argument: John expected Ann, Bob and Cindy to come, but in fact only Ann and Bob showed up. The correct prediction is that *It surprised John who came to the party* is false, and the assumption that the reading involved is the weakly exhaustive reading yields this prediction, because John did expect Ann and Bob to come. Nevertheless, the mention-some reading yields the same prediction, because the true mention-some answers to *Who came to the party?* are *Ann came*, *Bob came*, *Ann and Bob came* and John expected all of them to be true.

Moreover, George claims that the mention-some reading is in fact to be preferred, on the basis of the following argument. Suppose that John is only informed about Cindy: he knows that she called. But he did not expect this, so he is surprised that she called. Further suppose that, unbeknownst to John, Bob called too. In this situation, George claims, we would say that (21) is true:

(21) It surprised John who called.

Now, the true weakly exhaustive answer to *Who called?* is *Bob and Cindy called*, but clearly John does not believe it to be true, for he does not know anything about Bob. Hence, (21) is predicted to be neither true nor false if we assume the weakly exhaustive reading in the presuppositional content of *surprise*.

On the other hand, if we assume a mention-some reading, we get George's prediction. In fact, John believes a(n unexpected) true mention-answer to *Who called?*, namely he believes that Cindy called and according to George this can be enough to say that he is surprised by who called. Clearly in order to get this prediction we need to assume the mention-some reading both in the presuppositional and in the asserted component of the meaning of *surprise*, along the lines of the following entry:

Definition 1.12. Suprise+Q (mention-some)
Presupposition: a sentence of the form *It suprised* X Q is defined at a world w iff $\exists p \neq \emptyset \in [\![Q]\!]_w$ s.t. X believes p at w.
Assertion: if defined at w, *It suprised* X Q is true at w iff $\exists p \neq \emptyset \in [\![Q]\!]_w$ s.t. X believes p at w and X did not expect p.

This entry says that *It surprised* X Q is defined and true as long as there is a true mention-some answer p to the question Q such that X believes it and X did not expect it: e.g., if Cindy called, John knows it and did not expect it, then John is surprised by who called, no matter what John may or may not know about other individuals.

Now, we have shaky intuitions concerning (21) in the given situation, but we believe that the prediction that the sentence is undefined is probably more accurate. In the situation in which John is not informed about Bob, which called too, the following dialogue seems plausible enough:[9]

(22) a. *Mary:* It surprised John who called.

b. *Lucy:* Well, actually he doesn't even know who called.

Given that an analogous dialogue seems equally plausible if (22a) is replaced with *It didn't surprise John who called*, and that we can take *well, actually...* to signal a presupposition failure, we are tempted to conclude that (22a) is indeed undefined in the given situation.

Clearly this observation allows us to argue for the adoption of the weakly exhaustive reading in the presuppositional content of *surprise*: the subject needs to know who called in a weakly exhaustive sense in order to be surprised (and also not surprised) by who called. However, this is still compatible with the idea that being surprised by one (or more) mention-some answer(s) to *Who called?* is enough to be surprised by who called. According to this view *It surprised* X Q would be defined and true as long as X knows the weakly exhaustive answer to Q (e.g. for every person that called, X knows that he or she called) and she did not expect one or more mention-some answer(s) to Q (e.g. for some person that called, X did not expect him or her to call).

However, as pointed out by Spector and Égré (2014), these truth-conditions seem too weak as well. They imagine a situation where John takes a look at the list of the invited people that showed up at the party, and the overall list is not particularly surprising to him, except for the presence of Bob, which he did not expect to see. Now, according to Spector and Égré in this situation it is plausible to say that John is surprised that Bob came to the party but he is not surprised by who came to the party. If this observation is correct, then the mention-some reading will be indeed too weak to be involved not only in the presupposed component of the meaning of *surprise* but also in the asserted component.

1.4.3 ...or a stronger one?

Spector and Égré go one step further and argue that the weakly exhaustive reading is too weak as well, at least when it comes to the presuppositional content of *surprise*. In other words, the authors provide a situation where the subject knows the weakly exhaustive answer to the relevant question Q, she did not expect it and yet she cannot be said to be surprised by Q, precisely because she fails to know the strongly exhaustive answer to Q.

The situation imagined by Spector and Égré is the following. John has ten students, which took a certain exam. Ann, Bob ad Cindy passed it, and nobody else did. John did not expect Ann, Bob ad Cindy to pass, but he had no expectation whatsoever for the other seven students. Hence, when Ann, Bob and Cindy inform him that they passed, he is surprised. As for the other seven,

[9] A number of native informants confirmed the plausibility of the dialogue. I am indebted with Nadine Theiler for this observation.

he does not know whether they passed or not yet. Summing up: John knows the weakly exhaustive answer to the question *Who passed?* and he did not expect it. Now, suppose Kate knows all this: in particular, Kate knows that John was surprised that Ann, Bob and Cindy passed, and that he does not know anything about the other seven. Then, according to Spector and Égré and their native informants, (23) uttered by Kate would be awkward:

(23) *Kate:* It surprised John which of his students passed the exam.

The reason for this awkwardness is to be found precisely in the fact that John does not know who exactly passed the exam yet, i.e. he does not know the strongly exhaustive answer to *Who passed?*. In fact, it seems plausible that another speaker which is completely aware of the situation could reply to Kate's assertion with something along the lines of (24):

(24) *Mary:* Well, actually, he doesn't even know who passed it yet.

Now, Spector and Égré lay out this argument because it provides an interesting insight into the semantics of *surprise*, but their overall goal is more general and thus they do not give a semantic entry specific for *surprise*. What they give is a general semantic definition for any responsive verb which embeds a question and selects for its weakly exhaustive reading. However, we can adapt their definition to obtain something in the spirit of the semi-formal definitions given above:

Definition 1.13. Suprise+Q (Spector and Égré, 2014)
Presupposition: a sentence of the form *It suprised* X Q is defined at a world w iff X believes $\mathsf{ANS}_{GS}(Q, w)$ at w.[10]
Assertion: if defined at w, *It suprised* X Q is true at w iff X did not expect $\mathsf{ANS}_{K}(Q, w)$.

Unsurprisingly, this entry says that *It surprised* X Q is defined and true as long as X knows the strongly exhaustive answer to Q (e.g. for every person, X knows whether that person passed the exam or not) and she did not expect the weakly exhaustive answer to Q (e.g. X did not expect those who passed to pass).

As already mentioned, we can see that there is no general consensus in the literature concerning which readings are at play when verbs such as *surprise* and *realise* embed interrogative complements. The debate is ongoing and certainly interesting. However, it is not within the scope of this work to conclusively evaluate the different positions at play, nor to argue for a particular position. In fact, we believe that only more systematic data-oriented studies could shed further light on these issues, as the authors' intuitions are often shaky and rarely conclusive.[11]

[10] $\mathsf{ANS}_{GS}(Q, w)$ denotes the strongly exhaustive answer to Q in w and can be defined following Heim (1994) as the proposition which is true in a world v just in case the weakly exhaustive answer to Q in v is the same as the weakly exhaustive answer to Q in w.

[11] For example, an experimental perspective on these issues is adopted by Cremers and Chemla (forthcoming). However, *surprise* and *realise* are not among the items tested in their work.

As already pointed out, in this work we are mostly concerned with the fact that verbs such as *surprise* and *realise* fail to embed *whether*-complements and our account is especially aimed to give an explanation of this fact. As the reader will see, our approach to this problem will be compatible with different readings. Hence, what matters most for our work is the following section, in which two classes of recent approaches to the *whether* puzzle are summarised and criticised.

1.5 The *whether* puzzle

The point of view adopted in the previous section abstracted away from a well-known observation concerning the behaviour of emotive and epistemic factives. At least since (Karttunen, 1977), it has been observed that in general verbs such as *surprise, amaze* and *realise* cannot felicitously embed *whether*-complements (polar questions and alternative questions), while being able to embed *wh*-complements.[12] Karttunen's original example is about *amaze*:

(25) a. It is amazing what they serve for breakfast.
b. # It is amazing whether they serve breakfast.
c. # It is amazing whether they serve coffee, or tea.

Other examples show that *surprise* and *realise* exhibit an analogous behaviour:

(26) a. It surprised John who called.
b. # It surprised John whether Bob called.
c. # It surprised John whether Bob called, or Ann.

(27) a. Kate realised who came to the party.
b. # Kate realised whether Bob came to the party.
c. # Kate realised whether Bob came to the party, or Ann.

Notice that the semantic entries considered so far cannot account for this selection property. For example, assume that *It surprised* X Q is defined and true just in case X knows the weakly exhaustive answer to Q but she did not expect it and assume that Q is a polar question of the form $?P$. We get the prediction that if P holds then *It surprised* X Q is true iff X knows P and she did not expect P, and if P does not hold then *It surprised* X Q is true iff X knows $\neg P$ and she did not expect $\neg P$.

Karttunen dismisses the selection property of these verbs as a marginal counterexample to the generalization that verbs that take *wh*-complements also take *whether*-complements. Nevertheless, we believe that it raises an interesting challenge for the semantic analysis of embedding verbs and the complements they embed. In this section we review two recent approaches to this puzzle.

[12] This observation is rather uncontroversial. A quick search on the Corpus of Contemporary American English (`http://corpus.byu.edu/coca/`) confirmed that *suprise(d)+whether* is never attested and *realise(d)+whether* is attested in less than 10 cases.

1.5.1 A pragmatic approach: Sæbø (2007)

Many recent approaches to the *whether* puzzle (Sæbø, 2007, Guerzoni, 2007, Uegaki, 2014 a.o.) can be classified as pragmatic, in that they all try to give an explanation of why verbs such as *suprise* and *realise* cannot embed *whether*-complements on the basis of a number of general assumptions concerning the rules underlying the uses of the relevant expressions in a conversation. In general, the pragmatic strategies adopted to explain why a sentence such as *It surprised X whether P* is not felicitous are based on a semantics of *surprise* according to which the sentence *It surprised X whether P* is strictly less informative than a number of related alternative sentences. On the basis of this semantic fact, then, the pragmatic machinery is exploited to generate some form of systematic competition between the sentence and its alternatives that results in the wanted prediction of unacceptability.[13]

In this section we consider Sæbø's approach in some details, because we believe that it is the most clear example of a pragmatic approach to the *whether* puzzle. However, in the last part of the section we will try to argue against this approach (and the pragmatic approaches in general) with two different kinds of counterexamples.

Sæbø's approach is based on the notion of *competition* as defined within the pragmatic framework of *Bidirectional Optimality Theory* (BiOT).[14] Intuitively, a sentence of the form *It surprised X Q*, where *Q* is a *whether*-question, is not felicitous because it systematically competes with some alternative sentence where *surprise* embed a *that*-complement.

We do not need to dive into the details of BiOT here, but let us summarise a few concepts in order to be able to review Sæbø 's proposal. The basic idea at play is that a pair consisting of a natural language expression (or *form*) and an interpretation (*content*) can be in competition with another pair $\langle \text{form}, \text{content} \rangle$ as regards their optimality. For example, the same content can be expressed by two different forms but one of them may result in an optimal pair while the other is suboptimal.

The concept of optimality adopted by Sæbø is defined as follows:

$\langle f, c \rangle$ is optimal iff:

i. f is at least as good for c as any other candidate form f';

ii. c is at least as good for f as any other candidate content c';

The notion of *being good* is in turn defined in terms of conditional probability: X is said to be at least as good for Y than Z just in case the probability of X conditional on Y is higher than or equal to the probability of Z conditional on Y. For example, a certain form f will be better than another form f' for some

[13] This certainly holds for Sæbø's and Uegaki's proposals. Guerzoni's approach is more complex, in that the competition between the sentence and its alternatives generates some quantity implicatures which in turn result in a systematic contradiction with other components of the meaning of the sentence.

[14] See for example (Blutner, 2000) and the references given in (Sæbø, 2007).

content c just in case the probability of using f to express c is higher than the probability of using f' to express the same content.

Now, these concepts can be used, for example, to give a simple explanation of the well-known fact that if the common ground of a conversation already entails a certain proposition p, the construction *know+p* is preferred over the construction *believe+p*. For example, suppose that both Mary and Kate are perfectly aware that Bob called, and they were worried that John might have found out about this. Then (28b) sounds out of place:

(28) a. *Mary:* Hey Kate, I met John and he knows that Bob called.

b. *Mary:* Hey Kate, I met John and # he believes that Bob called.

We will assume that *know* and *believe* have the same semantic content except for the fact that *know* presupposes the truth of the declarative it embeds. Moreover, we will follow Sæbø and assume here that if an expression α presupposes a proposition π then in order for α to be defined at a world w it must be the case that π is entailed by the common ground of the conversation at w (CG_w).

Under these assumptions, one can explain the fact that *believe* is blocked in (28b) in terms of optimality. In fact, the form *he knows that Bob called* can only be used in the case where the common ground entails that Bob called ($CG \vDash p$), whereas the form *he believes that Bob called* is compatible with both cases ($CG \vDash p$ and $CG \nvDash p$); hence, we can compute the conditional probabilities of the four possible pairs, as displayed in the following table, where K_jp stands for *John knows that Bob called* and B_jp stands for *John believes that Bob called*:

Probability	$CG \vDash p$	$CG \nvDash p$
K_jp	1	0
B_jp	1/2	1/2

In the situation where the common ground entails that Bob called, the form *he knows that Bob called* is associated with the highest value in the table; in particular, it has a higher value than the form *he believes that Bob called* in the same situation, and this is why it is preferred (i.e. it is optimal). Moreover, the form *he believes that Bob called* is associated with a higher value than the form *he believes that Bob called* in the situation where the common ground does not entail that Bob called. Hence, the form *he believes that Bob called* would be preferred in that situation. This explains why it is blocked in (28b): it conveys that the common ground does not entail that Bob called, contradicting the fact that both Mary and Kate know that he did call.

Notice that this is a case of what is called *partial blocking*, in the sense that the expression is blocked in some situations and not in others. Now, the main idea underlying Sæbø's approach to the *whether* puzzle is that if a surprise verb embedded a *whether*-question the resulting expression would be systematically blocked, i.e. it would always be suboptimal no matter the situation.

In order to derive this prediction Sæbø needs to assume that emotive factives carry an additional presupposition, beside the one that we have considered in the previous sections, when they embed interrogative complements. According to his terminology, these verbs are *super factive*; other authors (most notably Guerzoni (2007) and Guerzoni and Sharvit (2007)) call them *speaker factive*.[15] The latter is more transparent: the idea is that when, for example, *surprise* embed a question Q, the resulting sentence presupposes not only that the subject knows the answer to Q but also that *the speaker* knows the answer to Q.

Notice that Sæbø's claim is really about *being incredible* and *being amazing*, which he calls "strict" verbs, as opposed to the more "liberal" *surprise*: for example, *being incredible* presupposes that the speaker knows the answer to the embedded question, while in the case of *surprise* "there is in any case a tendency for the speaker to know". We are not sure how to precisely interpret this difference, and Sæbø does not provide the reader with examples to substantiate his claim. Or rather, the example he gives in order to show that *being incredible* is speaker factive fails to make the point.[16]

In any case, other examples involving *surprise* and *realise* seem more convincing. It seems that the speaker needs to know who came to the party in order for sentences such as the following to be felicitous:

(29) a. It will surprise John who came to the party.
b. It won't surprise John who came to the party.

(30) a. John realised who came to the party.
b. John didn't realise who came to the party.

We concede that the sentences in (29) and (30) would sound out of place if uttered by a speaker who does not know who came to the party and for the time being we will assume that *amaze*, *suprise* and *realise* are indeed speaker factive, so that we can move on to Sæbø's analysis. However, there are cases in which our intuitions are less solid and we will return on the plausibility of this assumption below.

In a nutshell, Sæbø claims that a sentence such as (31a) systematically (i.e., no matter the situation) competes (and loses) with either (31b) or (31c) and this is why it is never allowed:

(31) a. # It's amazing whether Bob called.
b. It's amazing that Bob called.
c. It's amazing that Bob didn't call.

The reason underlying this competition is a consequence of speaker factivity. In fact, assuming that *amaze* is speaker factive, (31a) presupposes that the speaker knows whether Bob called or not ($K_s?p$). Hence, in order for (31a) to be defined, the common ground should either entail that the speaker knows that Bob called ($CG \vDash K_s p$) or that the speaker knows that Bob did not call ($CG \vDash K_s \neg p$).

[15] Guerzoni too exploits speaker factivity to give a pragmatic account of the *whether* puzzle and Uegaki agrees (p.c.) that speaker factivity may be one way to extend the proposal sketched in (Uegaki, 2014). We chose to review Sæbø's approach because it is more complete than Uegaki's and less complex than Guerzoni's and because we think that these approaches, while being quite different, have the same problems.

[16] We will return to this point below.

Since *know* is veridical, we conclude that the form # *It's amazing whether Bob called* is compatible with two situations, i.e. $CG \vDash p$ and $CG \vDash \neg p$. On the other hand, (31b) is only compatible with $CG \vDash p$ and (31c) only with $CG \vDash \neg p$. This reasoning allows us to construct the following table of conditional probabilities:[17]

Probability	$CG \vDash K_s p$	$CG \vDash K_s \neg p$
$A?p$	1/2	1/2
Ap	1	0
$A\neg p$	0	1

Given its presupposition, there are two situations in which (31a) would be defined and it is easy to see from the table that in both situations the sentence would be suboptimal.

Sæbø does not explicitly mention the case of alternative questions (nor does he talk about epistemic factives such as *realise*), but we believe that his analysis can be straightforwardly applied to this case. Briefly, the fact that e.g. (32a) is not felicitous will follow from the fact that it systematically competes and loses against either (32b) or (32c):

(32) a. # John realised whether Bob called, or Ann↓.
b. John realised that Bob called.
c. John realised that Ann called.

The competition is again a consequence of speaker factivity: in order for (32a) to be defined the common ground should either entail that the speaker knows that Bob called ($CG \vDash K_s bob$) or that the speaker knows that Ann called ($CG \vDash K_s ann$). Since *know* is veridical, we conclude that the form in (32a) is compatible with two situations, i.e. $CG \vDash bob$ and $CG \vDash ann$. On the other hand, (32b) is only compatible with $CG \vDash bob$ and (32c) only with $CG \vDash ann$. The table of probabilities is the following:

Probability	$CG \vDash K_s ann$	$CG \vDash K_s bob$
$R_j?(bob \vee ann)$	1/2	1/2
$R_j ann$	1	0
$R_j bob$	0	1

It should be clear that the role of speaker factivity is crucial: without assuming that e.g. # *John realised whether Bob called, or Ann* presupposes that the speaker knows who called among Bob and Ann we cannot exclude the situation in which the common ground is neutral regarding who called among Bob and Ann, and thus we cannot say that the *whether*-form competes with the two *that*-forms.

We have gone into the details of Sæbø's approach because we believe that it has the virtue of proposing a uniform explanation of the *whether* puzzle based

[17] $A?p$ stands for *It's amazing whether Bob called*, Ap for *It's amazing that Bob called* and $A\neg p$ for *It's amazing that Bob didn't call.*

(mostly) on independent assumptions concerning the relations between the form, the content and the common ground of an utterance.

On the other hand, we are still not convinced that the verbs considered in this chapter are indeed speaker factive. As we have already mentioned, Sæbø's claim is restricted to *being incredible* and *being amazing*. But the *whether* puzzle seems to be a general phenomenon involving emotive factives and epistemic factives. Hence, if Sæbø's proposal is of some value, it should be in general applicable to the verbs belonging to these two classes, which is why we have decided to follow Guerzoni (2007) and assume, for the sake of the exposition, that *surprise* and *realise* are speaker factive too. The problem is that it seems to us that the evidence brought in favour of this assumption is not very solid.

First of all, as we have already mentioned, the only example given by Sæbø in order to show that *being incredible* is speaker factive fails to make the point. In fact, he observes that *It's incredible what he has done today* implies *The speaker knows what he has done today* and this observation is correct; but we believe that it does not show unequivocally that the verb is speaker factive beside being subject factive, simply because in the sentence the speaker and the subject are not distinguished. In general, if a speaker says *it's incredible* φ without further specifications she means that φ is incredible *for her*.

This is why we turned to sentences in which the subject is explicit, such as *It will surprise John who called*, that is typically uttered by someone different from John, say Kate. Now, we agree that if Kate does not know who called then the sentence sounds strange. However, other examples are definitely less clear. Guerzoni herself admits that her intuitions are less solid when it comes to a sentence such as (33), that can be felicitous even if the speaker does not know who called as shown in (34):

(33) It surprised John who called.

(34) I don't know who called, but it surprised John: I could see it in his face.[18]

Furthermore, in a situation where Kate is not informed about who came to the party, she could nonetheless ask a question such as the one in (36) to Mary:

(35) *Mary:* Kate, do you want to know who came to the party?

(36) *Kate:* No, but tell me: will it surprise John who came?

If it is true that the question *Will it surprise John who came?* can be felicitous even if the speaker does not know who came, then it seems likely that the corresponding declarative *It will surprise John who came* does not presuppose that the speaker knows who came after all.

Clearly these examples are not enough to conclusively show that the verbs we are interested into are not speaker factive. However, we believe that the examples provided by Sæbø and Guerzoni are not conclusive either. The best way to go beyond the shaky intuitions of a very limited set of authors would

[18]I am indebted with Wataru Uegaki for this observation.

be to run a systematic data-oriented study aimed to establish what is exactly the presuppositional component of the meaning of *surprise* and *realise*. Since a conclusive answer to this question is currently missing, we believe that an approach to the *whether*-problem that manages to be descriptively adequate without assuming speaker factivity would be preferable.

Let us conclude by briefly pointing out another, more general, problem for any pragmatic approach that, similarly to Sæbø's, is based on the competition between the problematic sentence and its more tives. As we have seen, the crucial idea underlying these approaches is that a sentence such as *It surprised X whether P* has two more informative alternatives, i.e. *It surprised X that P* and *It surprised X that* $\neg P$.[19] How exactly these alternatives are computed depends on the semantics assigned to *suprised*, but in general it seems reasonable to assume that a sentence such as *It surprised X whether P*, were it grammatical, would only be used in the situation where the speaker is not in the position to use *It surprised X that P* nor *It surprised X that* $\neg P$, much similarly to what happens with a sentence such as *X knows whether P*.

Now, it is very easy to intuitively come up with the more informative alternatives of simple sentences such as *It surprised John whether it rains* and *It surprised John whether Ann called, or Bob*. However, it is not clear how this can be done with more complex sentences involving similar constructions:

(37) Every boy knows whether his mum called.

(38) # Every boy was surprised whether his mum called.

What are the more informative alternatives of (37) and (38)? Answering this question is crucial in order to account for the fact that (38) is not felicitous along the lines of a pragmatic approach. However, we cannot see an obvious way to do so and there seem to be nothing in Sæbø's work (nor in Guerzoni's) that sheds any light on this issue.

1.5.2 A semantic approach: Abels (2004)

Abels' goal is to give an explanation of why polar interrogatives cannot be embedded under verbs such as *surprise* which is based solely on considerations regarding the semantics of such embedding verbs and the embedded questions. In particular, the meaning of those verbs will have a presuppositional component that systematically fails to be satisfied whenever that meaning is combined with the meaning of an embedded polar question.

From this short introduction it can already be noticed that Abels' account is not as descriptively adequate as we would like it to be: in fact, by the author's own admission, the account explains why polar questions cannot be embedded under *surprise* but does not say anything about alternative questions. Of course, neither did Sæbø. However, we have shown that Sæbø's approach can be easily

[19] In the case of an embedded alternative question, each alternative corresponds to one of the disjuncts.

extended to alternative questions, while we believe that Abels' approach cannot in principle be extended. We will return to this later on. For the time being we want to sketch Abels' account because we believe that it is on the right track, and our own solution to the *whether* puzzle will partly build upon it.

First of all, Abels adopts a semantic theory of questions which is based on Hamblin's picture: the denotation of a question is the set of its possible answers. However, he is mostly concerned with the true members of this set, with the consequence that his approach can be more easily formulated in a way that assumes a theory of questions in the spirit of Karttunen's.

The only difference with Karttunen's theory regards the denotation assigned to polar questions. Recall that according to Karttunen the denotation of a polar question such as $?\varphi$ in a world w is a singleton set containing the true answer to $?\varphi$ in w, i.e. the singleton containing $[\![\varphi]\!]$ in case φ holds at w and the singleton containing $[\![\neg\varphi]\!]$ if φ does not hold at w. Now, Abels adopts the following definition:

$$[\![?\varphi]\!]_w := \{p \mid w \in p \text{ and } p = [\![\varphi]\!]\}$$

It should be clear that if φ holds at w then the denotation of the question coincides with Karttunen's denotation, whereas if φ does not hold at w the denotation coincides with the empty set. We do not concern ourselves with the plausibility of this definition (Abels briefly argues in favour of it in a footnote). Its role in Abels' proposal will soon be clear. As regards *wh*-questions, we assume that $[\![Q]\!]_w$ is the set of the basic true answers to Q.

The interesting aspect of Abels' proposal concerns the semantics of *suprise*. In particular, Abels agrees that when verbs such as *amaze* and *surprise* embed a question they carry the presupposition already considered in Section 1.4, i.e. that the subject knows the (weakly exhaustive) answer to the embedded question. However, he follows d'Avis, 2002 in observing that this answer should not be trivial: intuitively, one cannot be surprised by a tautology.[20]

Now, assuming that the weakly exhaustive answer to a question Q true at a world w ($\mathsf{ANS}_K(Q, w)$) is defined as the generalized intersection of the set $[\![Q]\!]_w$, we get that $\mathsf{ANS}_K(Q, w)$ equals the trivial proposition $\top$ just in case $[\![Q]\!]_w$ is the empty set.[21] When it comes to polar questions, $[\![?P]\!]_w$ is empty only if P is false. As for *wh*-questions, $[\![Q]\!]_w$ is empty when there are no basic true answers to Q: for example, if Q is *Who called?* then if nobody called at w $[\![Q]\!]_w$ is empty. This means that when it comes to a *wh*-question the requirement that the weakly exhaustive answer to Q be not trivial amounts to what we can call an *existence* requirement on the question.

We believe that when verbs such as *surprise* and *realise* embed a question they do carry the presupposition that the question has a non-trivial answer, which we will call an *existence presupposition*. Abels observes that "if John is

[20] This observation can also be found in (Groenendijk, 2014), where the author suggests a possible semantic solution to the *whether* puzzle which is very similar to Abels' approach.

[21] For the sake of completeness, notice that a trivial question will also have a trivial answer: if $[\![Q]\!]_w = \{\top\}$ then $\bigcap [\![Q]\!]_w = \top$.

surprised at who Mary invited, Mary must have invited somebody".[22] That the implied content is really presupposed rather than asserted is apparent in the following examples, where the implied content is preserved under negation and in a question:

(39) a. It surprised John who failed the test.
$\rightsquigarrow$ Someone failed.
b. It did not surprise John who failed the test.
$\rightsquigarrow$ Someone failed.
c. Did it surprise John who failed the test?
$\rightsquigarrow$ Someone failed.

Moreover, it is possible to successfully apply the "hey, wait a minute" test to (40a):

(40) a. *Mary:* It surprised John who failed the test.
b. *Lucy:* Hey, wait a minute! I didn't know that someone failed at all.

Similar examples work for *realise* as well:

(41) a. Kate realised who failed the test.
$\rightsquigarrow$ Someone failed.
b. Kate didn't realise who failed the test.
$\rightsquigarrow$ Someone failed.
c. Did Kate realise who failed the test?
$\rightsquigarrow$ Someone failed.

(42) a. *Mary:* Kate realised who failed the test.
b. *Lucy:* Hey, wait a minute! I didn't know that someone failed at all.

Summing up, we take these examples as evidence that sentences where *surprise* or *realise* embed a *wh*-question carry an existence presupposition, in the sense that there must be a non-trivial answer to the embedded question in order for the sentences to be evaluable at all.

We can now move back to Abels' proposal. He does not give an explicit semantic entry for *suprise*, but a list of requirements that cannot fail to be satisfied for a sentence such as *It surprised* X Q to be defined and possibly true. The requirements are the following:

i. There exists a proposition A s.t. $A \neq \top$ and A is the true weakly exhaustive answer to Q;

ii. X believes A;

iii. X did not expect A to be true, in the precise sense that there is a proposition B which is a possible non-trivial weakly exhaustive answer to Q such that B is not compatible with A and X expected B;

[22](Abels, 2004) p.8.

iv. B is not compatible with the set of worlds where the weakly exhaustive answer to Q is $\top$.[23]

Now, let us see what happens for a sentence such as *It surprised John whether Bob called*. First, suppose that Bob did not call. Then the weakly exhaustive answer to *Did Bob call?* is the trivial proposition, hence (i) is not satisfied and the sentence *It surprised John whether Bob called* is not defined. Moreover, the only sentence B that can satisfy (iii) is the contradiction, something rather strange for John to be expecting in any case. Suppose now that Bob did call. Then the weakly exhaustive answer to *Did Bob call?* is the proposition that Bob called and B must contain only worlds where Bob did not call. However, B is not compatible with the proposition that says that the answer to *Did Bob call?* is trivial, that is to say that B is not compatible with the set of worlds where Bob did not call. But this is a contradiction, hence the requirement in (iii-iv) cannot be simultaneously satisfied. Therefore, *It surprised John whether Bob called* is again undefined.

This reasoning shows that in both the two possible cases the sentence *It surprised John whether Bob called* is undefined. According to Abels, and we agree, this can be seen as an explanation of why it is never felicitous.

Let us conclude simply by pointing out that Abels' definition of the denotation of a polar question plays a crucial role in his approach to the *whether* problem. Specifically, it is crucial that the weakly exhaustive answer to a question such as $?P$ ends up being trivial when P does not hold. As a consequence, we believe that Abels' approach cannot be straightforwardly extended to alternative questions. In fact, the interpretation of an alternative question cannot be defined in such a way that the weakly exhaustive answer to it is trivial when one of the two disjuncts holds.

We have reviewed two recent approaches to the *whether*-puzzle. Sæbø (2007)'s proposal, together with other recent approaches (Guerzoni, 2007, Uegaki, 2014), is essentially pragmatic, insofar it gives an explanation of why *surprise* and *realise* fail to embed *whether*-complements on the basis of some general assumptions concerning the uses of these expressions in a conversation. The advantage of these approaches is that they are straightforwardly applicable to both polar questions and alternative questions in a uniform way. On the other hand, they rely on the assumption of speaker factivity. As we have pointed out, it seems to us that the empirical data supporting this assumption is not convincing. Moreover, we have some doubts concerning the descriptive power of the pragmatic approaches in general, in that they crucially rely on the availability of more informative alternatives of a sentence.

In the next chapter we propose a novel solution to the *whether*-puzzle which follows the main idea already found in Abels (2004)'s proposal: the fact that

[23] This latter requirement takes care of cases such as the one in which, for example, John did not expect anybody to call, in which the sentence *It surprised John who called* would sound strange. If John did not expect anybody to call, then the proposition B embodying John's expectation is the proposition that nobody called, i.e. the proposition true in a world only if the weakly exhaustive answer to *Who called?* equals $\top$ in that world.

surprise and *realise* fail to embed *whether*-complements can be explained purely on semantic grounds, on the basis of the interplay between the meaning of the embedding verbs and the embedded complements. As we have already pointed out, we believe that Abels' approach is in principle limited to polar questions. The main advantage of our approach is that it has the same (if not better) empirical coverage of Sæbø 's proposal, in that it covers polar and alternative questions in a uniform way, without the need of assuming speaker factivity.

Chapter 2

Proposal: highlighted items and existence presuppositions

In this chapter we present a novel approach to the semantics of responsive verbs and the complements they embed. In particular, we look at the semantics of emotive factives such as *surprise* and epistemic factives such as *realise* and we show how to account for the puzzling fact that such verbs cannot felicitously embed *whether*-complements. In Section 2.1 we give an informal sketch of our proposal. The account crucially relies on the notion of items highlighted by a sentence (Roelofsen and van Gool, 2010, Roelofsen and Farkas, forthcoming), an additional dimension of sentential meaning aimed to capture the anaphoric potential of a sentence. The general notion of highlighted items is introduced and motivated in Section 2.2. The semantic system adopted in our account to analyse sentential complements is presented in Section 2.3. In Section 2.4 we briefly recall the data to be accounted for, we introduce our semantic entries for the verbs *know*, *suprise* and *realise* and we show how the interplay between these entries and the semantic analysis of complements can account for the data. Section 2.5 concludes.

2.1 The proposal in a nutshell

In this section we give an informal sketch of our proposal with the aim of introducing the crucial elements of the account that will be discussed in details in the following sections.

Our solution to the *whether* puzzle is based on the interplay between the semantic features of verbs such as *surprise* and *realise* and the meaning assigned to the complements they embed. The main idea is that if one of these verbs embeds a *whether*-complement, then the resulting sentence is semantically useless.

The best way to explain how this works is to look at an example. Consider the polar question in (43) and the sentence in (44):

(43) Did Bob come to the party?

(44) # It surprised John whether Bob came to the party.

Let us start with the semantics of (43) and its embedded counterpart in (44). Following Roelofsen and van Gool (2010) and Roelofsen and Farkas (forthcoming), we assume that one of the components of the meaning of a sentence encodes its potential to set up discourse referents, i.e. semantic elements (called *higlighted items*) that are made available for subsequent anaphoric reference. For example, a declarative such as *It's raining in Amsterdam* is taken to highlight one propositional item (the proposition that it is raining in Amsterdam), and anaphoric expressions such as *so* can refer to it (for example in *If so, why are you riding your bike?*). Similarly, a polar question such as (43) is taken to highlight one propositional item (the proposition that Bob came). Finally, we generalise this assuming that a *wh*-question such as *Who called?* highlights one function (called *abstract*[1]) that assigns to each individual the proposition that he or she called.

The semantic dimension of highlighted items is one of the crucial components of our account. The other crucial component is found in the semantic content assigned to the verbs such as *surprise* and *realise*. In particular, following the observations mentioned in the previous chapter, we assume that when these verbs embed a question they give rise to sentences carrying an existence presupposition concerning the embedded question itself. For example, the sentence *It surprised John who failed the test* cannot be true nor false in the situation where nobody failed the test.

Now, we have assumed that an interrogative such as *Who failed the test?* is associated with an abstract that yields propositions of the form *x failed the test*, where x is an individual. Hence, a convenient way to encode the existence presupposition of a sentence such as *It surprised John who failed the test* is to require that at least one of these propositions is true in the actual world (i.e. at least one individual failed the test in the actual world). In other words, the item highlighted by the embedded question is satisfiable in the actual world.

More in general, we assume that a sentence of the form XVQ, where V is a verb such as *surprise* and *realise* and Q is any question, is defined only if all the items highlighted by Q are satisfiable.[2]

Now we can easily check what happens when Q is a polar question such as (43). Consider the sentence *It surprised John whether Bob came to the party.* The embedded question highlights the proposition that Bob came. This means that in order for the sentence to be defined, the item must be satisfied (i.e. true) in the actual world. If Bob did not come, the sentence is undefined. If Bob came, the sentence is defined and will be true exactly in the situation where John is surprised that Bob came.

We can conclude that the sentence *It surprised John whether Bob came to the party* is undefined in one possible situation and has the same truth-conditions

[1] Cf. (Groenendijk and Stokhof, 1984).

[2] As we will see in more details, it is crucial that *all* the items highlighted by Q are satisfiable. We will provide an independent motivation for this assumption later on.

of *It surprised John that Bob came* in the other possible situation. This makes it a semantically useless expression, and we take this to be an explanation of why the sentence is not felicitous.

A similar explanation will work for alternative questions as well. Briefly, we will assume that an alternative question such as *Did Ann called, or Bob?* highlights two propositional items, namely the proposition that Ann called and the proposition that Bob called. Moreover, we will assume that an alternative question carries a *not-both* presupposition, in the sense that it is defined only if at least one of the disjuncts does not hold.

Now, let us see what happens when an alternative question such as *whether Ann called, or Bob* is embedded under a verb V such as *surprise* or *realise* with the mentioned semantics. Remember that we require that all the items highlighted by the embedded question should be satisfied, in order for the sentence *It surprised John whether Ann called, or Bob* to be defined. Hence, it can be defined just in case both Ann and Bob called. But then the presupposition carried by the embedded question is not satisfied, which we take to entail that the sentence itself is not defined either. Therefore, there is no situation in which *It surprised John whether Ann called, or Bob* is defined, and we take this an explanation of why it is not felicitous.

2.2 Polarity particle responses and anaphoric potential

The novel aspect of our account of responsive verbs and the complements they embed crucially relies on the adoption of a semantic system in which the meaning of a sentence embodies both its semantic content (the information provided and/or requested by the sentence) and its anaphoric potential (the capacity of the sentence to set up discourse referents for subsequent anaphoric expressions). This section provides an overview of the independent motivation behind the adoption of such a system, drawing from the analysis of polarity particle responses carried out by Roelofsen and Farkas (forthcoming).

2.2.1 Basic data

We restrict our attention to responses starting with the two English polarity particles *yes* and *no*.[3] The main observation concerning these particles is that they are anaphoric, in the sense that their interpretation depends on the availability and nature of a suitable antecedent, similarly to what happens with anaphoric personal pronouns. Compare (45) and (46), where *yes* and *no* get different interpretations depending on the preceding discourse:

(45) a. Ann called.

[3] However, the approach adopted by Farkas and Roelofsen is cross-linguistic and they consider data drawn also from languages with polarity particle systems different from English (e.g. ternary systems).

b. Yes ($\rightsquigarrow$ Ann called.)
c. No ($\rightsquigarrow$ Ann didn't call.)

(46) a. Did Bob come to the party?
b. Yes ($\rightsquigarrow$ Bob came.)
c. No ($\rightsquigarrow$ Bob didn't come.)

Expressions such as *so* are taken to be anaphoric in the same sense: their interpretation depends on the availability and nature of an antecedent, as shown in (47) and (48):

(47) a. John left.
b. If so, why is his car in the garage?
($\rightsquigarrow$ If John left, why is his car in the garage?)

(48) a. Did Kate leave?
b. If so, why is her car in the garage?
($\rightsquigarrow$ If Kate left, why is her car in the garage?)

From these examples we can already observe that anaphoric expressions such as *yes*, *no* and *so* can occur in responses to both declaratives, as in (45) and (47), and polar questions, as in (46) and (48). However, other interrogatives do not licence this kind of responses:

(49) a. Is the door open, or closed↓?[4]
b. # Yes. / # No.
c. # If so, you should close it.

(50) a. Who came to the party?
b. # Yes. / # No.
c. # If so, the party was fun.

Why are these responses licensed after declaratives and polar questions and not after alternative and *wh*-questions? If the assumption concerning the anaphoric nature of *yes*, *no*, *so* holds, then answering this question entails explaining how the anaphoric potential of declaratives and polar questions differs from the anaphoric potential of alternative and *wh*-questions.

2.2.2 Anaphoric potential

First of all one should understand what exactly is the anaphoric potential of a sentence. It is useful to recall here a classic example (due to Barbara Partee[5]) concerning the anaphoric potential of referential expressions:

(51) I dropped ten marbles and found all of them, except one. It is probably under the sofa.

[4]The arrow signals a falling pitch on the second disjunct.
[5]see Heim, 1982

(52) I dropped ten marbles and found only nine of them. #It is probably under the sofa.

The first sentences in (51) and (52) have the same truth-conditional content. Nonetheless, the continuation *It is probably under the sofa* is perfectly acceptable in (51) because a referent for *it* is immediately available, while problematic (or at least more difficult to process) in (52). This shows that truth-conditions are not enough to determine the anaphoric potential, which is then understood as the capacity of certain expressions to set up discourse referents that may be picked up by anaphoric expressions in the subsequent discourse.[6]

In this setting we are interested in both declarative and interrogative sentences, hence it is better to adopt a more general perspective and talk about the *semantic content* of a sentence, rather then talking about its truth-conditions. Traditionally, the semantic content associated with a declarative corresponds to the information provided by the declarative, modelled in terms of truth-conditions, and the semantic content associated with an interrogative corresponds to the information requested by the question, modelled in terms of answerhood-conditions. Recently, the framework of Inquisitive Semantics has been proposed to give a uniform treatment of the semantic content of declarative and interrogative sentences (Ciardelli *et al.*, 2012, 2013 a.o.). In any case, what matters here is that the semantic content of a sentence, i.e. the information provided and/or requested by the sentence, is not enough to account for its anaphoric potential for a number of reasons.

As regards truth-conditions, the fact that they are not enough should already be clear insofar as the anaphoric expressions *yes*, *no* and *so* are felicitous in responses to polar questions and talking about the truth-conditions of a (polar) question does not seem to make much sense at all.

Turning to answerhood-conditions, consider the following questions.[7] (53) (54) and (55) have arguably the same answerhood-conditions: for example, in a partition analysis of questions all of them have the same intension, i.e. a partition of the logical space into two cells (one containing exactly the possible worlds where the number of planets is even and one containing those where it is odd).

(53) a. Is the number of planets even?
b. Yes ($\rightsquigarrow$ It's even).
c. No ($\rightsquigarrow$ It's odd).
d. I don't think so.
($\rightsquigarrow$ I don't think it's even.)

(54) a. Is the number of planets odd?
b. Yes ($\rightsquigarrow$ It's odd).
c. No ($\rightsquigarrow$ It's even).

[6] This kind of arguments originally motivated the development of so-called *Dynamic Semantics* (Kamp, 1981, Heim, 1982, Groenendijk and Stokhof, 1991 a.o.)

[7] The example is taken from (Roelofsen and Farkas, forthcoming).

d. I don't think so.
(⇝ I don't think it's odd.)

(55) a. Is the number of planets even, or odd↓?

b. # Yes. / # No.

c. # I don't think so.

The example shows that (53) (54) and (55), while having the same semantic content (answerhood-conditions), have different anaphoric potential because the anaphoric particles *yes*, *no*, *so* receive different interpretations when uttered after (53) and (54) and are not felicitous when uttered after (55). Similarly to what happens with Partee's example above, we take this example to show that the semantic content associated with the questions is not enough to determine their anaphoric potential.

Another observation made by Farkas and Roelofsen concerns the fact that *yes* and *no* seem to be sensitive to the polarity of their antecedents.[8] Compare the availability and effects of the responses starting with *yes* and *no* in (56) versus (57):[9]

(56) a. Peter passed the test.

b. *Agreement:* Yes, he did. / # No, he did.

c. *Disagreement:* # Yes, he didn't. / No, he didn't.

(57) a. Peter didn't pass the test.

b. *Agreement:* Yes, he didn't. / No, he didn't.

c. *Disagreement:* Yes, he DID. / No, he DID.[10]

In response to a positive assertion such as (56) *yes* can only express agreement and *no* can only express disagreement. With a negative assertion such as (57) things are more complicated and both particles can be used in either kind of response. This fact cannot be accounted for if we reduce anaphoric potential to semantic content, in that (56) and (57) have complementary semantic contents but the polarity particle responses that they license do not seem to behave in a complementary way.

Finally, it is useful to observe that declaratives and polar questions differ with respect to the commitments that they give rise to and the way in which these commitments relate to the commitments resulting from subsequent responses. In particular, it is observed that responding with *no* to a declarative may give rise to a conversational crisis, i.e. a situation where the speakers have made conflicting commitments, while responding with *no* to a polar question never does:

(58) a. Did Bob call?

b. Yes.

[8] See also (Pope, 1976), (Ginzburg and Sag, 2000), (Kramer and Rawlins, 2009) a.o.

[9] The example is taken from (Roelofsen and Farkas, forthcoming).

[10] Capitalization signals prosodic stress on the constituent. For experimental evidence showing that these responses are available see (Brasoveanu *et al.* 2013).

c. No.

(59) a. Bob called.

b. Yes.

c. No. (*crisis*)

This observation is taken to show that while declaratives and polar questions are similar in a very relevant way (their anaphoric potential), they also differ with respect to their semantic content, or whatever component of meaning is taken to encode the potential of a sentence to give rise to a commitment towards the truth or falsity of some proposition. Hence, anaphoric potential cannot coincide with semantic content.

2.2.3 Conclusions

The above discussion allows Farkas and Roelofsen to set up a number of general requirements for a semantic account of discourse initiatives and polarity particle responses. What is crucial for our work is their proposal to adopt a semantic system in which the meaning of a sentence embodies both its semantic content and its anaphoric potential.

The first dimension of meaning is aimed to study the differences and similarities between declaratives and interrogatives as concerns the information they provide and/or request, and thus the discourse commitments they give rise to. We will follow Farkas and Roelofsen's choice of Inquisitive Semantics as the framework in which such dimension of meaning can be defined, because the flexibility of the notion of semantic content adopted in the framework proves useful for our goals as well.

The second dimension of meaning is aimed to account for the anaphoric potential of sentences and should be fine-grained enough to capture the differences in polarity. This latter aspect is not essential for our goals and we will abstract away from it. However, we will adopt Farkas and Roelofsen's general idea that the anaphoric potential of a sentence is determined by a set of semantic items that are made particularly salient (*highlighted*) when the sentence is uttered, thereby becoming available for subsequent anaphoric reference.

This idea provides the starting point for an explanation of the data concerning the distribution and interpretation of polarity particle responses collected above. For example, it is assumed that a declarative or a polar question has the potential to make salient only one propositional item, which is then available to be picked up by an anaphoric expression. Conversely, two propositional items are made salient by an alternative question, thereby making it more difficult (if not impossible) for a subsequent anaphora to refer back.

Farkas and Roelofsen's account is rather complex and we are not going to discuss it here. In the following section we will give some examples in which the relationship between the anaphoric potential of a sentence and the subsequent responses is analysed, in order to give the reader a feeling of how the basic idea is put to work. As for now, we hope that the preceding discussion convinced the reader that the study of discourse initiatives and polarity particle responses provides a solid motivation for the adoption of a system such as the one introduced in the following section.

2.3 The system $\mathsf{Inq}_{\mathsf{B}}^{H}$

$\mathsf{Inq}_{\mathsf{B}}^{H}$ is a two-dimensional semantic system.[11] Given a language $\mathcal{L}$, each sentence of $\mathcal{L}$ is associated with a meaning which embodies both its semantic content and its anaphoric potential. More in detail, if φ is a sentence of $\mathcal{L}$, we will write $\left\langle [\![\varphi]\!]_g, [\varphi]_g^H \right\rangle$ to denote the meaning of φ relative to the first-order assignment g. The first component of this meaning, $[\![\varphi]\!]_g$, is called the *issue* expressed by φ (relative to g), as defined in Inquisitive Semantics, and embodies the informative and inquisitive content of φ (Ciardelli *et al.*, 2012, 2013 a.o.).[12] The second component of the meaning, $[\varphi]_g^H$, is the set of the items highlighted by φ (relative to g), i.e. the set of the items made available by an utterance of φ for subsequent anaphoric reference.

2.3.1 Preliminaries

In order to give a precise definition of $\left\langle [\![\varphi]\!]_g, [\varphi]_g^H \right\rangle$, we first introduce a first-order language $\mathcal{L}$, with $\vee, \wedge, \neg, \exists, \forall, !, ?$ as the basic logical constants used to build up complex sentences; atomic sentences have the form $R(t_1, \ldots, t_n)$, where R is an n-ary first-order predicate and $t_1, \ldots, t_n$ is a sequence of n individual terms (constants or variables). The operator ! can be applied to any sentence φ to obtain a new sentence $!\varphi$ (called the *non-inquisitive closure* of φ). The question operator ? can bind a (possibly empty) sequence of individual variables $x_1, \ldots, x_n$ (often abbreviated as $\vec{x}$) and be applied to a sentence φ to obtain a new sentence $?\vec{x}.\varphi$; as we will see, ? is a generalisation of the so-called *non-informative closure* operator defined in Inquisitive Semantics.

The basic semantic objects in the system are possible worlds, defined as first-order models for $\mathcal{L}$ based on a fixed structure $\mathcal{M}$, called a *discourse structure* for $\mathcal{L}$:

Definition 2.1. Discourse structure, possible world, intensional model

i. A *discourse structure* for $\mathcal{L}$ is a pair $\mathcal{M} = \langle D, I \rangle$, where D is a set of individuals and I is an interpretation function that maps every individual constant c of $\mathcal{L}$ to an object $I(c) \in D$.

[11] For simplicity, we decided to follow Roelofsen and Farkas (forthcoming) and spell out the system in a static, two-dimensional fashion; however, the system $\mathsf{Inq}_{\mathsf{B}}^{H}$ would be suitable for a dynamic formulation, where both components of the meaning of a sentence would be determined by its context change potential. The development of such full-fledged dynamic system is left for future work.

[12] The framework of Inquisitive Semantics and its most basic implementation $\mathsf{Inq}_{\mathsf{B}}$ are introduced and discussed below.

ii. A *possible world* based on $\mathcal{M}$ is a pair $w = \langle \mathcal{M}, I_w \rangle$, where I_w is an interpretation function that maps every n-ary predicate R of $\mathcal{L}$ to a relation $I_w(R) \subseteq D^n$.

iii. An *intensional model* based on $\mathcal{M}$ is a set M of possible worlds (based on $\mathcal{M}$). In what follows, W denotes the set of all possible worlds based on $\mathcal{M}$.

The idea behind this definition is the simplifying assumption that the domain of individuals is fixed across worlds and that individual constants behave as rigid designators, each referring to the same individual in every world. As a consequence, two worlds differ exclusively with respect to the interpretation of predicates. An intensional model M is taken to be a set of possible world, i.e. a body of information relative to which the expressions of $\mathcal{L}$ are evaluated; notice that in general we will assume $M = W$ and drop the reference to M whenever possible.

Before diving into the definition of the meaning of a sentence in $\mathsf{Inq}_\mathsf{B}^H$ we introduce the notion of the truth-set of a sentence, which corresponds to the classical notion of the proposition expressed by a sentence, i.e. the set of worlds where the sentence is true. In what follows, $|\varphi|_{M,g}$ stands for the truth-set of φ relative to the model M and the assignment g. The assignment g is a function from (sequences of) individual variables to (sequences of) entities in D and $g[\vec{x}/\vec{d}]$ is the assignment which coincides with g except for the fact that it associates the sequence of objects $d_1, \ldots, d_n$ to the sequence of variables $x_1, \ldots, x_n$.

Definition 2.2. Truth-set

i. $|R(t_1, \ldots, t_n)|_{M,g} := \left\{ w \in M \mid \left\langle [\![t_1]\!]_{M,g}, \ldots, [\![t_n]\!]_{M,g} \right\rangle \in I_w(R) \right\}$[13]

ii. $|\varphi \vee \psi|_{M,g} := |\varphi|_{M,g} \cup |\psi|_{M,g}$

iii. $|\varphi \wedge \psi|_{M,g} := |\varphi|_{M,g} \cap |\psi|_{M,g}$

iv. $|\neg\varphi|_{M,g} = M \backslash |\varphi|_{M,g}$

v. $|\exists \vec{x}.\varphi|_{M,g} := \bigcup\limits_{\vec{d} \in D^n} |\varphi|_{M,g[\vec{x}/\vec{d}]}$

vi. $|\forall \vec{x}.\varphi|_{M,g} := \bigcap\limits_{\vec{d} \in D^n} |\varphi|_{M,g[\vec{x}/\vec{d}]}$

vii. $|!\varphi|_{M,g} = |\varphi|_{M,g}$

viii. $|?\vec{x}.\varphi|_{M,g} = M$

[13] We adopt the standard interpretation of terms: $[\![t]\!]_{M,g} := \begin{cases} I(t), \text{ if } t \text{ is a constant;} \\ g(t), \text{ if } t \text{ is a variable.} \end{cases}$

If we restrict our attention to the classical fragment of $\mathcal{L}$, this definition essentially coincides with the classical algebraic approach to propositions: the truth-set of an atomic sentence is nothing but the set of worlds where the sentence is true and the truth-sets of complex sentences are recursively built up through the standard set-theoretic operations of union, intersection and complementation, with the existential quantifier and the universal quantifier behaving respectively as generalised disjunction and conjunction. As regards the question operator ?, we assume that the truth-set of a question coincides with the set of all the possible worlds in M, reflecting the idea that in general a question does not provide any information. Finally, the operator ! is taken to have no effect whatsoever to the truth-set of the sentence to which it is applied.[14]

2.3.2 Issues

We can now move on to define the two components of meaning in $\mathsf{Inq}_{\mathsf{B}}^{H}$. As mentioned above, a sentence φ is associated with a pair $\left\langle [\![\varphi]\!]_g, [\varphi]_g^H \right\rangle$, where $[\![\varphi]\!]_g$ is the issue expressed by φ (relative to g) as defined in Inquisitive Semantics. First of all, then, let us briefly introduce the framework of Inquisitive Semantics and summarise the main features of its most basic implementation, called $\mathsf{Inq}_{\mathsf{B}}$.[15]

Inquisitive Semantics is a semantic framework aimed at providing new foundations for the formal study of information exchange through linguistic communication. Information exchange can be seen as a dynamic process of requesting and providing information and the crucial features of the framework is a new notion of sentential meaning which is flexible enough to capture both the informative and the inquisitive content of sentences in a uniform way.

Intuitively, the meaning of a sentence is seen as a proposal to update the common ground of the conversation in one of possibly many different ways. Each possible update corresponds to one piece of information (modelled as a set of worlds) that can be added to the common ground. Typically, a declarative sentence such as *It's raining in Amsterdam* specifies only one possible enhancement of the common ground while an interrogative such as *What's the weather like today?* proposes a choice between several different alternatives. Crucially, in Inquisitive Semantics both kinds of sentences are associated with semantic objects of the same kind. In general, then, the utterance of a sentence has a two-fold effect: it conveys information, in that it locates the actual world within

[14] We will come back to this operator later on.

[15] The development of the framework began with the works by Groenendijk (2009), Groenendijk and Roelofsen (2009), Mascarenhas (2009) and Ciardelli (2009). The notion of an issue as a uniform semantic way to capture informative and inquisitive content is developed and studied by Ciardelli *et al.* (2013). The system $\mathsf{Inq}_{\mathsf{B}}$ is currently considered the most basic implementation of the ideas developed in these works, and it is discussed in details in the works by Ciardelli *et al.*, (2012) and Roelofsen (2013a). Recently, Ciardelli (2014) argued for the adoption of issues, as defined in Inquisitive Semantics, as the meanings of questions, in that they allow for a treatment of questions that is as general as the proposition set approach (e.g. Hamblin, 1973 and Karttunen, 1977) and as principled and explanatory as the partition approach ((Groenendijk and Stokhof, 1984)).

a subset of all possible worlds; it requests information, in that it invites a reply that allows to choose between one among the different possible enhancement.

More formally, the meaning of a sentence is modelled as a set of information states, called *issue*, defined as follows:

Definition 2.3. Information state, downward-closure, issue

i. An *information state* is a set of possible worlds.

ii. A set A of information states is *downward-closed* iff for every $s \in A$ it holds that if $s' \subseteq s$, then $s' \in A$ as well.

iii. If A is a set of information states, $A^{\downarrow} := \{s' \in \mathcal{P}(W) \mid s' \subseteq s \text{ for some } s \in A\}$ is called the *downward-closure* of A.

iv. An *issue* is a non-empty, downward-closed, set of information states.

The intuitive idea behind this definition is that an issue is modelled as the set of all the information states that contain enough information to settle the issue itself. Hence, if a state s belongs to an issue and thus contains enough information to settle it, any state s' which is more informed than s belongs to the issue as well. Accordingly, the maximal states belonging to an issue (also called *alternatives*) can be seen as the minimally informative pieces of information that settle the issue.

What follows coincides with the definition of the issue expressed by a sentence φ (relative to g) as given in $\mathsf{Inq_B}$, with the exception of the entry for ?, which is a generalisation of the non-informative closure operator defined in $\mathsf{Inq_B}$.[16] We make the assumption that if $\vec{x}$ is an empty sequence, then $?\vec{x}.\varphi$ is equivalent to $?\varphi$ and $\exists\vec{x}.\varphi$ is equivalent to φ. Finally, notice that A^* denotes the so-called *pseudo-complement* of A, defined as $\{\overline{\bigcup A}\}^{\downarrow}$ (Roelofsen, 2013a).

Definition 2.4. Issues[17]

i. $[\![R(t_1,\dots,t_n)]\!]_g := \{|R(t_1,\dots,t_n)|_g\}^{\downarrow}$

ii. $[\![\varphi \vee \psi]\!]_g := [\![\varphi]\!]_g \cup [\![\psi]\!]_g$

iii. $[\![\varphi \wedge \psi]\!]_g := [\![\varphi]\!]_g \cap [\![\psi]\!]_g$

iv. $[\![\neg\varphi]\!]_g := [\![\varphi]\!]_g^*$

v. $[\![\exists\vec{x}.\varphi]\!]_g := \bigcup_{\vec{d} \in D^n} [\![\varphi]\!]_{g[\vec{x}/\vec{d}]}$

[16] However, it has to be noted that from the point of view of the semantic content the generalisation is not essential: the first component of the meaning of a sentence in $\mathsf{Inq}_\mathsf{B}^H$ essentially coincides with the issue expressed by the sentence in $\mathsf{Inq_B}$; later on, it will become clear that our version of ? is adopted here in order to allow for a uniform definition of the items highlighted by a (polar, alternative or *wh*-) question.

[17] Here we assume $M = W$ and drop the reference to M.

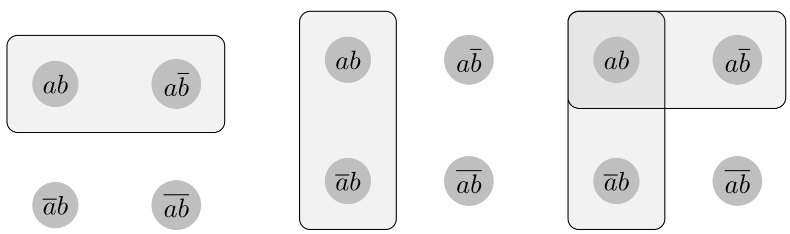
vi. $[\![\forall \vec{x}.\varphi]\!]_g := \bigcap_{\vec{d} \in D^n} [\![\varphi]\!]_{g[\vec{x}/\vec{d}]}$

vii. $[\![!\varphi]\!]_g := \{\bigcup [\![\varphi]\!]_g\}^{\downarrow}$

viii. $[\![?\vec{x}.\varphi]\!]_g := [\![\exists \vec{x}.\varphi]\!]_g \cup [\![\exists \vec{x}.\varphi]\!]_g^*$

Let us briefly discuss the definition by going through its entries. First of all, we consider atomic sentences. Intuitively, a sentence such as *It's raining in Amsterdam* simply provides some information and does not invite any reply. Accordingly, the issue expressed by an atomic sentence contains one set of worlds corresponding to the proposition traditionally expressed by the sentence and its downward-closure, i.e. all its subsets. Hence, it does not contain more than one alternative state.

On the other hand, $\vee$ and $\exists$ generate alternatives and thus they give rise to inquisitive constructions.[18] This happens because both $\vee$ and $\exists$ are defined in terms of set-theoretic union, an operation that collects all the states belonging to the issues on which it operates. For example, if $[\![call(a)]\!]_g$ contains all the sets of worlds where Ann called and $[\![call(b)]\!]_g$ contains all the sets of worlds where Bob called, then the union of the two sets will contain all the sets of world where either Ann or Bob called; in particular, it will contain two (overlapping but) alternative states, as can be seen in Figure 2.2.[19]



(a) $[\![call(a)]\!]_g$ (b) $[\![call(b)]\!]_g$ (c) $[\![call(b) \vee call(a)]\!]_g$

Figure 2.1: Disjunction in Inquisitive Semantics.

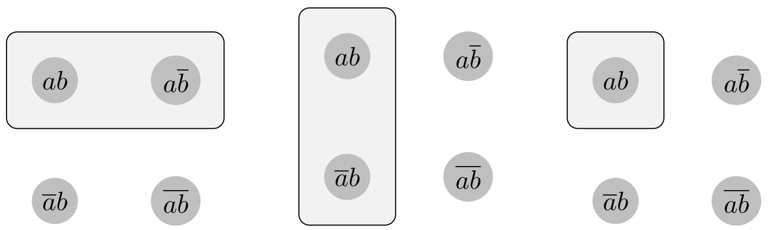
Here we assume a discourse model with $D = \{Ann, Bob\}$ and a language with only one predicate, *call*, so we can consider exactly four possible worlds, one for each possible specification of the interpretation of *call*. Let ab be the world where both Ann and Bob called, $a\overline{b}$ the world where Ann called and Bob did not call, and so on.

The connective $\wedge$ and the quantifier $\forall$ are defined in terms of set-theoretic intersection. As an example, consider again the issues $[\![call(a)]\!]_g$ and $[\![call(b)]\!]_g$.

[18] This is in accordance with a body of works in Alternative Semantics where the alternative treatment of disjunctions and existentials is motivated by a number of empirical phenomena. See for example (Kratzer and Shimoyama, 2002), (Menéndez-Benito, 2005), (Alonso-Ovalle, 2006) and (Aloni, 2007) a.o.

[19] Notice that in order to keep the picture readable, we only represent maximal states.

If we take their intersection, we get a set that contains only those sets of worlds where both Ann and Bob called. This means that the resulting issue will have exactly one maximal state, containing all the worlds where both called. Hence, the conjunctive sentence *Ann and Bob called* is predicted to be non-inquisitive.



(a) $[\![call(a)]\!]_g$ (b) $[\![call(b)]\!]_g$ (c) $[\![call(b) \wedge call(a)]\!]_g$

Figure 2.2: Conjunction in Inquisitive Semantics.

The operator ! is called the *non-inquisitive closure* and can be applied to a sentence φ in order to obtain the so called *non-inquisitive closure* of φ, i.e. a sentence that has the same informative content of φ but is not inquisitive. To do so, the issue expressed by $!\varphi$ is defined as (the downward-closure of) the generalised union of the issue expressed by φ. This means that all the states contained in $[\![\varphi]\!]_g$ are collapsed into one state, hence the resulting issue does not contain more than one alternative.

Negation behaves in a similar way: the issue $[\![\neg\varphi]\!]_g$ is defined as (the downward-closure of) the set-theoretic complement of the union of $[\![\varphi]\!]_g$. As a consequence, negated sentences always express issues that do not contain more than one alternative state, hence they are never inquisitive.

Finally, let us show how our entry for ? allows us to analyse the three kinds of questions this work is concerned with, namely polar, alternative and *wh*-questions.

Polar questions. First of all, assume that $\vec{x}$ is an empty sequence; thus, $?\vec{x}.\varphi \equiv ?\varphi$ and $\exists\vec{x}.\varphi \equiv \varphi$. For example, consider the sentence in (60) and its translation in our first-order language:

(60) Did Ann call?
$\mapsto$ $?call(a)$ or equivalently $?!call(a)$

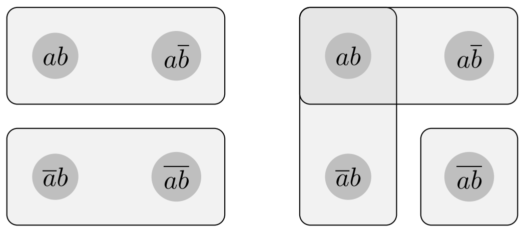
According to clause (viii) above, the issue expressed by $?call(a)$ is computed as follows:

$$\begin{aligned}[\![?call(a)]\!]_g &= [\![call(a)]\!]_g \cup [\![call(a)]\!]^*_g \\ &= \{|call(a)|_g\}^{\downarrow} \cup \{\overline{\bigcup [\![call(a)]\!]_g}\}^{\downarrow}\end{aligned}$$

Now, with some calculation it can be shown that $\overline{\bigcup [\![call(a)]\!]_g} = |\neg call(a)|_g$, and the final result is thus:

$$[\![?call(a)]\!]_g = \{|call(a)|_g\}^{\downarrow} \cup \{|\neg call(a)|_g\}^{\downarrow}$$

The issue expressed by $?call(a)$ can be represented (disregarding downward closure) as in Figure 2.3a.



(a) $[\![?call(a)]\!]_g$ (b) $[\![?x.call(x)]\!]_g$

Figure 2.3: Examples of questions.

In order to generalise this, we stipulate that polar questions are translated in our system simply by applying the question operator ? to the translation of the corresponding declaratives. Hence, in general, a polar question will have the form $?!\varphi$, where ! makes sure that ? is applied to a non-inquisitive sentence. This matters especially for disjunctive polar questions such as *Did Ann or Bob call?*, which will be translated as $?!(call(a) \vee call(b))$. The operator ! has the effect to collapse the two alternatives introduced by the disjunction into one, thus ensuring that the issue expressed by $?!(call(a) \vee call(b))$ contains exactly two maximal states, i.e. the one corresponding to the proposition that Ann or Bob called and the one corresponding to the proposition that neither Ann nor Bob called.[20]

***Wh*-questions.** Consider now the case in which $\vec{x}$ is not empty, e.g. in the formula $?x.call(x)$, which we take to be the translation of a *wh*-question such as the one in (61):

(61) Who called?
$\mapsto ?x.call(x)$

According to clause (viii) above, the issue expressed by $?x.call(x)$ is computed as follows:

$$[\![?x.call(x)]\!]_g = [\![\exists x.call(x)]\!]_g \cup [\![\exists x.call(x)]\!]^*_g$$

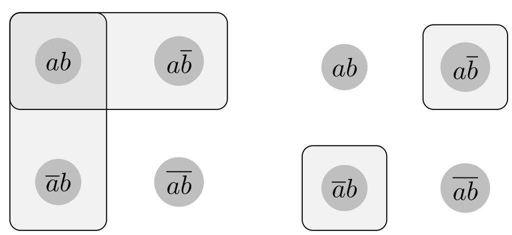
Now, $[\![\exists x.call(x)]\!]_g$ is defined to be equal to the generalised union, for any $d \in D$, of $[\![call(x)]\!]_{g[x/d]}$, i.e. to the issue containing exactly every state in which at least one individual called. In the adopted model, this is the issue containing any state

[20] As we will see, the proposed translation for disjunctive polar questions crucially contrasts with the one adopted for alternative questions in that in translating alternative questions we will drop the operator ! in order to exploit the capacity of the disjunction to introduce alternatives.

that contains at least one world among $ab, a\overline{b}, \overline{a}b$; moreover, with some calculation it can be shown that $[\![\exists x.call(x)]\!]^*_g$ boils down to the issue containing the only state where nobody called (i.e. the singleton state $\{\overline{ab}\}$). The union of the two represents the issue expressed by $?x.call(x)$ and it is visualised in Figure 2.3b. Notice that any state belonging to the issue is taken to embody enough information to settle the issue itself; hence, the issue expressed by $?x.call(x)$ can be thought of as the semantic content of a mention-some reading of the corresponding question *Who called?*.[21]

Alternative questions. Consider a disjunctive question such as the one in (62), where the arrow signals a falling pitch on the second disjunct:[22]

(62) Did Bob call, or Ann↓?



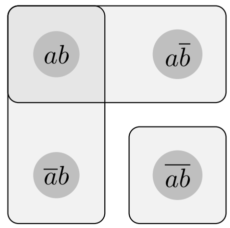
(a) $[\![call(b) \vee call(a)]\!]_g$ (b) $[\![\Sigma(call(b) \vee call(a))]\!]_g$

Figure 2.4: Possible analysis of an alternative question.

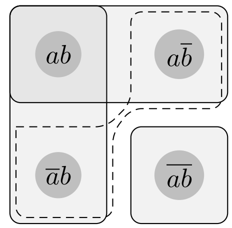
There are different possible ways to analyse (62) within the framework of Inquisitive Semantics. For example, an inquisitive disjunction such as $call(b) \vee call(a)$ (depicted in Figure 2.4a) could be seen as a good approximation of the intuitive resolution conditions of (62). Roelofsen (2013b) proposes that alternative questions (in his terminology *closed disjunctive lists*) be translated as inquisitive disjunctions with the addition of a special operator of *exclusive strengthening* (denoted as Σ) which strengthens the issue expressed by the disjunction removing the overlap between the two maximal states, as shown in Figure 2.4b.

[21] We do not attempt here to give a general procedure to translate *wh*-questions into our formal language. However, it is worth noticing that in general the translation of a *wh*-question will have the form $?\vec{x}.!\varphi$, where the sequence of variables $\vec{x}$ is free in φ. The operator ! (left out in the example with *Who called?*) ensures that the question operator ? is applied to a non inquisitive sentence, in order to avoid complications arising from the interplay between ? and inquisitive disjunctions.

[22] We assume that the falling pitch on the last disjunct of a disjunctive question crucially enforces the alternative reading of the question. This assumption follows Pruitt and Roelofsen (2013)'s experimental work on the interpretation of disjunctive questions, which shows that the final pitch contour is the most informative prosodic feature, whereas the focus-marking on all the disjuncts plays a significant role but is not enough to force the alternative interpretation by itself.



(a) $[\![?(call(b) \vee call(a))]\!]_g$



(b) $[\![?(call(b) \vee call(a))]\!]_g$

Figure 2.5: Possible analysis of an alternative question.

For the sake of uniformity with the way in which other questions are translated in this work, we choose to translate (62) as $?(call(b) \vee call(a))$. This means that the issue expressed by the question is computed by taking the union between $[\![call(b) \vee call(a)]\!]_g$ and $[\![call(b) \vee call(a)]\!]_g^*$. In the adopted model this can be depicted as in Figure 2.5a. We believe that this analysis can do the job, especially with the addition of the presuppositional component represented by the dashed line in Figure 2.5b (i.e. the requirement that exactly one of the disjuncts holds).[23] We do not attempt here to give a compositional derivation of this presuppositional component, since this would lead us astray from the main goal of this work, and we simply assume it as given together with the semantic content of any alternative question.[24]

Before moving to the second component of meaning in $\mathsf{Inq_B}$, let us introduce some operations on issues that will prove useful later on.

INFO. This operation simply yields the informative content of the issue to which it is applied:

$$\mathsf{INFO}(A) := \bigcup A$$

ALT. This operation is applied to an issue A and a possible world w and yields the set of maximal states, or alternatives, in A that contain w:[25]

[23]Notice that our main goal is to explain why alternative questions cannot be felicitously embedded under *surprise* and *realise*. As we will see, our explanation crucially relies on the meaning associated to alternative questions but, in particular, on the set of items they highlight. We will see that what really matters in the derivation of the set of highlighted items of an alternative question is the fact that it involves a disjunction. In principle then, our account is compatible with any of the mentioned analysis of alternative questions, insofar as they are all based on disjunctive constructions.

[24]Ciardelli *et al.*, (2012) introduce a presuppositional variant of Inquisitive Semantics that could be taken as a starting point to develop an account of the presuppositional component of the meaning of alternative questions.

[25]It is worth noticing that it may well be that an issue does not contain any maximal state. A well-known case in the literature on Inquisitive Semantics is represented by the so-called *boundedness formula* (Ciardelli, 2009), that expresses an issue with no maximal states. In such a case the definition of ALT would return the empty state. In this work we will abstract away from this problem and assume that there is always at least one maximal state. However,

$$\mathsf{ALT}(A, w) := \{s \in A \mid w \in s \text{ and } \neg\exists t \in A \text{ s.t. } s \subset t\}$$

For example, assume the usual domain containing Ann and Bob and consider the sentence *Who called?*. As we have seen, the issue expressed by $?x.call(x)$ contains (all the subsets of) the state where Ann called, (all the subsets of) the state where Bob called and the state where nobody called. Hence, there are three maximal states, namely $\{ab, a\overline{b}\}$, $\{ab, \overline{a}b\}$ and $\{\overline{ab}\}$. Hence, if w is a world where only Ann called, then $\mathsf{ALT}([\![?x.call(x)]\!]_g, w)$ is the singleton set containing $\{ab, a\overline{b}\}$; if w is a world where only Bob called, then $\mathsf{ALT}([\![?x.call(x)]\!]_g, w)$ is the singleton set containing $\{ab, \overline{a}b\}$; if w is a world where both called, then $\mathsf{ALT}([\![?x.call(x)]\!]_g, w)$ contains both $\{ab, a\overline{b}\}$ and $\{ab, \overline{a}b\}$; finally, if nobody called in w, then $\mathsf{ALT}([\![?x.call(x)]\!]_g, w)$ contains only $\{\overline{ab}\}$. In other words, if A is the issue expressed by a question Q, then $\mathsf{ALT}(A, w)$ is the set of basic answer to Q true in w.

WEAK. This operation is applied to an issue A and a world w and yields the intersection of every maximal state in A containing w:

$$\mathsf{WEAK(A, w)} := \bigcap \mathsf{ALT}(A, w)$$

The idea behind this definition should be clear: f A is the issue expressed by a question Q, taking the generalised intersection of the basic answers to Q in w amounts to computing a proposition that coincides with the complete answer to Q, in the sense of Karttunen (1977). Going back to the previous example, if we suppose that in the actual world both Ann and Bob called, then $\mathsf{ALT}([\![?x.call(x)]\!]_g, w) = \{\{ab, a\overline{b}\}, \{ab, \overline{a}b\}\}$; hence, $\mathsf{WEAK}([\![?x.call(x)]\!]_g, w) = \bigcap \mathsf{ALT}([\![?x.call(x)]\!]_g, w) = \{ab\}$, which is the proposition that Ann and Bob called. On the other hand, if only Bob called at w, then $\mathsf{ALT}([\![?x.call(x)]\!]_g, w) = \{\{ab, \overline{a}b\}\}$ and thus $\mathsf{WEAK}([\![?x.call(x)]\!]_g, w) = \{ab, \overline{a}b\}$, which is the proposition that Bob called.

EXH. This operation is applied to an issue A and yields the exhaustification of A, as defined by Theiler (2013); the definition of $\mathsf{EXH}(A)$ is given in terms of a binary relation between worlds denoted with $\sim_A$:

$$w \sim_A v \text{ iff } \forall s \in A \text{ if } w \in s \text{ or } v \in s \text{ then } \exists t \in A \text{ s.t. } s \subseteq t \text{ and } w, v \in t.$$

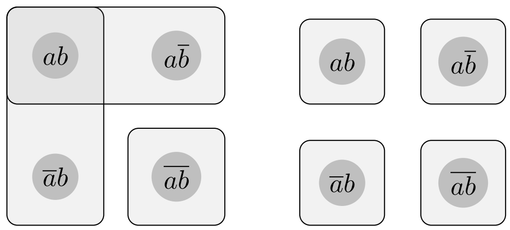
According to this definition two worlds w, v are related via $\sim_A$ just in case they either belong to the same state $s \in A$ or, if one of them belongs to one state $s \in A$ then there is a bigger state in A that contains both of them. We can now move to the definition of EXH:

$$\mathsf{EXH}(A) := \{s \in A \mid \forall w, v \text{ if } w, v \in s \text{ then } w \sim_A v\}$$

The exhaustification of an issue A is defined as the set of states belonging to A which contain only $\sim_A$-related worlds. For example, consider again the issue

it is possible to give a more general definition of ALT that can cope with the problematic cases in a better way, as discussed by Theiler (2014).

$[\![?x.call(x)]\!]_g$ depicted in Figure 2.6a. Remember that the picture shows only the maximal states, but the issue itself contains also all the subsets of the maximal states.



(a) $[\![?x.call(x)]\!]_g$ (b) $\mathsf{EXH}[\![?x.call(x)]\!]_g$

Figure 2.6: The issue expressed by *Who called?* and its exhaustification.

Now, let us ask ourselves which states in $[\![?x.call(x)]\!]_g$ will belong to its exhaustification $\mathsf{EXH}([\![?x.call(x)]\!]_g)$. Let us start with the states $\{ab, a\bar{b}\}$ and $\{ab, \bar{a}b\}$. We have that neither belongs to the exhaustification, because the world ab is not $\sim_A$-related to $a, \bar{b}$ nor to $\bar{a}, b$; in fact, in one case $ab \in \{ab, a\bar{b}$ but there is no $t \supseteq \{ab, a\bar{b}\}$ that contains also $\bar{a}, b$ and, in the other case, $ab \in \{ab, \bar{a}b\}$ but there is no $t \supseteq \{ab, \bar{a}b\}$ that contains also $a\bar{b}$. As for the singleton states contained in the issue, it is easy to see that $\sim_A$ is reflexive, hence every singleton state will be contained in the exhaustification. The resulting set is depicted in Figure 2.6b. In other words, the exhaustification of the issue expressed by a question is the partition of the logical space corresponding to the strongly exhaustive reading of the question, in the spirit of Groenendijk and Stokhof (1984).

2.3.3 Highlighted items

We can now turn to the second component of meaning, $[\varphi]^H_g$, which represents φ's anaphoric potential, and is modelled as the set of items that an utterance of φ makes available for subsequent anaphoric reference.

In the approach developed by Roelofsen and van Gool (2010) and Roelofsen and Farkas (forthcoming) the notion of highlighted items is limited to a propositional setting, where *wh*-questions cannot be expressed. In our approach we develop an idea found in Farkas and Roelofsen's work in order to obtain a slightly generalised notion of highlighted items which can be uniformly applied to declaratives and (polar, alternative and *wh*-) questions. In doing so, we draw both from the notion of highlighted propositions, as developed by van Gool, Farkas and Roelofsen, and from the notion of an n-place abstract associated with a question (cfr. Groenendijk and Stokhof, 1984, Krifka, 2001, Aloni and van Rooij, 2002 a.o.).

As seen in Section 2.2, declaratives and polar questions licence responses containing anaphoric expressions such as *yes*, *no*, *so*, while in general alternative questions and *wh*-questions don't. As already mentioned, the first step towards an explanation of this fact is the assumption that declaratives and polar questions differ from other interrogatives with respect to their anaphoric potential.

More in detail, we will assume that a declarative highlights only one item which corresponds to the proposition it expresses; similarly, a polar question highlights the same propositional item highlighted by the corresponding declarative. In both cases, then, there will be only one salient propositional item which can be easily picked up by a subsequent anaphoric expression.

On the other hand, we will take alternative questions to highlight two propositional items, each corresponding to one of the disjuncts occurring in the question. This will explain why anaphoric responses are in general not felicitous after an alternative question, insofar as there is not a unique salient item to refer to.

Finally, a *wh*-question will be taken to highlight a n-ary function (often called *abstract*) from n-tuples of individuals to propositions. The basic observation behind this choice is that *wh*-questions do not licence responses containing anaphoric *yes*, *no*, *so*, but they do license so-called *term answers*, as illustrated in (63-64). The idea is that the function highlighted by the question can be applied to the individual denoted by a term answer to yield a propositional answer to the question.[26]

(63) a. Who came to the party?
b. # Yes./# No.
c. # If so, the party was funny.

(64) a. Who came to the party?
b. Ann.
c. Bob.

Before turning to the formal definition of the set of highlighted items for a sentence φ, we want to consider a possible objection to the preceding discussion. One may be tempted to argue against our choice to distinguish *wh*-questions from alternative questions with respect to their anaphoric potential on the grounds that alternative questions seem to licence term answers too, as exemplified in (65). Why, then, alternative questions are taken to highlight propositional items while *wh*-questions are taken to highlight n-place abstracts?

(65) a. Did Ann called, or Bob$\downarrow$?
b. Ann.
c. Bob.

First of all, let us argue in favour of the choice to associate alternative questions with propositional highlighted items and not with, say, a unary function from

[26] Roughly speaking, n equals the number of *wh*-words in the question. For example, a question such as *Who called?* highlights one unary abstract and it licenses unary term answers (*Ann*; *Bob*), while a question such as *Who ate what?* highlights one binary abstract and licenses binary term answers (*Ann, one apple*; *Bob, one orange*).

individuals (belonging to a restricted domain) to propositions. Consider the example in (66):

(66) a. Is the door open, or not open↓?
b. # Yes. / # No.

Clearly, (67a) is not a polar questions, because it does not licence bare *yes/no* responses, while polar questions typically do. We believe that it is an alternative question, while not a typical one. As observed in (Krifka, 2001), (67a) licences the responses in (67b-c):

(67) a. Is the door open, or not open↓?
b. Yes, it's open.
c. No, it's not open.

Now, we do not have a full explanation of the behaviour of (67a) but we believe that this example is more compatible with the choice to associate alternative questions with propositional highlighted items rather than with *n*-ary abstracts, because in the latter case it would not be clear how the highlighted item could serve as an antecedent for the subsequent expressions *yes* and *no*.[27]
Let us now turn to *wh*-questions. We want to argue in favour of the choice to associate *wh*-questions with *n*-place abstracts and not, say, with sets of alternative propositions. First of all, notice that *wh*-questions never licence bare *yes/no* responses nor responses in which *yes* and *no* are followed by some prejacent. Hence, there is no reason to assume that propositional items are involved in the anaphoric potential of a *wh*-question. On the other hand, we believe that there is at least one reason to prefer *n*-place abstracts. Consider the example in (68), where (68b) provides a partial answer to (68a):

(68) a. Who came to the party?
b. Those who paid the ticket.

We believe that *those who paid the ticket* can be seen as behaving like a generalised quantifier which is applied to the set of individuals that came to the party and yields the proposition that those who paid the ticket came to the party. Now, this line of explanation is easily available if we assume that a *wh*-question such as *Who came to the party?* highlights an abstract, which can be seen as a property (in this case, the property of being one who came to the party) made salient by the question and thus accessible to the response. On the other hand, it seems to us that it would be much more difficult to explain how *those who paid the ticket* succeeds in recovering the relevant property from *Who came to the party?* if the latter highlighted a set of alternative propositions (e.g. that Ann came to the party, that Bob came to the party, ...), which are nothing but sets of possible worlds.

[27]An explanation of the behaviour of (67a) in terms of highlighted propositional items would rely on observations concerning the polarity of the highlighted items (see Roelofsen and Farkas, forthcoming). As pointed out in Section 2.2, we abstract away from such considerations in this work.

We can finally introduce the recursive definition of $[\varphi]_g^H$, the set of items highlighted by φ (relative to g).[28] This set contains $k \geq 1$ functions of arity $n \geq 0$ mapping n-tuples of individuals sets of worlds (i.e. classical propositions).

In what follows, α_n stands for a function of arity n from n-tuples of individuals in D^n to sets of worlds. We make the assumption that if $n = 0$, then D^n contains exactly the empty sequence $\langle\rangle$; moreover, we assume that any function α_n applied to the empty sequence is equivalent to α_n itself.

Definition 2.5. Highlighted items

i. $[R(t_1, \ldots, t_n)]_g^H := \{|R(t_1, \ldots, t_n)|_g\}$

ii. $[\varphi \vee \psi]_g^H := [\varphi]_g^H \cup [\psi]_g^H$

iii. $[\varphi \wedge \psi]_g^H := [\varphi]_g^H \cup [\psi]_g^H$

iv. $[\neg\varphi]_g^H := \{\overline{|\varphi|_g}\}$

v. $[\exists\vec{x}.\varphi]_g^H := \{|\exists\vec{x}.\varphi|_g\}$

vi. $[\forall\vec{x}.\varphi]_g^H := \{|\forall\vec{x}.\varphi|_g\}$

vii. $[!\varphi]_g^H := \{|\varphi|_g\}$

viii. $[?\vec{x}.\varphi]_g^H := \{\alpha_n \in \mathcal{P}(W)^{D^n} \mid \forall\vec{d} \in D^n, \alpha_n(\vec{d}) \in [\varphi]_{g[\vec{x}/\vec{d}]}^H\}$

Let us discuss the definition by going through its eight entries and giving some intuitive justification for each of them. In doing so, we will have the occasion to give some examples so that the reader can get acquainted with the system.

Atomic sentences. As we said, the highlighted items contained in $[\varphi]_g^H$ are the ones that are made salient for subsequent anaphoric reference by an utterance of φ. It is quite natural to assume that anaphoric expressions such as *so* can succeed in referring back to whichever item was highlighted in the preceding discourse only if there is exactly one such item, similarly to what happens with anaphoric pronouns.[29] This is what happens in the case of basic declaratives such as the one in (69), where *so* manages to refer back to an item which is uniquely determined. The choice to define this item as nothing but the proposition expressed by the sentence (its truth-set) can be justified by noticing that (70b) is a tautology and that (71b) sounds inconsistent:

[28] The definition is inspired by Roelofsen and Farkas (forthcoming)'s definition of the anaphoric potential of sentences, with the exception of the entry (viii).

[29] For example, the pronoun *he* fails to refer in (*), because the preceding utterance introduces two equally available referents:

(*) John and Bob didn't come to the party. He went to the cinema instead.

(69) a. Ann came to the party.
b. If so, why didn't I meet her?

(70) a. Bob came to the party.
b. If so, then Bob came to the party.

(71) a. Bob came to the party.
b. I think so, but Bob didn't come.

The set of items highlighted by an atomic sentence is then taken to be the singleton set containing the truth-set of the sentence, as in (i).

Quantifiers. As far as anaphoric potential is concerned, it seems that an existentially or universally quantified sentence behaves as a simple declarative, insofar as it licenses anaphoric responses, as exemplified in (72):

(72) a. Somebody/Everybody brought wine to the party.
b. Yes. / No.
c. If so, the party was fun.

Accordingly, the set of items highlighted by a quantified sentence is taken to be the singleton set containing the truth-set of the sentence.

Questions. Let us move to the last entry of our definition, the one concerning questions. As we have already mentioned, polar questions are taken to highlight the same items as the corresponding declaratives, as shown in (74):

(73) a. Ann called.
b. Yes ($\rightsquigarrow$ Ann called).

(74) a. Did Ann call?
b. Yes ($\rightsquigarrow$ Ann called).

To see how the clause in (viii) can account for this, remember that polar questions are translated in our language simply by applying the question operator ? to the translation of the corresponding declaratives. More precisely, a polar question is a sentence of the form $?\vec{x}.\varphi$, where $\vec{x}$ is an empty sequence, and φ translates a declarative. In general, if ? does not bind any variable when applied to φ, then the set of items highlighted by the question $?\varphi$ simply coincides with the set of items highlighted by φ itself. This is so because if $\vec{x} = \langle\rangle$, (viii) boils down to the following:

$$[?\varphi]_g^H = \{\alpha \in \mathcal{P}(W) \mid \alpha \in [\varphi]_g^H\} = [\varphi]_g^H$$

For example, if $\varphi \equiv call(a)$, then $[\varphi]_g^H = \{|call(a)|_g\}$ and $[?\varphi]_g^H = \{|call(a)|_g\}$ as well. Something similar happens with more complex polar questions too, but we will consider them when we discuss the entry for disjunction and conjunction.

First, let us show what is the idea behind (viii) in the general case, i.e. when $\vec{x}$ is not empty. We said that after a *wh*-question such as (75a), responses involving polarity particles and other propositional anaphoric expressions are not licensed, while term-answers are, and thus *wh*-question are taken to highlight n-place abstracts instead of truth-sets.

(75) a. Who came to the party?
b. # Yes. / # No.
c. Ann. / Bob.

Given a *wh*-question, the entry in (viii) allows us to compute the set of abstract(s) highlighted by it. Let us consider a simple example, i.e. a formula such as $?x.call(x)$, translating the question *Who called?*. If we apply (viii) to it we get the following:

$$[?x.call(x)]_g^H = \{\alpha_1 \in \mathcal{P}(W)^D \mid \forall d \in D, \alpha_1(d) \in [call(x)]_{g[x/d]}^H\}$$

This says that the abstracts in $[?x.call(x)]_g^H$ are those functions α_1 that take an individual $d \in D$ and yield and element $\alpha_1(d)$ belonging to set of items highlighted by $call(x)$, *relative to the assignment* $g[x/d]$. Since $call(x)$ is atomic, this latter set is the singleton set containing $|call(x)|_{g[x/d]}$, hence $\alpha_1(d) = |call(x)|_{g[x/d]}$. To simplify this, assume $D = \{Ann, Bob\}$. We get the following:

$$\begin{aligned}[?x.call(x)]_g^H &= \{\alpha_1 \mid \forall d \in \{Ann, Bob\}, \alpha_1(d) \in [call(x)]_{g[x/d]}^H\} \\ &= \{\alpha_1 \mid \alpha_1(Ann) = |call(x)|_{g[x/Ann]} \text{ and } \alpha_1(Bob) = \\ &\quad |call(x)|_{g[x/Bob]}\}\end{aligned}$$

The function α_1 takes *Ann* and yields the proposition that Ann called and takes *Bob* and yields the proposition that Bob called. We can conveniently denote α_1 in the metalanguage by means of lambda-abstraction, as $\lambda d.|call(x)|_{g[x/d]}$. Hence, $[?x.call(x)]_g^H = \{\lambda d.|call(x)|_{g[x/d]}\}$.

Disjunction and conjunction. Let us start with disjunction. As we have seen in the first section, alternative questions such as (76a) do not licence plain *yes*/*no* responses:

(76) a. Did Ann come to the party, or Bob↓?
b. # Yes. / # No.

The explanation that can be given for this fact is that alternative questions do not highlight a single propositional item that can be subsequently picked up, but two. We take this to be the characteristic treat of alternative questions and, as we will see, this is crucial in our explanation of why verbs such as *suprise* and *realise* cannot embed alternative questions.

Now, we have already noticed that if ? does not bind any variable when applied to a sentence φ, then the set of items highlighted by the question $?\varphi$ simply coincides with the set of items highlighted by φ itself. Given our translation for (76a), i.e. $?(call(a) \vee call(b))$, it is clear that ? does not bind any variables, hence $[?(call(a) \vee call(b))]_g^H = [call(a) \vee call(b)]_g^H$. But this means that what is responsible for the fact that $[?(call(a) \vee call(b))]_g^H$ contains two items must be the fact that the formula is a disjunction. In particular, we expect this set to contain exactly $|call(a)|_g$ and $|call(b)|_g$. This reasoning justifies our choice to compute the set of items highlighted by a disjunction by taking the union of the sets associated with the two disjuncts.

A similar explanation works for conjunction as well. Consider the conjunction of questions in (77*a*). The response with the bare particle *yes* might not be infelicitous, while maybe a bit difficult to process, but certainly a speaker replying with (77c) would not be contradicting herself:

(77) a. Did Ann call? And did Bob?
b. Yes.
c. Yes, Bob called, but Ann didn't.

We believe that this observation shows that *yes* does not refer to the conjunctive proposition that Ann and Bob called, otherwise (77c) would sound inconsistent. It seems more likely that there are two items available, one highlighted by each conjunct, of which perhaps the second is more salient and can be more easily picked up in (77c). If this is correct, then we have a motivation for requiring that also the set of items highlighted by a conjunction is computed by taking the union of the sets associated with the two conjuncts.

Now, an obvious observation is that simple disjunctive and conjunctive declaratives such as (78a) and (78c) actually do licence anaphoric responses, and thus the sets of highlighted items associated with them should be singleton sets.

(78) a. Ann or Bob called last week.
b. If so, why didn't you tell me before?
c. Ann and Bob called last week.
d. If so, why didn't you tell me before?

Similarly, disjunctive and conjunctive polar questions generally licence *yes*/*no*-responses, as shown in (79):

(79) a. Did Ann or Bob come to the party?
b. Yes. / No.
c. Did Ann and Bob come to the party?
d. Yes. / No.

These observations are correct, which is why we need the non-inquisitive closure operator !.

Non-inquisitive closure. From the point of view of anaphoric potential, the effect of ! when applied to a sentence φ is to yield a sentence which behaves similarly to a basic declarative, thereby highlighting only one item that corresponds to the proposition expressed by the sentence itself.

This allows us to account for the observation that disjunctive and conjunctive declaratives and polar questions should highlight singleton sets of items. For example, we require that a sentence such as *Ann or Bob called*, especially when it is embedded as a declarative complement (e.g. *John knows* that *Ann or Bob called*) be translated as $!(call(a) \vee call(b))$. This will ensure that the set of items highlighted by *Ann or Bob called* will contain exactly one item, namely $|call(a) \vee call(b)|_g$. Similarly, a conjunctive polar question such as *Did Ann and Bob come the party?* will be translated as $?!(come(a) \wedge come(b))$.

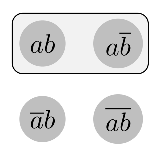
Negation. The idea behind the entry for negation is similar, in the sense that negative sentences are taken to always highlight one single item which corresponds to the proposition expressed by the negation of the sentence.[30] Accordingly, the set of items highlighted by $\neg\varphi$ is defined as the singleton containing the set-theoretic complement of the truth-set of φ.

2.3.4 Sentential complements in $\mathsf{Inq}_\mathsf{B}^H$

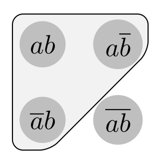
This section consists in a schematic summary of what has been introduced so far and gives an idea of how we can analyse complements in $\mathsf{Inq}_\mathsf{B}^H$. The examples given here will be used in the discussion of the sentences where these complements are embedded under responsive verbs, in the following section. For each kind of complement we give a natural language example, its translation in the formal language, the meaning that is computed for it in $\mathsf{Inq}_\mathsf{B}^H$ and a graphical representation of the issue expressed.

Declaratives.

Example: that Ann called.
$\mapsto call(a)$, or equivalently $!call(a)$
Meaning: $[\![call(a)]\!]_g = \{|call(a)|_g\}^{\downarrow}$
$[call(a)]_g^H = \{|call(a)|_g\}$



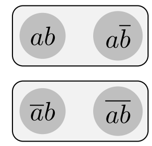
Example: that Ann or Bob called.
$\mapsto !(call(a) \vee call(b))$
Meaning: $[\![!(call(a) \vee call(b))]\!]_g = \{|call(a) \vee call(b)|_g\}^{\downarrow}$
$[!(call(a) \vee call(b))]_g^H = \{|(call(a) \vee call(b))|_g\}$



[30] This assumption accounts for the observable behaviour of anaphoric *so* when it follows negative declaratives, and abstracts away from the complications arising from the fact that *yes* and *no* are sensitive to the polarity of their antecedents.

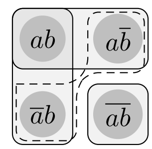
Polar questions.

Example: whether Ann called.
$\mapsto ?call(a)$, or equivalently $?!call(a)$
Meaning: $[\![?call(a)]\!]_g = \{|call(a)|_g, |\neg call(a)|_g\}^{\downarrow}$
$[?call(a)]^H_g = \{|call(a)|_g\}$



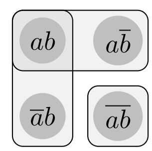
Alternative questions.[31]

Example: whether Bob called, or Ann↓.
$\mapsto ?(call(b) \vee call(a))$
Meaning: $[\![?(call(b) \vee call(a))]\!]_g = \{|call(b)|_g, |call(a)|_g, \overline{|call(a) \vee call(b)|_g}\}^{\downarrow}$
$[?(call(b) \vee call(a))]^H_g = \{|call(b)|_g, |call(a)|_g\}$



***Wh*-questions.**[32]

Example: Who called?.
$\mapsto ?x.call(x)$
Meaning: $[\![?x.call(x)]\!]_g = \{|call(b)|_g, |call(a)|_g, \overline{|call(a) \vee call(b)|_g}\}^{\downarrow}$
$[?x.call(x)]^H_g = \{\lambda d.|call(x)|_{g[x/d]}\}$



2.4 *Know*, *Surprise*, *Realise*

2.4.1 A uniform semantics

First of all, let us briefly address a general point concerning the semantic analysis of responsive verbs. We think (*contra* Spector and Égré, 2014) that a semantic approach to responsive verbs which can account for the fact that they embed both declarative and interrogative complements in a uniform way is to be preferred to an account that needs to stipulate two different lexical entries for each verb (one for the declarative-embedding variant and another for the interrogative-embedding variant). Spector and Égré (2014) adopt the latter approach, in the sense that they try to develop a general recipe to derive the meaning of the interrogative-embedding variant of a given responsive verb in terms of the meaning of the corresponding declarative-embedding variant.

It is not within the scope of this work to evaluate to what extent they succeed in doing so. What we want to stress, here, is that it is possible to give a general characterization of the relations that must hold between a given responsive verb V, a subject X and a complement C (no matter its semantic category) in order for the sentence XVC to be true. Our intuition is that when we say, e.g. that John knows that Ann called and that Kate knows whether Bob called or not, we are talking about two individuals both having the same kind of attitude (the one encoded by *know*) towards the same kind of semantic objects (the meanings of the complements).

A uniform approach to the semantics of responsive verbs, one that does not have to stipulate different variants of one and the same verb, will simply strike us as more explanatory. Accordingly, the semantic entries for *know*, *surprise* and *realise* that we will give and discuss below are aimed to account for the truth-conditions of sentences of the form XVC, where V is a given responsive verb and C is a sentential complement. Clearly, the adoption of the notion of an issue to capture informative and inquisitive content (of any complement) in a uniform way will be crucial with this respect.

2.4.2 Data

Let us briefly recall what are the main data concerning the linguistic behaviour of *know*, *surprise* and *realise* that we want to account for with our account.

Factivity and veridicality. *Know*, *surprise* and *realise* are factive verbs, which means that when they embed a declarative complement P the resulting sentence presupposes the truth of P:

(80) a. John knows that Bob called.
$\rightsquigarrow$ Bob called.
b. John doesn't know that Bob called.
$\rightsquigarrow$ Bob called.

(81) a. It surprised Kate that Bob came to the party.
$\rightsquigarrow$ Bob came.
b. It didn't surprise Kate that Bob came to the party.
$\rightsquigarrow$ Bob came.

(82) a. Kate realised that Bob is a bad guy.
$\rightsquigarrow$ Bob is a bad guy.
b. Kate didn't realise that Bob is a bad guy.
$\rightsquigarrow$ Bob is a bad guy.

Moreover, we have observed that *know*, *surprise* and *realise* are also veridical with respect to their interrogative complements. This means that if a verb V embeds an interrogative complement Q, then the resulting sentence XVQ entails the truth of a sentence of the form XVP where P is (some kind of) a true answer to Q:

(83) John knows who called yesterday.
Ann and Bob called.
Therefore, John knows that Ann and Bob called.

(84) It surprised John who called yesterday.
Only Bob called.
Therefore, it surprised John that Bob called.

(85) Kate realised who came to the party.
Only Ann came.
Therefore, Kate realised that Ann came.

Different readings. As shown in the first chapter there is no general agreement in the literature concerning which readings are exactly at play with which embedding verbs. Some authors claim that *know* always selects for a strongly exhaustive reading and *surprise* and *realise* for a mention-some reading (e.g. George, 2011); other authors argue that *surprise* and *realise* select for a weakly exhaustive reading instead, which is sometimes also available for *know* (e.g. Guerzoni and Sharvit, 2007).

The debate is ongoing and certainly interesting. However, it does not fall within the scope of this work to conclusively evaluate the different positions at play, nor to argue for a particular position, as we believe that only systematic data-oriented studies could shed further light on these issues.

As already pointed out, in this work we are mostly concerned with the fact that verbs such as *surprise* and *realise* fail to embed *whether*-complements and our account is especially aimed to give an explanation of this fact. As the reader will see, in formulating our semantic entries for *know*, *surprise* and *realise*, we will make the simplifying assumption that *know* always selects for the strongly exhaustive reading while *surprise* and *realise* always select for the weakly exhaustive reading. However, we want to stress that this choice is not intended to signal our preference with one particular position in the debate: as we will show, our account of the *whether*-puzzle is compatible with other choices as well.[33]

Existence presupposition. In the first chapter we took the following examples as evidence that sentences where *surprise* or *realise* embed a *wh*-question carry an existence presupposition, in the sense that there must be a positive (weakly exhaustive) answer to the embedded question in order for the sentences to be evaluable at all.

(86) a. *Mary:* It surprised John who failed the test.
b. *Lucy:* Hey, wait a minute! I didn't know that someone failed at all.[34]

(87) a. It surprised John who failed the test.
$\rightsquigarrow$ Someone failed.
b. It did not surprise John who failed the test.
$\rightsquigarrow$ Someone failed.
c. Did it surprise John who failed the test?
$\rightsquigarrow$ Someone failed.

(88) a. *Mary:* Kate realised who failed the test.

[33] In particular, the flexibility that $\mathsf{Inq}_\mathsf{B}^H$ inherits from Inq_B will allow us to derive also the mention-some reading of questions embedded under *know*, *suprise* and *realise*.
[34] Cfr. (von Fintel, 2004).

b. *Lucy:* Hey, wait a minute! I didn't know that someone failed at all.

(89) a. Kate realised who failed the test.
$\rightsquigarrow$ Someone failed.

b. Kate didn't realise who failed the test.
$\rightsquigarrow$ Someone failed.

c. Did Kate realise who failed the test?
$\rightsquigarrow$ Someone failed.

As we will see, our semantic entries for *surprise* and *realise* will account for these observations by requiring that the abstracts associated with the embedded questions are satisfiable in the world of evaluation, i.e. that for each abstract there is at least one individual in the domain such that the abstract yields a true proposition when applied to that individual.

The *whether*-puzzle. Finally, we want to account for the well-known puzzling observation that *surprise* and *realise* do not behave as other responsive verbs in that they cannot felicitously embed *whether*-complements (while being able to embed *wh*-complements):

(90) It surprised John who called.

(91) # It surprised John whether Bob called (, or Ann).

(92) Kate realised who came to the party.

(93) # Kate realised whether Bob came to the party (, or Ann).

Our account of these observations crucially relies on the interplay between the presuppositional component of the meaning associated with the embedding verbs and the set of items highlighted by the embedded complements. The basic idea is that in the case of *whether*-complements embedded under *surprise* and *realise* this interplay would give rise to constructions that are semantically useless, and thus not realised in English. In order to be able to dive into the details of this account we first need to introduce embedding verbs and their semantics.

2.4.3 *Know*

So far we have talked about embedding verbs in English such as *know*, *surprise* and *realise* but we have not said anything explicit about how such verbs and the constructions in which they occur can be translated and analysed in our formal system. Our language $\mathcal{L}$ and its semantics $\mathsf{Inq}_\mathsf{B}^H$ were introduced to translate and analyse sentential complements and they need to be extended in order to be able to analyse any of the sentences mentioned in the previous section.

We try to keep things as simple as possible and we propose to extend our language $\mathcal{L}$ by adding a new category of binary predicates corresponding to the embedding verbs that we want to analyse and by allowing constructions of the form $\mathsf{verb}(\chi, \varphi)$, where verb is one of the newly added predicates, χ is an individual constant of $\mathcal{L}$ and φ is a complement. For example, we can add the predicates know and surprise and construct sentences such as $\mathsf{know}(j, ?call(b))$ and $\mathsf{surprise}(k, ?x.call(x))$. Clearly, we take $\mathsf{know}(j, ?call(b))$ to translate *John knows whether Bob called* and $\mathsf{surprise}(k, ?x.come(x))$ to translate *It surprised Kate who came to the party.*

In this section and the following one we introduce the semantics of sentences of the form $\mathsf{verb}(\chi, \varphi)$ by explicitly stating the conditions under which such sentences are defined and true with respect to a world w and an assignment g. This means that we will have an immediate way to compute the propositions expressed by such sentences (relative to g), i.e. their truth-sets. Clearly, in order to integrate the new constructions in our semantic system we will need to specify not only their truth-sets but also the issues they express and the set of items they highlight. This can easily be done if we make the simplifying assumption that these constructions semantically behave like basic declaratives, i.e. they are never inquisitive and they always highlight the single item corresponding to the proposition they express.[35] As long as this assumption holds we can define the issue expressed by a sentence of the form $\mathsf{verb}(\chi, \varphi)$ as the downward-closure of its truth-set and the set of items highlighted by it as the singleton set containing its truth-set.

Let us finally move to the semantic entry for know:

Definition 2.6. know

$\mathsf{know}(\chi, \varphi)$ is *defined* at w, g iff i. φ is defined at w, g;
ii. $w \in \mathsf{INFO}(\llbracket\varphi\rrbracket_g)$
if defined, it is *true* at w, g iff $\exists p \in \mathsf{EXH}(\llbracket\varphi\rrbracket_g)$ s.t. i. $w \in p$;
ii. χ believes p at w.

The first element in the presuppositional component of the definition takes care of projecting the eventual presupposition(s) of φ onto the complex sentence.[36] The second element accounts for the factivity of *know*. Let us assume that φ is defined. A sentence of the form $\mathsf{know}(\chi, \varphi)$ is taken to have a defined truth value at a given world w just in case w belongs to the informative content of the complement φ. Now, if φ is a *that*-complement, this amounts to requiring that $w \in |\varphi|_g$, i.e. that φ is true. On the other hand, if φ is a *whether*-complement or a *wh*-complement its informative content equals W, the set of all worlds, hence in general the requirement is trivially met. The case in which $w \notin W$ corresponds to a situation where the question is not truthfully answerable in w;

[35] This is a safe assumption to make as long as we restrict our attention to the data that this work is concerned with, but it has been noticed by Theiler (2014) that some declarative constructions involving questions embedded under non-veridical verbs can actually be inquisitive.

[36] From a general point of view this is needed to account for the fact that a sentence such as (*) seems to lack a definite truth value, inheriting the presupposition failure of the embedded complement:

(*) John knows that the king of France is bald.

Moreover, we need to project the presupposition(s) of the complements because of the way in which we decided to translate alternative questions in the previous section.

our presupposition ensures that in such a case the construction $\mathsf{know}(\chi, \varphi)$ will not be defined.

Turning to the truth-conditions of $\mathsf{know}(\chi, \varphi)$, we choose to encode in the lexical entry for *know* the selection of the strongly exhaustive reading of the embedded complement. Notice that EXH has no effect on the issues expressed by non-inquisitive sentences. Hence, if φ is a *that*-complement then $\mathsf{know}(\chi, \varphi)$ will be true at w (if defined) just in case the subject χ believes any proposition which is a subset of the truth-set of φ (i.e. he or she believes φ). On the other hand, if φ is an interrogative complement then the requirement is that χ believes the true strongly exhaustive answer to it.[37]

Let us show some examples. Assume a discourse model with $D = \{Ann, Bob, John\}$, a language with only the predicate *call*, and consider exactly four possible worlds, one for each possible specification of the interpretation of *call* (we can assume a contextual restriction on the domain such that John is not among the individuals relevant for the denotation of *call*). Consider the sentence in (94) and its translation:

(94) John knows that Bob called.
$\mapsto \mathsf{know}(j, call(b))$

(94) is predicted to be defined at w just in case $w \in \mathsf{INFO}([\![call(b)]\!]_g) = |call(b)|_g$, i.e. just in case Bob called at w. If defined, it is predicted to be true just in case John believes any piece of information belonging to $|call(b)|_g{}^{\downarrow}$, i.e. just in case he correctly believes at least that Bob called. Notice that monotonicity is correctly predicted to hold: if John knows that Bob called and that Ann called, John also knows that Bob called.

Consider now (95) and (96):

(95) John knows whether Bob called.
$\mapsto \mathsf{know}(j, ?call(b))$

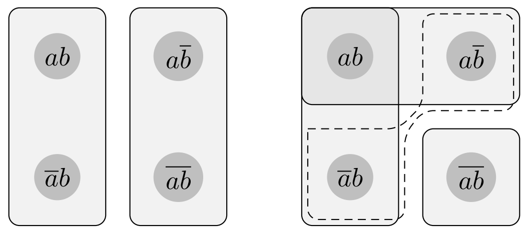
(96) John knows whether Bob called, or Ann↓.
$\mapsto \mathsf{know}(j, ?(call(b) \vee call(a))$

The issues expressed by the embedded questions are depicted in Figure 2.7.

[37] As mentioned above, it is possible to formulate a semantic entry for *know* which is flexible enough to account for both the strongly exhaustive reading of embedded *wh*-questions and the mention-some reading. This can be obtained simply by dropping the reference to EXH, as follows:

Definition 2.7.
$\mathsf{know}(\chi, \varphi)$ is *defined* at w, g iff i. φ is defined at w, g;
ii. $w \in \mathsf{INFO}([\![\varphi]\!]_g)$
if defined, it is *true* at w, g iff $\exists p \in [\![\varphi]\!]_g$ s.t. i. $w \in p$;
ii. χ believes p at w.

The intuitive idea behind this definition is that correctly believing any piece of information that settles the issue expressed by a *wh*-question φ counts as *knowing* φ, which captures the truth-conditions usually associated with a mention-some reading of φ. Clearly, if we want to capture the strongly exhaustive reading now, we need to directly encode it in the question itself, e.g. by means of an operator analogous to EXH but belonging to the formal language.



(a) $[\![?call(b)]\!]_g$ (b) $[\![?(call(b) \vee call(a))]\!]_g$

Figure 2.7: The issues expressed by the complements.

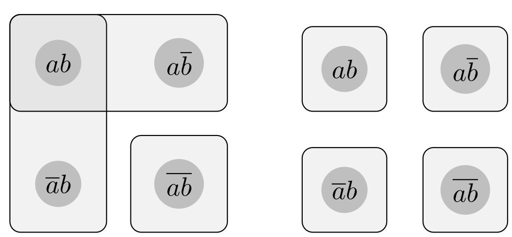
Assuming that both questions are defined at w, the presuppositions of the complex sentences are satisfied. Consider (95): it is predicted to be true at w just in case John's beliefs entail the true answer to *Did Bob called?*,[38] i.e. he believes that Bob called if Bob called in w and that Bob did not call if Bob did not call in w.

As for (96), it is predicted to be true at w just in case John's beliefs entails the true exhaustive answer to *Did Bob called, or Ann↓?*, i.e. he believes that exactly Bob called if Bob called in w and that exactly Ann called if Ann called in w.[39]

Finally, consider (97):

(97) John knows who called.
$\mapsto \mathsf{know}(j, ?x.call(x))$

The issue expressed by the embedded question together with its exhaustification are depicted in Figure 2.8.



(a) $[\![?x.call(x)]\!]_g$ (b) $\mathsf{EXH}[\![?x.call(x)]\!]_g$

Figure 2.8: The issues expressed by the complements.

If the presupposition of $?x.call(x)$ are satisfied then our sentence is defined too. As it should be expected, the sentence is predicted to be true at w just in case John correctly believes the strongly exhaustive answer to *Who called?*.

[38] In fact, EXH has no effect on the issue expressed by a polar question.

[39] This is so because the exhaustivity operator applied to $[\![?(call(b) \vee call(a))]\!]_g$ yields a partition, but two cells (namely $\{ab\}$ and $\{\overline{ab}\}$) are discarded due to the presupposition of the alternative question.

2.4.4 *Surprise* and *realise*

We can now move on and introduce our semantic entries for *surprise* and *realise*. Let us start with the former:

Definition 2.8. surprise

$\mathsf{surprise}(\chi, \varphi)$ is *defined* at w, g iff i. φ is defined ad w, g;
ii. $\forall \alpha_n \in [\varphi]_g^H, \exists \vec{d} \in D^n$ s.t. $w \in \alpha_n(\vec{d})$;
iii. χ believes $\mathsf{WEAK}([\![\varphi]\!]_g, w)$ in w;
if defined, it is *true* at w, g iff χ did not expect $\mathsf{WEAK}([\![\varphi]\!]_g, w)$ in w.

As before, the first component of the presuppositional content ensures that the presuppositions of the complement are inherited by the sentence. The third component accounts for the observation made above that being surprised presupposes correctly believing. This component and the truth-conditions both encode the fact that *surprise* selects for the weakly exhaustive reading of the questions it embeds.

The crucial element of the presuppositional content of *surprise* is the second component, repeated here as (ii).

(ii) $\forall \alpha_n \in [\varphi]_g^H, \exists \vec{d} \in D^n$ s.t. $w \in \alpha_n(\vec{d})$

This condition requires that every function in the set of items highlighted by the complement has to be satisfiable in the world of evaluation, in the sense that for every function in the set there has to be a sequence of individuals which is associated to a true proposition by the function. Let us show what this amounts to for each kind of complement with the help of some examples.

We can start with the complements allowed under *surprise* and then move to the ones that cannot be felicitously embedded, in order to show how our approach accounts for their behaviour.

Consider the sentence in (98) and its translation:

(98) It surprised Kate that Bob called.
$\mapsto \mathsf{surprise}(k, call(b))$

First of all assume that (i) and (iii) are satisfied in w (i.e. $call(b)$ is defined in w and Kate correctly believes that Bob called). Now, given that $[call(b)]_g^H$ contains only one $0-$place item, i.e. the proposition $|call(b)|_g$, the requirement in (ii) boils down to $w \in |call(b)|_g$, i.e. factivity. Hence, as expected, the sentence is defined just in case its complement is true and true only if Kate did not expect that Bob called.

Consider now a construction resulting from embedding a *wh*-question under *surprise*, such as (99):

(99) It surprised Kate who called.
$\mapsto \mathsf{surprise}(k, ?x.call(x))$

Again, assume that (i) and (iii) are satisfied. (ii) requires that every abstract in $[?x.call(x)]_g^H$ is satisfiable in w. We know that $[?x.call(x)]_g^H$ contains exactly one unary abstract, i.e. $\lambda d.|call(x)|_{g[x/d]}$. In order for this function to be satisfiable in w, there must be an individual in the domain, call it e, such that $w \in |call(x)|_{g[x/e]}$. This simply amounts to requiring that in w someone called. It should be clear, then, how (ii) accounts for the existence presupposition observed when *surprise* embeds a *wh*-question. As expected, as soon as the presuppositions are satisfied, $\mathsf{surprise}(k, ?x.call(x))$ is predicted to be true at w just in case Kate did not expect the weakly exhaustive answer to the question *Who called?*.

We want to stress that (ii) is introduced to ensure that the embedded question has a *positive* (weakly exhaustive) answer true at w. In other words, (ii) takes care of the existence presupposition. This amounts to requiring that every abstract highlighted by the question is satisfiable. We ask that *every* abstract is satisfiable because complex embedded clauses may highlight more than one abstract, as in the following example:

(100) It surprised Kate who came to the party and who went to cinema.
$\rightsquigarrow$ Someone came to the party and someone went to the cinema.

If we translate the sentence in (100) as $\mathsf{surprise}(k, ?x.party(x) \wedge ?x.cinema(x))$ we get that the embedded complement highlights two items, namely $\lambda d.|party(x)|_{g[x/d]}$ and $\lambda d.|cinema(x)|_{g[x/d]}$. Now, in order to predicted the correct existence presupposition shown in (100), where the implication concerns both the *wh*-questions conjoined in the complement, we need to make sure that both abstracts are satisfied in w.

We can now turn to polar and alternative questions, in order to show why they cannot be felicitously embedded under *surprise*. As already mentioned, our approach predicts that sentences of the form *It surprised X whether...* are not felicitous because the interplay between the semantics of *suprise* and the meaning of *whether*-complements makes these sentences semantically useless.

To see how this works in more detail, consider (101):

(101) # It surprised Kate whether Bob called.
$\mapsto \mathsf{surprise}(k, ?call(b))$

Assume that $?call(b)$ is defined. Then according to Definition 2.8, the sentence $\mathsf{surprise}(k, ?call(b))$ is defined only if the item in $[?call(b)]_g^H$ is satisfiable, i.e. only if $w \in |call(b)|_g$. This simply means that if Bob called, then (101) is true just in case Kate believes that Bob called but did not expect it; however, if Bob did not call, the sentence is undefined, exactly as it happens with *It surprised Kate that Bob called.*

This means that in general a sentence of the form *It surprised X whether P* is equivalent to *It surprised X that P* when *P* is true and undefined otherwise. We believe that this makes it a semantically useless expression, especially if compared to what happens with *know* when it embeds a polar question: intuitively, *X knows whether P* can be used by a speaker to attribute a state of knowledge to X even if the speaker does not share that knowledge herself. But what could be the use of a construction such as *It surprised X whether P* with the said semantic behaviour? If the answer is *none*, we take this to be an explanation of why *It surprised X whether P* is not felicitous.

A similar explanation can be given for alternative questions. Consider (102):

(102) # It surprised Kate whether Bob called, or Ann↓.
$\mapsto \mathsf{surprise}(k, ?(call(b) \vee call(a))$

The presupposition of the embedded alternative question now plays an important role. According to Definition 2.8, $\mathsf{surprise}(k, ?(call(b) \vee call(a))$ is defined in w only if

i. exactly one among Bob and Ann called at w (i.e. the presupposition of the alternative question is satisfied at w);

ii. every item in $[?(call(b) \vee call(a))]_g^H$ is satisfiable in w.

Consider (ii): it amounts to requiring that both items in $\{|call(a)|_g, |call(b)|_g\}$ are satisfiable in w, i.e. that both Ann and Bob called in w. Clearly this is in direct contradiction with (i). This means that $\mathsf{surprise}(k, ?(call(b) \vee call(a))$ has conflicting presuppositions, hence it can never be defined in w (let alone true).[40]

In general, then, a sentence of the form *It surprised X whether P, or Q* is always undefined. This makes it a useless expression and explains why it is not felicitous.

To conclude, we simply point out that analogous explanations work for *realise* as well, as long as we assume the following semantic entry:

Definition 2.9. realise

$\mathsf{realise}(\chi, \varphi)$ is *defined* at w, g iff
i. φ is defined at w, g;
ii. $\forall \alpha_n \in [\varphi]_g^H, \exists \vec{d} \in D^n$ s.t. $w \in \alpha_n(\vec{d})$;
iii. χ did not believe $\mathsf{WEAK}([\![\varphi]\!]_g, w)$;

if defined, it is *true* at w, g iff χ believe $\mathsf{WEAK}([\![\varphi]\!]_g, w)$ in w.

It should be clear how this definition accounts for the data about *realise* that we collected in the previous section. The selection of the weakly exhaustive reading is encoded in the entry; the requirement concerning the satisfiability of the abstracts encodes the existence presupposition and, combined with our semantic analysis of complements, it accounts for the fact that *realise* cannot felicitously embed polar and alternative questions.

[40] It is important to notice that a similar situation obtains also if we adopt a different treatment of alternative questions that does not assume the presupposition in (i). For example, suppose that we translate *whether Bob called, or Ann* as $call(b) \vee call(a)$ and we assign to it the meaning compute in $\mathsf{Inq}_\mathsf{B}^H$ without any presupposition. Then $\mathsf{surprise}(k, call(b) \vee call(a))$ can be defined at w only if every function in $[call(b) \vee call(a)]_g^H$ is satisfiable in w, i.e. only if both Bob and Ann called. But then the sentence will be undefined in three out of four possible cases.

2.5 Conclusions

In this chapter we presented the semantic system $\mathsf{Inq}_\mathsf{B}^H$, in which the meaning of a sentence is modelled in terms of the issue expressed by the sentence (the information provided and/or requested) and the anaphoric potential of the sentence (the set of items made available for subsequent anaphoric reference). Within the system we developed a uniform analysis of declarative complements as well as interrogative complements, focusing on polar, alternative and *wh*-questions.

In the last part of the chapter we presented our lexical entries for *surprise* and *realise*. Crucially, the presuppositional component of the meaning associated with these verbs makes reference to the anaphoric potential of the meaning associated with the complements they embed. More precisely, we encoded an existence presupposition in the lexical entries, by requiring that the items highlighted by the complements must be satisfied in the world of evaluation.

As we have shown, the interplay between the meaning of the embedding verbs and the meaning of the embedded complements allow us to provide a semantic explanation for the *whether*-puzzle: if a verb such as *surprise* or *realise* embedded a polar or alternative question the result would always be a semantically useless expression.

We believe that our approach has some advantages over other proposals found in the literature. From the point of view of the empirical coverage, our approach fares certainly better than Abels (2004)'s, in that it covers both polar and alternative questions in a uniform way. In addition to this, we noticed that the pragmatic approaches found in the literature crucially refer to the more informative alternatives of a sentence and that they may face a problem when it is not clear how to compute these alternatives. We did not go into the details of this issue in this work, but we believe that a purely semantic approach such as ours would not suffer from this problem, simply because it does not make any reference to the more informative alternatives of a sentence.

Another weakness of the pragmatic approaches is that they need to assume speaker factivity. As already pointed out, the data gathered in the literature so far does not seem to be enough to conclusively determine whether verbs such as *surprise* and *realise* are speaker factive or not, and it seems that only a systematic empirical study could shed further light on this matter. We believe that our approach fares better on this respect in that it is based on the assumption that *surprise* and *realise* have an existence presupposition, which is empirically less controversial than speaker factivity.

On a related note, let us conclude by pointing out that our choice to base our solution on the existence presupposition has certainly some advantages but might also be a source of weakness itself. For example, consider the verb *discover*, which is an epistemic factive such as *realise*. It can be argued that a sentence such as *John discovered who came to the party* presupposes that someone actually came. According to our approach, then, if *discover* has the existence presupposition, it should not embed *whether*-complement. However, it seems that a sentence such as *We will soon discover whether there's life on Mars* is felicitous.

Now, we acknowledge that this observation about *discover* might pose a problem for our approach that will need to be addressed in future work. However, it should be noticed that a quick search on the Corpus of Contemporary American English (`http://corpus.byu.edu/coca/`) returns that *discover+whether* is rarely attested ($<$100 cases) while *discover(s)+whether* and *discover(ed)+whether* are never attested. Hence, even if a sentence such as *We will soon discover whether there's life on Mars* is felicitous, it might be that something else is going on in these cases which might still be compatible with our account.

Be it as it may, the example about *discover* shows that in principle we cannot exclude the existence of verbs that have an existence presupposition but can embed *whether*-complements. As a consequence, we recognise that it is important to find a principled way to argue in favour of the link between the existence presupposition and the unacceptability of embedded *whether*-complements. We will leave this for future work.

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